Geo. Q. Moon & Co., Inc., Binghamton, N. Y.
Moon's Fresh Ground Mixed Feed
Old Times Horse Feed
Special A Scratch Feed

Moran-Patton Co., 230-236 Cedar St., New Haven, Conn.
C. B. Mash

Fred C. Morse, Guilford, Conn.
Old Mill Buttermilk Laying Mash
Old Mill Dairy Ration
Old Mill Mash Feed
Old Mill Provender
Old Mill Scratch Feed

Mt. Vernon Milling Co., Mt. Vernon, Ind.
Poco Hominy Feed

Mystic Milling & Feed Co., Rochester, N. Y.
Genesee Scratching Grains

National Milling Co., Toledo, Ohio.
Osota Feed

R. N. Neal & Co., Inc., Memphis, Tenn.
"Triangle" Brand Prime 36% Protein Cottonseed Meal
"Triangle" Brand 43% Protein Cottonseed Meal

N. E. By-Products Corp., 20 West St., Lawrence, Mass.
Blue Seal Meat Scraps
White Seal Meat Scraps

Newsome Feed & Grain Co., Carson Station, Pittsburgh, Pa.
Palmo Midds

Niagara Falls Milling Co., Niagara Falls, N. Y.
Choice Wheat Middlings

Northwestern Consolidated Milling Co., Minneapolis, Minn.
Planet Feed
Pure Wheat Bran
Wheat Flour Midds
Wheat Mixed Feed
Wheat Standard Midds
XXX Comet

Norton Tallow Co., Somerville, Mass.
Norton's High Grade Meat and Bone Poultry Feed
Norton's High Grade Bone Meal for Poultry

Nowak Milling Corporation, Hammond, Ind.
Domino Alfalfa Horse Feed
Domino Baby Chick Starter with Buttermilk
Domino Butterine Dairy Feed
Domino Chick Feed

Domino Crate Fattener with Buttermilk
Domino Developing Feed
Domino 24½% Dry Dairy Feed
Domino Growing Mash with Buttermilk
Domino Hog Feed
Domino Laying Mash with Buttermilk
Domino Pep O Lene Horse Feed
Domino Pigeon Feed
Domino Scratch Feed
Domino Union Dairy Feed
Domino Vim O Lene Horse Feed
Export Scratch Feed
Fidelity Dairy Feed
Fidelity Horse Feed
Fidelity Scratch Feed
Fidelity Stock Feed
Hammond Dairy Feed
Marathon Chick Feed
Marathon Dairy Feed
Marathon Horse Feed
Marathon Laying Mash with Buttermilk
Marathon Scratch Feed

The Ogilvie Flour Mills Co., Ltd., Montreal, Canada.
Ogilvie's Pure Wheat Bran
Ogilvie's Pure Wheat Shorts

Ontario Milling Co., Inc., Oswego, N. Y.
Uncle John's 24% Cream Pot Ration

Estate of S. V. Osborn, Branford, Conn.
Osborn Mash
Osborn Provender
Osborn Scratch

The Park & Pollard Co., Inc., Buffalo, N. Y.
Arlington Horse Feed
Baby Buster Chick Feed
Belmont Horse Feed
Bet-R-Milk Ration
Bidwell Dry Mash (Black Rock Milling Co.)
Bidwell Scratch Feed (Black Rock Milling Co.)
Bison Stock Feed Sweetened
Bonnie Booster
Chelsea Horse Feed
Corn Feed Meal
Corn and Oats ½ & ½
Economy Feed
GoTuIt Hog Ration
Growing Feed
Herdhelth Ration
Intermediate Chick Feed
Lay or Bust Dry Mash
Leghorn Special Dry Mash
Milk Maid 24% Dairy Ration
Overall 24% Dairy Ration
Over the Top Scratch Feed
Pigeon Feed

Pretty Special Mixed Feed
Red Ribbon Chick Feed
Red Ribbon Scratch Feed
Stevens "44" Dairy Ration
Stevens "44" Sweetened Dairy Ration
Stevens Milkade Calf Meal
The Park & Pollard Dairy Growing Ration
The Park & Pollard 16% Dairy Ration
The Park & Pollard 20% Dairy Ration
The Park & Pollard Co. Stock Feed
Universal Ration
Wheat Flour Middlings

The Patent Cereal Co., Geneva, N. Y.
Hominy Feed

Penick & Ford, Ltd., Inc., Cedar Rapids, Iowa.
Douglas Corn Gluten Feed
Douglas Corn Gluten Meal

M. C. Peters Mill Co., Omaha, Neb.
Peter's Alfalfa Flour
Peter's Arab Horse Feed

Peterson-Hendee Co., Derby, Conn.
P-H Mash
P-H Scratch Feed

Pillsbury Flour Mills Co., Minneapolis, Minn.
Dairy Ration
Durum Wheat Bran and Screenings
Fancy Mixed Feed and Screenings
Hard Wheat A Middlings and Screenings
Hard Wheat Bran and Screenings
Hard Wheat Standard B Middlings and Screenings
Palisade Chick Feed
Palisade Scratch Feed No Grit
Pillsbury's Chick Grains No Grit
Pillsbury's Egg Mash
Pillsbury's Growing Grains
Pillsbury's Growing Mash with Buttermilk
Pillsbury's Scratch Grains
Pillsbury's Starting Food with Buttermilk
Rye Middlings and Screenings
Wheat Bran and Screenings
Wheat Gray Shorts
XX Daisy

Frank S. Platt Co., New Haven, Conn.
Platco Perfection Grain Mixture
Platt's Pigeon Mixture
Platco Laying Mash

Postum Cereal Co., Inc., Battle Creek, Mich.
Burt's Dairy Feed
Burt's Cereal Feed
Burt's Hominy Feed
Burt's Stock Feed

Pratt Food Co., Philadelphia, Pa.
Pratt's Baby Chick Food with Buttermilk
Pratt's Supreme Growing Mash with Buttermilk
Pratt's Supreme Pigeon Feed with Corn
Pratt's Supreme Stock Feed
Pratt's Victory Laying Mash
Pratt's Victory Large Scratch Feed

H. C. Puffer Co., 194 Lyman St., Springfield, Mass.
Egg-Em-On Growing Feed
Egg-Em-On Laying Mash
Egg-Em-On Scratch Grains
Producer Dairy Feed

Quaker Oats Co. (Aunt Jemima Mills Branch), Chicago, Ill.
Bell Cow Bran with Ground Screenings
Bell Cow Shorts with Ground Screenings
Big Egg Scratch Grains No Grit
Big "Q" Dairy Ration
Boss Dairy Ration
Buckeye Feed
Fine Ground Oat Feed
Ful-O-Pep Chick Starter
Ful-O-Pep Coarse Chick Feed
Ful-O-Pep Egg Mash
Ful-O-Pep Fine Chick Feed
Ful-O-Pep Growing Mash
Ful-O-Pep Scratch Grains
Green Cross Horse Feed
Quaker Dairy Feed
Richford White Diamond Stock Feed
Schumacher Calf Meal
Schumacher Feed
Schumacher Little Chick Feed
Schumacher Scratch Grains, No Grit
Sterling Stock Feed with Molasses
Sugared Schumacher Feed
Vim Feed
White Hominy Feed
Yellow Hominy Feed

Ralston Purina Co., St. Louis, Mo.
Protena Dairy Feed
Purina Baby Chick Chow Feed
Purina Calf Chow Feed
Purina Chicken Chowder Feed
Purina Chicken Fat Chow Feed
Purina Chicken Fatena Feed
Purina Chick Growena Feed
Purina Chick Startena Feed
Purina Cow Chow Feed
Purina Hen Chow Feed
Purina Intermediate Hen Chow Feed
Purina Legume Chow Feed
Purina O Molene Feed
Purina Pig Chow Feed
Purina Pigeon Chow Feed
Purina Steer Fatena Feed
Winner Scratch Feed

E. Rauh & Sons Animal Feed Co., Indianapolis, Ind.
Rauh's Meato

John Reardon & Sons Co., Cambridge, Mass.
Reardon's 45% Meat and Bone Scrap
Reardon's 55% Meat Scrap

The Red Wing Milling Co., Red Wing, Minn.
Red Wing Special Wheat Bran with Ground Screenings

Rockville Grain & Coal Co., Rockville, Conn.
Diamond Scratch Feed

Rosenbaum Bros., 208 South LaSalle St., Chicago, Ill.
Advance Dairy Feed
Advance Egg Mash
Advance Horse Feed
Advance Scratch, No Grit
Four O'Clock Scratch Grains
Horse Sense Grain Feed
Rosebro Horse Feed
"77" Chick Scratch, No Grit
"77" Dairy Feed
"77" Horse Feed
"77" Scratch Feed, No Grit
"77" Stock Feed
Special Rosebro Horse Feed
Sugared Vitality
Vitality Chick Starter
Vitality Coarse Chick Screenings
Vitality Dairy Feed
Vitality Egg Mash with Buttermilk
Vitality Egg Mash without Buttermilk
Vitality Fattening Feed
Vitality Fine Chick Screenings
Vitality Growing Mash
Vitality Horse Feed
Vitality Milk Ration
Vitality Pigeon Feed, No Corn, No Grit
Vitality Scratch, No Grit
Vitality Stock Feed
Will Pay Dairy Ration

Russell Miller Milling Co., Minneapolis, Minn.
Alta Hard Wheat Middlings
Hard Wheat Occident Bran
Hard Wheat Occident Mixed Feed

Russia Cement Co., Gloucester, Mass.
Chic-Chuk "The Ideal Concentrated Poultry Food"

The Paty Schwartz Co., New London, Conn.
Homespun Dairy Ration
Homespun Laying Mash
Homespun Scratch Grains
Homespun Stock Feed

Seymour Grain & Coal Co., Seymour, Conn.
"See-More Egg" Buttermilk Mash
"See-More Milk" Dairy Ration
"See-More Egg" Scratch Feed

The Sheets Elevator Co., Cleveland, Ohio.
Diamond Horse Feed
Haskell's Stock Feed
S. B. Alfalfa Horse Feed
S. B. Horse and Mule Feed

Sheffield Elevator Co., Minneapolis, Minn.
Sherwin-Williams Old Process Meal

Shelton Feed Co., Shelton, Conn.
Nelson Mixed Chicken Feed
Nelson Laying Mash

Winchell Smith, Inc., Farmington, Conn.
"Mill Streams" Boomerang Dairy Feed
"Mill Streams" Fortune Hunter Scratch Grains
"Mill Stream" "Lightnin" Laying Mash
"Mill Streams" Twenty Percent Dairy Ration

Springfield Rendering Co., Springfield, Mass.
Springfield Bone Meal
Springfield Ground Meat Scraps

A. E. Staley Mfg. Co., Decatur, Ill.
Staley's Corn Gluten Feed

St. Albans Grain Co., St. Albans, Vt.
Brewers' Dried Grains
Charlestock Feed
Paragon Dairy Feed for Dairy Cows
Paragon Hominy Feed
Paragon Scratch Feed
Wirthmore Balanced Ration for Dairy Cows
Wirthmore Buttermilk Mash Feed with Fish and Meat Scraps
Wirthmore 20% Dairy Feed
Wirthmore Flour Middlings
Wirthmore Gritless Chick Feed
Wirthmore Growing Feed with Dried Buttermilk and Beef Scraps
Wirthmore Intermediate Chick Feed
Wirthmore Scratch Feed
Wirthmore Stock Feed
Wirthmore 16% Summer Ration Containing Minerals
Wirthmore Wheat Feed

John T. Stanley Co., Inc., 642 West 30th St., New York, N. Y.
Stanley's 45% to 50% Protein Meat Scrap

St. Lawrence Flour Mills Co., Ltd., Montreal, Canada.
Bran

David Stott Flour Mills, Detroit, Mich.
Hominy Feed

Syracuse Milling Co., Syracuse, Onondaga County, N. Y.
Onondaga Dairy Feed
Onondaga Scratch Grains
Symco Scratch Grains
Syragold Chick Feed
Syragold Chick Starter
Syragold Dairy Feed
Syragold Dry Mash
Syragold Egg Mash
Syragold Growing Mash
Syragold Milk Ration
Syragold Scratch Grains
Syragold Stock Feed

Thornton & Chester Milling Co., 110 Pearl St., Buffalo, N. Y.
T & C Wheat Bran
T & C Wheat Midds
T & C Wheat Mixed Feed
T & C Wheat Standard Midds

Tioga Mill & Elevator Co., Waverly, N. Y.
Derby Corn and Oat Feed
Derby Horse Feed
Derby Meal
Derby Scratch Feed
Egatine
Or-Co Feed
Red Brand Tioga Dairy Feed
Tioga Laying Feed

Ubiko Milling Co., Cincinnati, Ohio.
Dried Beet Pulp
"Union Grains" Ubiko Biles Ready Dairy Ration

United Flour & Feed Co., 26 Gansevoort St., Albany, N. Y.
Cowles' Special Laying Mash
Cowles' Special Scratch Feed
Ground-Corn-Oats ½ & ½
Rex Dairy Feed
Rex Scratch Feed
United Dairy Ration
United Laying Mash (Storrs Formula)
United Laying Mash (with Buttermilk)
United Scratch Feed
United Wheat Flour Middlings
Waldorf Milk Grains

Van Iderstine Co., Railroad and Greenpoint Aves., Long Island City, N. Y.
VICO High Protein Meat Scrap for Poultry

Van Vechten Milling Co., Inc., Rochester, N. Y.
Irving Mills Rye Feed

Victor Flour Mills, Pittsford, N. Y.
Victor Spring Wheat Bran with Ground Screenings
Victor Spring Wheat Middlings with Ground Screenings

Washburn-Crosby Co., Minneapolis, Minn.
Eventually Gold Medal Chick Feed—No Grit
Eventually Gold Medal Chick Mash (with Dried Buttermilk)
Eventually Gold Medal Developing Feed—No Grit
Eventually Gold Medal Growing Mash (with Dried Buttermilk)
Eventually Gold Medal Hard Wheat Bran and Wheat Screenings
Eventually Gold Medal Hard Wheat Flour Middlings and Wheat Screenings
Eventually Gold Medal Hard Wheat Mixed Feed and Wheat Screenings
Eventually Gold Medal Hard Wheat Standard Middlings and Wheat Screenings
Eventually Gold Medal Pure Hard Wheat Adrian Red Dog
Eventually Gold Medal Scratch Feed—No Grit
Eventually Gold Medal Stock Feed
Eventually Gold Medal Vitamin Dairy Ration (containing wheat germ embryo)
Eventually Gold Medal Vitamin Dairy Ration (24% Protein)
Eventually Gold Medal Vitamin Egg Mash (containing wheat germ embryo) 20-8.5-5.0
Eventually Gold Medal Vitamin Egg Mash (containing wheat germ embryo) 20-8.5-5.5
Gold Medal Corn and Oat Feed No. 2
Gold Medal Hominy Feed (Guaranteed Pure)
North Store Scratch Feed—No Grit
Sonny South Hominy Feed (Louisville Milling Co., Louisville, Ky.)

Wilson & Co., Chicago, Ill.
Red "W" Meat Scraps 50%
Red "W" Meat Scraps 55%

Worcester Rendering Co., Auburn, Mass.
P. W. Bone Meal
P. W. Meat Scrap
P. W. Special Meat Scrap

Yantic Grain & Products Co., Norwich, Conn.
Big (Y) Dairy Ration
Big (Y) Flour Middlings
Big (Y) Growing Feed
Big (Y) Laying Mash
Big (Y) Mixed Feed
Echo Dairy Feed
Perfection Dairy Feed
Uncas Dairy Feed
Uncas Scratch Feed
Uncas Stock Feed

Inspection for 1925.

During the year analyses of 755 samples of feeding stuffs and other forms of fodder materials have been made. Of these, 488 represent official samples drawn by the station inspector, and 52 were unofficial samples submitted by individuals. The remainder, 215 in number, were examined for the Storrs station in connection with field and other experiments, and are not discussed in this report.

Our inspector has visited 87 cities and towns of the State and drawn 543 samples of feeding stuffs up to the time of closing this report, March 1st, 1926. This number includes all of the brands which could be found on sale.

Inspection of feeding stuffs is done largely in the fall months so that the analytical work connected therewith may be finished before the beginning of the fertilizer inspection. But many feeds, particularly poultry feeds, do not appear in the market until spring. Such must, therefore, be sampled and examined as they are found and will be included in our report for next year.

As soon as samples are examined the results are reported to the manufacturers or jobbers and to the dealers, or others from whose stocks the samples were drawn. In cases of deficiencies check samples have been taken from other sources if possible.

Official samples analyzed for inspection purposes may be classified as follows:

Cottonseed products	12
Linseed products	7
Wheat products	75
Rye products	2
Maize products	25
Brewers' and Distillers' products	2
Dried beet pulp	1
Proprietary Mixed Feeds:	
Horse feeds	35
Dairy feeds	93
Stock feeds	34
Calf feeds, etc.	4
Poultry feeds	164
Beef scrap, etc.	34
Total	488

Analyses of official samples are given in Table I. Results for protein and crude fiber which fail to meet guaranties by more than 0.75 per cent in each case, and for fat which are deficient by more than 0.25 per cent, are given in bold face type.

The inspection can best be summarized in the following tabulated statement.

Kind of Feed	Samples examined	Samples deficient	No. deficient in protein	No. excessive in fiber	No. deficient in fat	Total deficiencies	Percentages substantially conforming to, or exceeding, guaranties
Cottonseed Meal	11	2	2	0	0	2	..
Cottonseed Feed	1	0	0	0	0	0	..
Linseed Meal	7	0	0	0	0	0	..
Wheat Bran	21	0	0	0	0	0	..
Wheat Middlings	28	1	1	0	0	1	..
Wheat Red Dog	5	2	0	0	2	2	..
Wheat Feed	21	4	0	1	1	2	..
Rye Products	2	0	0	0	0	0	..
Corn Gluten Feed	6	0	0	0	0	0	..
Corn Gluten Meal	2	0	0	0	0	0	..
Corn Feed Meal	2	0	0	0	0	0	..
Hominy Feed	15	4	0	0	4	4	..
Brewers' and Distillers' Grains	2	2	2	0	1	3	..
Dried Beet Pulp	1	0	0	0	0	0	..
Total	124	13	5	1	8	14	90
Proprietary feeds, including beef scrap:							
Horse Feed	35	11	3	6	7	16	..
Dairy Feed	93	16	2	3	11	16	..
Stock Feed	34	12	2	7	4	13	..
Calf Feed, etc.	4	0	0	0	0	0	..
Poultry Feed	164	20	7	2	11	20	
Beef Scrap, etc.	34	10	9	..	1	10	..
Total	364	69	23	18	34	75	80
Total	488	82	28	19	42	89	83

From this summary it is evident that of non-proprietary feeds only about 10 per cent failed to conform to their guaranties by any considerable amounts; in other words 90 per cent substantially met or exceeded their guaranties.

In the case of proprietary mixed feeds, as might be expected, the proportion of deficiencies is greater; here only 80 per cent substantially met or exceeded guaranties.

For the total number of samples about 17 per cent fell considerably short of guaranties; 83 per cent substantially conformed thereto.

A total of 1443 guaranties are represented by the 488 samples analyzed, of which 1351, or 94 per cent, have been substantially met or exceeded.

Only three instances of tags being attached by means of wire were found. This practice is illegal in this State.

In one instance a minimum fiber guaranty was given whereas the law requires that the maximum shall be stated. This manufacturer was notified to revise his tags to conform to the legal requirements.

In a previous report[1] it was shown that for the five-year period 1920-24 a total of 864 official samples of feeding stuffs had been examined, and of these 83 had shown considerable deficiencies in one or more of the guaranteed ingredients. In other words about 90 per cent practically conformed to the guaranteed analyses.

The data for the past year shows a corresponding percentage which is somewhat lower, viz., 83 per cent. There are two reasons for this. During the last year samples have been judged somewhat more stringently as to deficiencies; but chiefly, the proportion of proprietary feeds, in which the number of deficiencies is greatest, has comprised about ¾ of the total samples whereas in the five-year period this group comprised only about ½ of the samples examined.

[1] Conn. Exp. Station Bull. 268, 1924.

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925.

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein (N x 6.25)		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	OIL SEED PRODUCTS. *Cottonseed Meal.*										
3134	*Helmet.* Ashcraft-Wilkinson Co., Atlanta, Ga.	*New Milford:* Geo. T. Soule	6.40	5.20	41.50	41.00	10.29	10.00	29.95	6.66	6.00
3133	*Monarch.* Ashcraft - Wilkinson Co., Atlanta, Ga.	*New Milford:* Geo. T. Soule	6.74	6.08	44.56	43.00	7.15	10.00	26.69	8.78	6.00
3132	*Paramount.* Ashcraft-Wilkinson Co., Atlanta, Ga.	*Canaan:* Ives & Pierce	7.55	6.11	36.75	36.00	12.70	14.00	30.44	6.45	5.50
3082	*Buckeye.* Buckeye Cotton Oil Co., Cincinnati, Ohio	*Danielson:* Dayville Grain Co.	5.58	5.07	37.44	36.00	13.18	14.00	31.26	7.47	5.00
3527	*Beauty.* S. P. Davis, Little Rock, Ark.	*Wallingford:* A. E. Hall	5.23	5.26	39.06	36.00	12.14	14.00	32.31	6.00	6.00
3581[1]	*Steerboy.* S. P. Davis, Little Rock, Ark.	*Middletown:* Meech & Stoddard, Inc.	7.15	6.00	41.38	43.00	9.58	10.00	28.53	7.36	6.00
3022	*Dixie.* Humphreys-Godwin Co., Memphis, Tenn.	*Bethel:* Morrison & Dunham	6.54	5.53	40.19	41.12	10.74	10.00	29.15	7.85	5.00
3579[1]	*"Lovit."* L. B. Lovitt & Co., Memphis, Tenn.	*Middletown:* Meech & Stoddard, Inc.	9.53	5.10	36.94	36.00	13.83	14.00	28.69	5.91	5.00
3519	*Durham.* Memphis Cottonseed Products Co.	*Waterbury:* Spencer Grain Co.	6.43	5.13	39.81	36.00	10.70	14.00	29.38	8.55	5.00
3089	*"Triangle."* R. N. Neal & Co., Memphis, Tenn.	*New Haven:* R. G. Davis & Sons	5.89	5.00	36.81	36.00	13.68	14.00	32.43	6.19	5.00

[1] Wire tags, illegal. Registered after March 1st, 1926.

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	OIL SEED PRODUCTS—*Continued.*										
	Cottonseed Meal—Continued.										
3165	*"Triangle" 43%.* R. N. Neal & Co., Memphis, Tenn.	*Plantsville:* C. A. Cowles	6.10	6.99	45.63	43.00	7.70	10.00	26.49	7.09	6.00
	Cottonseed Feed.										
2937	*Danish.* Humphreys-Godwin Co., Memphis, Tenn.	*Hamden:* Ira W. Beers	5.55	6.22	40.25	36.00	10.60	15.00	31.10	6.28	5.00
	Linseed Meal, Old Process.										
3104	*Amco.* American Milling Co., Peoria, Ill.	*New Haven:* R. G. Davis & Sons	8.14	5.12	31.25	30.00	8.63	10.00	40.00	6.86	5.00
3518	*Pure.* Archer Daniels Midland Co., Minneapolis, Minn.	*Seymour:* Seymour Grain & Coal Co.	8.33	4.81	35.31	34.00	7.40	9.00	38.32	5.83	5.00
3144	Hirst & Begley, Chicago, Ill	Mfr's Sample	6.62	4.98	38.06	34.00	7.13	9.00	36.23	6.98	6.00
2261	*Pure.* Mann Bros. Company, Buffalo, N. Y.	*Norfolk:* Aug. P. Curtis	10.22	4.50	34.63	34.00	7.85	10.00	35.24	7.56	6.00
2248	*Kellogg's.* Spencer Kellogg, Buffalo, N. Y.	*Plantsville:* C. A. Cowles	8.50	4.87	36.25	34.00	7.60	10.00	36.93	5.85	5.00
3073	Kellogg & Miller, Amsterdam, N. Y.	*Derby:* Peterson-Hendee Co.	8.58	4.75	35.50	34.00	7.31	9.00	37.76	6.10	4.00
3535	Sherwin-Williams Co., Winnepeg, Canada	*Newtown:* R. H. Holcomb & Co.	6.28	5.23	36.69	35.00	7.88	7.50	35.54	8.38	5.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	WHEAT PRODUCTS.										
	Wheat Bran.										
2824	*Dandy.* Copeland Flour Mills, Midland, Canada	*Merrow:* I. F. Wilcox	10.00	5.30	15.00	15.00	10.38	11.50	53.64	5.68	3.50
2957	*Duluth Imperial.* Duluth Superior Milling Co., Duluth, Minn.	*Putnam:* Dayville Grain & Coal Co.	9.33	5.05	14.88	14.00	8.45	13.00	56.56	5.73	3.75
2939	*Rainbow.* The Galt Flour Mills, Galt, Canada	*New Hartford:* Geo. W. Case	9.18	5.70	16.88	15.00	10.08	11.50	51.81	6.35	3.50
2290	Wm. Hamilton & Son, Honeoye, Falls, N. Y.	*Derby:* Peterson-Hendee Co.	10.33	5.78	14.44	13.25	8.41	11.60	57.00	4.04	2.90
2223	*Choice.* Hecker - Jones - Jewell Milling Co., New York City	*Ansonia:* Ansonia Flour & Feed Co.	10.25	5.88	15.00	13.00	9.58	14.00	53.81	5.48	3.50
2930[2]	*Choice.* Hecker - Jones - Jewell Milling Co., New York City	*New Haven:* R. G. Davis & Sons	10.55	6.11	14.88	13.50	8.94	14.00	53.99	5.53	3.50
2770	*Lakewood.* Lake of the Woods Milling Co., Montreal, Canada	*Hazardville:* Amos D. Bridges' Sons	9.48	5.37	14.75	15.00	10.08	11.50	54.65	5.67	3.50
2293	Maple Leaf Milling Co., Toronto, Canada	*Hamden:* Ira W. Beers	9.38	5.41	15.81	15.00	9.48	11.50	54.44	5.48	3.50
2800	Maple Leaf Milling Co., Toronto, Canada	*Lakeville:* E. W. Spurr Co.	9.68	5.20	15.56	15.00	9.39	11.50	54.91	5.26	3.50
2879[3]	*Niagara Choice.* Niagara Falls Milling Co., Niagara Falls, N. Y.	*Meriden:* H. Grulich	9.55	5.50	15.13	15.00	9.23	11.00	54.95	5.64	3.50

[2] With screenings. [3] Registered after March 1st, 1926.

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25 Found	Protein Guaranteed, not less than	Fiber Found	Fiber Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat Found	Fat Guaranteed, not less than
	WHEAT PRODUCTS—*Continued.*										
	Wheat Bran—Continued.										
3024	*Pure.* Northwestern Consolidated Milling Co., Minneapolis, Minn.	*Danbury:* F. C. Benjamin	9.25	6.49	15.13	13.00	9.84	12.00	53.66	5.63	4.00
2886	*Ogilvie Pure.* Ogilvie Flour Mills Co., Montreal, Canada	*Guilford:* F. H. Rolf	8.53	5.79	15.50	15.00	10.19	11.50	54.66	5.33	3.50
2267	Pillsbury Flour Mills Co., Minneapolis, Minn.	*Litchfield:* Wadhams Co.	9.91	6.23	15.50	14.00	10.18	12.00	52.85	5.33	4.00
2895	*Bell Cow.* Quaker Oats Company, Peterborough, Canada ..	*Waterbury:* H. S. Coe & Co., Inc.	10.00	4.97	15.13	15.00	8.50	10.00	56.15	5.25	3.50
3532	*Red Wing Special.* Red Wing Milling Co., Red Wing, Minn.	*Willimantic:* Willimantic Grain Co.	6.75	5.91	15.13	13.50	9.70	15.60	57.06	5.45	4.10
2834	*Black Hawk.* Robin Hood Mills, Ltd., Moose Jaw and Calgary, Canada	*Seymour:* Seymour Grain & Coal Co.	8.95	5.67	16.56	15.00	9.55	11.50	52.89	6.38	3.50
2795	*Occident.* Russell Miller Milling Co., Minneapolis, Minn.	*Windsor:* Farmers' Grain & Supply Co.	10.41	5.77	15.63	14.00	9.14	11.50	53.25	5.80	4.00
2236	St. Lawrence Flour Mills, Montreal, Canada	*Hamden:* Ira W. Beers	12.19	5.13	15.94	15.00	9.04	11.50	52.59	5.11	3.50
2943	*Victor Spring.* Victor Flour Mills, Victor, N. Y.	*Guilford:* F. H. Rolf	8.68	5.83	15.25	16.00	9.30	11.00	55.69	5.25	4.00
2241	*Gold Medal.* Washburn-Crosby Co., Minneapolis, Minn.	*Plantsville:* C. A. Cowles	11.30	4.85	15.69	14.00	8.65	12.00	54.21	5.30	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25 Found	Protein Guaranteed, not less than	Fiber Found	Fiber Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat Found	Fat Guaranteed, not less than
	WHEAT PRODUCTS—*Continued.*										
	Wheat Bran—Concluded.										
2296	*Pioneer.* Western Canada Flour Mills, Toronto, Canada	*Torrington:* Litchfield County Co-op.	8.90	5.55	16.19	15.00	9.80	11.50	53.76	5.80	3.50
	Wheat Middlings.										
2823	*Dandy.* Copeland Flour Mills, Midland, Canada	*Merrow:* I. F. Wilcox	11.50	3.54	17.63	16.00	5.73	8.00	56.05	5.55	5.00
3069	*Eagle.* Eagle Roller Mill Co., New Ulm, Minn.	*So. Norwalk:* Roodner Feed Co.	8.45	3.83	17.94	16.00	4.81	6.00	58.93	6.04	5.00
2769	*Elmore Snow.* Elmore Milling Co., Oneonta, N. Y.	*Thompsonville:* Geo. S. Phelps & Co.	10.43	3.59	16.88	16.00	5.35	7.00	58.46	5.29	4.25
2291	*Special.* Fairchild Milling Co., Cleveland, Ohio	*Seymour:* Seymour Grain & Coal Co.	10.79	3.25	15.88	15.00	4.23	8.00	61.90	3.95	3.50
2292	*Standard.* Fairchild Milling Co., Cleveland, Ohio	*Seymour:* Seymour Grain & Coal Co.	9.83	4.54	17.06	13.00	7.10	9.00	55.81	5.66	4.00
3061	*Dairy Maid.* Federal Mill & Elevator Co., Lockport, N. Y.	*Putnam:* Bosworth Bros.	9.25	3.68	16.88	15.50	4.81	6.00	60.60	4.78	4.50
3166	*Superior.* Flory Milling Co., Bangor, Pa.	*Thomaston:* I. Levey	11.08	3.55	15.25	14.00	4.59	8.00	60.24	5.29	3.00
2940	*Rainbow.* The Galt Flour Mills, Galt, Canada	*New Hartford:* Geo. W. Case ..	9.29	4.58	18.88	16.00	7.63	8.00	52.44	7.18	5.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	WHEAT PRODUCTS—*Continued.*										
	Wheat Middlings—Continued.										
2289	Wm. Hamilton & Son, Honeoye Falls, N. Y.	*Derby:* Peterson-Hendee Co.	11.35	3.15	15.63	14.90	3.15	5.40	62.59	4.13	4.90
3330	Wm. Hamilton & Son, Honeoye Falls, N. Y.	*Derby:* Peterson-Hendee Co.	9.58	4.10	17.38	14.90	4.50	5.40	59.24	5.20	4.90
2211	*H.* Hecker-Jones-Jewell Milling Co., New York City	*West Cheshire:* G. W. Thorpe	10.65	4.39	16.00	14.00	7.03	9.50	56.78	5.15	5.00
3028	Hecker-Jones-Jewell Milling Co., New York City	*Stratford:* Farmers' Flour & Grain Co.	9.42	4.91	17.38	15.00	7.38	9.50	54.38	6.53	4.75
2298	*Rex.* Maple Leaf Milling Co., Toronto, Canada	*Granby:* E. H. Rollins	9.30	4.27	17.69	15.00	6.95	9.50	55.36	6.43	5.00
2772	*Choice.* Niagara Falls Milling Co., Niagara Falls, N. Y.	*Derby:* Peterson-Hendee Co.	9.88	3.70	17.44	15.50	5.44	9.50	57.94	5.60	4.00
3023	Northwestern Consolidated Milling Co., Minneapolis, Minn.	*Danbury:* C. S. Barnum & Son.	8.98	4.23	17.63	15.00	5.93	6.00	56.70	6.53	4.00
2781	Northwestern Consolidated Milling Co., Minneapolis, Minn.	*Windsor:* Farmers' Grain & Supply Co.	8.85	4.25	15.88	15.00	8.01	9.50	56.61	6.40	4.00
2885	*Ogilvie's.* Ogilvie Flour Mills, Winnepeg, Canada	*Branford:* S. V. Osborn Estate.	10.13	3.99	16.94	16.00	6.25	8.00	57.30	5.39	5.00
2921	Park & Pollard Co., Buffalo, N. Y.	*Westerly:* C. W. Campbell Co.	9.88	2.95	14.44	16.00	4.43	6.00	64.12	4.18	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	WHEAT PRODUCTS—*Continued.*										
	Wheat Middlings—Concluded.										
2270	Pillsbury Mills, Minneapolis, Minn.	*Torrington:* Litchfield County Co-op. Assoc.	10.03	3.37	17.81	16.00	4.02	6.00	59.93	4.84	4.00
2268	*Standard B.* Pillsbury Mills, Minneapolis, Minn.	*Torrington:* Litchfield County Co-op. Assoc.	10.53	3.88	16.63	15.00	5.93	9.50	57.86	5.17	4.00
2894	*Bell Cow.* Quaker Oats Co., Peterborough, Canada	*Waterbury:* H. S. Coe & Co., Inc.	9.44	3.98	17.13	15.00	6.00	8.00	57.51	5.94	4.00
2838	*Black Hawk.* Robin Hood Mills, Ltd., Moose Jaw and Calgary, Canada	*Waterbury:* Spencer Grain Co.	10.24	8.58	18.25	17.00	6.83	8.00	49.72	6.38	5.00
2796	*Alta.* Russell Miller Milling Co., Minneapolis, Minn.	*Windsor:* Farmers' Grain & Supply Co.	9.50	4.16	17.81	15.00	5.89	8.50	56.19	6.45	4.50
2237	*Wirthmore.* St. Albans Grain Co., St. Albans, Vt.	*Hamden:* Ira W. Beers	10.35	3.46	16.13	14.00	5.43	8.00	59.65	4.98	4.00
2942	*Victor Spring.* Victor Flour Mills, Victor, N. Y.	*Guilford:* F. H. Rolf	8.76	4.25	17.00	17.65	6.10	9.50	58.04	5.85	5.00
2959	*Gold Medal.* Washburn-Crosby Co., Minneapolis, Minn.	*Norwich:* Norwich Grain Co.	10.56	3.19	15.38	16.00	3.73	6.00	62.55	4.59	4.00
2240	*Gold Medal.* Washburn-Crosby Co., Minneapolis, Minn.	*Plantsville:* C. A. Cowles	10.38	4.31	16.44	15.00	7.36	9.50	55.50	6.01	4.00
2969	*Big Y.* Yantic Grain & Products Co., Norwich	*Moosup:* Moosup Grain Co.	9.25	3.81	17.38	17.00	5.00	5.00	59.48	5.08	5.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25: Found	Protein N x 6.25: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	WHEAT PRODUCTS—*Continued.*										
	Wheat Red Dog.										
3070	*Eagle.* Eagle Roller Mill Co., New Ulm, Minn.	*So. Norwalk:* Roodner Feed Co.	9.11	2.96	18.00	16.50	2.65	3.50	61.78	5.50	4.50
2252	*Red Dog Flour.* Hecker-Jones-Jewell Mill. Co., New York	*Torrington:* D. L. Talcott	10.15	3.22	16.75	15.75	3.63	4.00	60.92	5.33	5.00
2777	*Red Dog Flour.* Hecker-Jones-Jewell Mill. Co., New York	*Wallingford:* A. E. Hall	10.58	2.29	16.94	15.00	1.73	4.00	64.73	3.73	4.25
2809	*Gold Medal Adrian Red Dog.* Washburn-Crosby Co., Minneapolis, Minn.	*Thompsonville:* Geo. S. Phelps & Co.	10.51	1.94	16.81	16.00	1.90	4.00	65.16	3.68	4.00
3193	*Gold Medal Adrian Red Dog.* Washburn-Crosby Co., Minneapolis, Minn.	*Norwich:* Yantic Grain & Products Co.	10.24	2.81	17.13	16.00	2.15	4.00	62.92	4.75	4.00
	Wheat Feed. (Mixed Feed.)										
3191	*Wingold.* Bay State Milling Co., Winona, Minn.	*Danbury:* F. C. Benjamin	9.45	4.19	16.56	16.20	4.98	8.10	60.37	4.45	4.20
3108	*Boston.* Duluth Superior Milling Co., Duluth, Minn.	*Manchester:* Manchester Grain Co.	8.25	4.53	15.13	15.00	7.58	9.50	58.81	5.70	4.00
3060	*Dairy Maid.* Federal Mill & Elevator Co., Lockport, N. Y.	*Putnam:* Bosworth Bros.	9.73	5.39	16.13	15.50	6.85	8.00	57.32	4.58	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25: Found	Protein N x 6.25: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	WHEAT PRODUCTS—*Continued.*										
	Wheat Feed. (Mixed Feed)—Continued.										
2247	*Gold Mine.* H. H. King Flour Mills Co., Minneapolis, Minn.	*Derby:* Peterson-Hendee Co.	10.85	4.85	15.50	15.00	7.83	9.50	55.53	5.44	4.50
2259	*Red Star.* E. Manchester & Sons, Winsted	*Winsted:* E. Manchester & Sons	10.20	4.12	16.63	15.50	6.40	7.50	57.33	5.32	4.00
2774	*Bull.* Maritime Milling Co., Buffalo, N. Y.	*New Milford:* Geo. E. Ackley Co.	9.95	4.71	16.38	15.00	6.80	8.00	56.28	5.88	4.00
2780	*Red Wing.* Meech & Stoddard, Inc., Middletown	*East Hartford:* Meech Grain Co.	9.05	5.18	15.88	15.00	7.24	10.00	57.27	5.38	4.50
3522	*Moon's.* George O. Moon & Co., Binghamton, N. Y.	*Thomaston:* Cunningham & Wallace	7.88	5.59	16.63	14.00	7.58	10.00	57.89	4.43	4.00
3036	*Osota.* National Milling Co., Toledo, Ohio	*Suffield:* Spencer Bros.	9.35	5.32	16.19	15.00	7.88	10.00	55.58	5.68	4.50
2871[4]	*Choice.* Niagara Falls Milling Co., Niagara Falls, N. Y.	*Torrington:* F. W. Wadhams	9.30	4.63	15.63	14.50	6.90	8.00	58.00	5.54	4.00
2881	*Planet.* Northwestern Consolidated Milling Co., Minneapolis, Minn.	*So. Coventry:* E. W. Latimer	10.86	4.61	16.25	15.00	6.03	8.00	57.08	5.17	4.00
3126	Northwestern Consolidated Milling Co., Minneapolis, Minn.	*Kensington:* S. F. Labieniec	10.73	4.96	16.50	15.00	7.12	8.50	55.19	5.50	4.00

[4] Registered after March 1st, 1926.

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	WHEAT PRODUCTS—*Concluded.*										
	Wheat Feed. (Mixed Feed)—Concluded.										
2880	*XXX Comet.* Northwestern Consolidated Milling Co., Minneapolis, Minn.	*Bloomfield:* Bloomfield Farmers' Exchange	10.25	2.77	17.38	16.00	1.85	4.00	62.67	5.08	4.00
2926	*Pretty Special.* Park & Pollard Co., Buffalo, N. Y.	*Woodbury:* C. L. Adams Co.	9.53	4.94	15.88	16.00	7.78	9.00	55.59	6.28	4.00
2786	*Pillsbury's.* Pillsbury Flour Mills, Minneapolis, Minn.	*New Milford:* Geo. T. Soule	10.54	3.51	18.50	15.00	4.17	8.50	57.86	5.42	4.00
2272	*XX Daisy.* Pillsbury Flour Mills, Minneapolis, Minn.	*Canaan:* Ives & Pierce	10.30	2.65	18.13	16.00	2.43	4.00	61.83	4.66	4.00
2221	*Occident.* Russell Miller Milling Co., Minneapolis, Minn.	*Ansonia:* Ansonia Flour & Feed Co.	10.48	4.69	16.25	15.00	7.43	9.50	55.28	5.87	4.50
2278	*Wirthmore.* St. Albans Grain Co., St. Albans, Vt.	*Kent:* Kent Grain & Coal Co.	10.18	4.76	15.63	15.00	6.25	8.00	58.80	4.38	4.50
2927	*Or-Co.* Tioga Mill & Elevator Co., Waverly, N. Y.	*Hawleyville:* W. A. Honan	9.48	5.79	17.00	15.00	7.45	10.00	55.78	4.50	5.00
2242	*Gold Medal.* Washburn-Crosby Co. Minneapolis, Minn.	*Watertown:* Watertown Coöp. Assoc.	10.55	4.04	15.94	16.00	5.21	7.50	60.18	4.08	4.00
2793	*Big Y.* Yantic Grain & Products Co., Norwich	*Norwich:* Yantic Grain & Products Co.	8.95	4.56	15.88	16.00	8.04	7.00	57.37	5.20	4.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	RYE PRODUCTS.										
3095	*Irving Mills* VanVechten Milling Co., Rochester, N. Y.	*Higganum:* Felix A. Petrofsky	8.36	3.74	17.13	13.00	4.10	10.00	63.14	3.53	2.00
2266	Miner-Hillard Milling Co., Wilkes-Barre, Penn.	*Torrington:* F. W. Wadhams	9.93	3.66	15.31	12.00	3.68	5.00	64.37	3.05	2.50
	MAIZE PRODUCTS.										
	Corn Gluten Feed.										
3188	American Maize Products Co., New York	*Bloomfield:* Bloomfield Farmers' Exchange	6.28	3.57	24.63	23.00	8.35	8.50	54.11	3.06	2.00
3153	*Clinton.* Clinton Corn Syrup Refining Co., Clinton, Iowa	*Seymour:* Seymour Grain & Coal Co.	7.75	4.53	25.63	23.00	6.68	8.50	51.45	3.96	2.00
2208	*Buffalo.* Corn Products Refining Co., New York	*Hamden:* Ira W. Beers	10.10	5.39	25.00	23.00	7.58	8.50	49.05	2.88	2.00
2839	*Keokuk.* J. C. Hubinger Bros Co., Keokuk, Iowa	*Winsted:* E. Manchester & Sons	8.73	3.17	23.50	23.00	6.88	8.50	52.87	4.85	2.00
3162	*Douglas.* Penick & Ford, Ltd., Inc., Cedar Rapids, Iowa	*New London:* Paty Schwartz Co.	9.19	6.05	25.00	23.00	7.60	8.00	49.31	2.85	1.00
3116	*Staley's.* A. E. Staley Mfg. Co., Decatur, Ill.	*Derby:* Peterson-Hendee Co.	8.10	6.03	24.56	23.00	6.54	8.00	52.83	1.94	1.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	MAIZE PRODUCTS—*Continued.*										
	Corn Gluten Meal.										
2245	*Diamond.* Corn Products Refining Co., New York	*Torrington:* D. L. Talcott......	9.53	1.32	41.94	40.00	2.89	4.00	41.93	2.39	1.00
3098	*Douglas.* Penick & Ford, Inc., Cedar Rapids, Iowa	*Woodbury:* C. L. Adams Co. ...	6.90	2.87	43.44	40.00	3.23	4.00	41.68	1.88	1.00
	Corn Feed Meal.										
2925	Park & Pollard Co., Buffalo, N. Y.	*Seymour:* Klaridis Bros.	10.78	1.78	9.94	9.00	4.18	4.00	68.98	4.34	2.50
2977	*Derby.* Tioga Mill & Elevator Co., Waverly, N. Y.	*Hawleyville:* W. A. Honan	9.70	1.75	9.88	9.02	3.10	3.50	70.93	4.64	3.06
	Hominy Feed.										
2210	Aunt Jemima Mills Co., St. Joseph, Mo.	*Cheshire:* G. W. Thorpe	10.70	2.92	11.25	10.00	4.60	8.00	64.81	5.72	5.00
2950	*Homco.* Decatur Milling Co., Decatur, Ill.	*Wallingford:* A. E. Hall	9.55	2.44	10.50	10.00	5.03	6.00	65.80	6.68	7.00
3182	*Homco.* Decatur Milling Co., Decatur, Ill.	*Branford:* S. V. Osborn Estate.	10.15	2.43	10.50	10.00	4.30	6.00	65.22	7.40	7.00
2929	*Emco.* Evans Milling Co., Indianapolis, Ind.	*New Haven:* Moran-Patton Co..	9.13	2.60	10.69	10.00	4.61	6.00	67.84	5.13	7.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	MAIZE PRODUCTS—*Concluded.*										
	Hominy Feed—Concluded.										
2233	*K. B. C.* Kellogg Company, Battle Creek, Mich.	*Plantsville:* C. A. Cowles	9.15	2.11	10.50	10.00	3.78	5.00	68.52	5.94	6.00
2799	*Sonny South.* Louisville Milling Co., Louisville, Ky.	*Hamden:* Ira W. Beers	7.98	3.05	11.63	10.00	5.43	6.00	64.85	7.06	7.00
3081	*Bufceco.* Mapl-Flake Mills, Inc., Chicago, Ill.	*New Hartford:* Geo. W. Case ..	9.03	2.90	10.94	10.00	3.90	6.00	67.30	5.93	5.00
2251	*Steam-cooked.* Miner-Hillard Milling Co., Wilkes-Barre, Penn.	*Torrington:* F. W. Wadhams ..	10.73	2.33	10.38	10.00	4.05	5.00	68.13	4.38	4.00
2224	Patent Cereals Co., Geneva, N. Y.	*Seymour:* Seymour Grain & Coal Co.	10.30	2.54	10.44	10.00	4.68	5.00	67.54	4.50	5.00
2790	*Burt's.* Postum Cereal Co., Inc., Battle Creek, Mich.	*Collinsville:* F. W. Konold	10.36	1.97	10.13	10.00	2.78	5.00	70.03	4.73	6.00
2872	*White.* Quaker Oats Company, Chicago, Ill.	*Litchfield:* Wadhams Co.	8.88	1.94	10.25	10.50	4.72	6.00	69.27	4.94	5.00
2897	*Yellow.* Quaker Oats Company, Chicago, Ill.	*Watertown:* Watertown Coöp. Assoc.	8.33	2.55	11.06	10.50	4.45	6.00	67.98	5.63	5.00
3063	*Paragon.* St. Albans Grain Co., St. Albans, Vt.	*Danielson:* Quinebaug Mills	9.44	2.89	10.69	10.00	3.65	7.00	67.44	5.89	6.00
3118	David Stott Flour Mills, Detroit, Mich.	*New London:* Paty Schwartz Co.	9.93	2.09	10.63	9.50	3.84	7.50	67.67	5.84	5.50
2949	*Gold Medal.* Washburn-Crosby Minneapolis, Minn.	*Winsted:* Chas. R. Hawley	9.80	2.30	10.31	10.00	3.47	6.00	68.42	5.70	5.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	BREWERS' AND DISTILLERS' PRODUCTS.										
3075	*Alco.* Dried Distillers' Grains. C. J. Martenis Grain Co., Produce Exchange, New York	*Seymour:* Seymour Grain & Coal Co.	5.80	1.43	23.50	25.00	10.89	13.00	48.95	9.43	5.50
3077	*Ricormalt.* Waterloo Distilling Corp., Waterloo, N. Y.	*Plantsville:* C. A. Cowles	3.76	3.65	26.81	28.00	9.85	14.00	46.19	9.74	10.00
	DRIED BEET PULP.										
2232	Larrowe Milling Co., Detroit, Mich.	*West Cheshire:* G. W. Thorpe ..	8.83	2.80	9.38	8.00	18.23	22.00	60.01	0.75	0.50
	PROPRIETARY MIXED FEEDS.										
	Horse Feed.										
3083	*Beacon.* Beacon Milling Co., Cayuga, N. Y.	*Danbury:* C. S. Barnum & Son.	7.46	3.89	10.44	9.00	7.53	11.00	67.39	3.29	2.50
2830	*Provender.* C. W. Campbell Co., Westerly, R. I.	*Westerly:* C. W. Campbell Co...	10.75	2.42	10.56	10.00	7.38	8.00	64.76	4.13	4.00
2297	*Co-Pro-Co.* Corn Products Refining Co., New York	*Kent:* Kent Grain & Coal Co. ..	7.94	4.93	9.63	9.00	10.30	12.00	64.30	2.90	2.50
3017	*Davis.* R. G. Davis & Sons, New Haven	*Glenbrook:* Davis-Scofield Co. ..	8.84	4.07	9.88	9.00	7.68	10.00	66.11	3.42	3.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Horse Feed—Continued.										
2931	*No. 1 Provender.* R. G. Davis & Sons, New Haven	*New Haven:* R. G. Davis & Sons	10.10	2.55	11.00	10.00	7.52	6.00	64.71	4.12	4.50
3198	*No. 1 Provender.* R. G. Davis & Sons, New Haven	*Westville:* R. G. Davis & Sons..	10.19	2.50	10.63	10.00	7.83	6.00	65.10	3.75	4.50
2199	*Alfalfa Meal.* Denver Alfalfa Mill & Products Co., Lamar, Col.	*Derby:* Peterson-Hendee Co. ...	7.68	8.52	14.38	12.00	29.48	35.00	37.91	2.03	1.00
2836	*Eastern States.* Eastern States Farmers' Exch., Springfield, Mass.	*Seymour:* John Swan	9.24	3.05	14.06	12.00	4.83	9.00	64.32	4.50	4.00
2817	*Lancaster 60.* John W. Eshelman & Son, Lancaster, Pa. ...	*Simsbury:* Woods-Chandler Co.	8.23	4.94	11.63	9.00	10.53	10.00	61.53	3.14	2.50
2203	*Red Rose 85.* John W. Eshelman & Son, Lancaster, Pa. ...	*Seymour:* Seymour Grain & Coal Co.	11.00	3.73	10.81	9.00	8.25	10.00	62.11	4.10	3.00
3067	*"Ata Boy."* Flory Milling Co., Bangor, Penn.	*So. Norwalk:* Roodner Feed Co.	5.53	8.77	7.88	5.00	9.68	15.00	67.26	0.88	1.50
3068	*Blue Mountain.* Flory Milling Co., Bangor, Penn.	*So. Norwalk:* Roodner Feed Co.	6.63	9.05	8.00	7.00	10.18	11.00	63.69	2.45	2.00
3140	*Hunter.* Grain Belt Mills Co., St. Joseph, Mo.	*New Haven:* R. G. Davis & Sons	8.70	5.69	11.63	9.00	8.38	14.00	63.35	2.25	2.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Horse Feeds—Continued										
2958	Dwight Hamlin Co., Pittsburgh, Penn.	*Norwich:* Yantic Grain & Products Co.	6.49	6.59	10.81	12.00	10.96	10.00	64.00	1.15	2.00
2860	*Algrane.* Hecker H. O. Co., Buffalo, N. Y.	*Westerly:* C. W. Campbell Co.	8.98	5.10	11.63	11.00	10.03	9.75	60.53	3.73	4.00
3186	*Algrane.* Hecker H. O. Co., Buffalo, N. Y.	*Westerly:* C. W. Campbell Co.	8.90	5.01	10.19	11.00	11.00	9.75	61.05	3.85	4.00
3135	*Imperial.* Imperial Grain & Milling Co., Toledo, Ohio	*East Hartford:* Meech Grain Co.	9.15	2.31	9.75	9.50	5.85	4.00	68.51	4.43	4.00
3015	*Nabob.* Francis H. Leggitt Co., Stamford	*Stamford:* Francis H. Leggitt Co.	8.90	5.02	11.25	9.00	10.31	10.00	61.57	2.95	2.50
3041	*Armour's.* Mapl-Flake Mills, Inc., Chicago, Ill.	*Stamford:* W. L. Crabb	8.30	5.47	13.88	11.00	11.00	9.00	57.02	4.33	4.00
3047[3]	*Oat.* Mapl-Flake Mills, Chicago, Ill.	*New Haven:* R. G. Davis & Sons	5.38	6.15	4.63	5.50	26.20	30.00	56.36	1.28	1.50
3529	*Red Wing.* Meech & Stoddard, Inc., Middletown	*East Hartford:* Meech Grain Co.	8.53	3.70	11.38	9.00	7.75	10.00	64.24	4.40	3.00
3523	*Old Times.* Geo. O. Moon & Co., Binghamton, N. Y.	*Thomaston:* Cunningham & Wallace	8.58	2.64	11.13	8.50	7.09	9.00	66.33	4.23	4.50

[3] Not sold as such. Used in mixtures.

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not more than	Found	Guaranteed, not less than		Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Horse Feeds—Continued.										
2849	*Provender.* Fred C. Morse, Guilford	*Guilford:* Fred C. Morse	10.85	2.31	11.06	9.00	4.49	5.00	66.69	4.60	3.00
3169	*Domino.* Vim-O-Lene. Nowak Milling Corp., Hammond, Ind.	*Waterville:* Wooster Feed Store	9.01	3.07	9.69	8.00	5.20	9.00	69.55	3.48	2.00
2882	*Osborn Provender.* S. V. Osborn Estate, Branford	*Branford:* S. V. Osborn Estate.	9.68	2.44	11.06	10.00	8.55	8.00	64.29	3.98	4.00
2778	*Arlington.* Park & Pollard Co., Buffalo, N. Y.	*Plainville:* F. B. Newton	7.73	4.44	10.88	9.00	6.94	11.00	66.61	3.40	2.50
2218	*Belmont.* Park & Pollard Co., Buffalo, N. Y.	*Shelton:* Shelton Feed Co.	8.45	4.81	10.75	10.00	6.00	12.00	66.56	3.43	2.00
2228	*Chelsea.* Park & Pollard Co., Buffalo, N. Y.	*Waterbury:* Spencer Grain Co.	8.15	8.10	7.50	8.00	11.92	12.00	63.24	1.09	2.00
2915	*Corn and Oats, ½ & ½.* Park & Pollard Co., Buffalo, N. Y.	*Colchester:* P. Cutler, Inc.	10.33	2.91	11.81	10.00	6.80	8.00	63.92	4.23	1.50
3189	*Arab.* M. C. Peter's Mill Co., Omaha, Neb.	*Hartford:* C. A. Pease	6.50	5.97	12.31	10.00	12.43	15.00	60.01	2.78	2.00
2976	*Vim Feed.* Quaker Oats Co., Chicago, Ill.	*New London:* Paty Schwartz Co.	5.08	6.62	7.88	5.00	23.73	28.00	53.91	2.78	2.00
3086	*Purina O Molene.* Ralston Purina Mill, St. Louis, Mo.	*New Haven:* Moran-Patton Co.	7.63	4.27	11.94	9.70	8.24	9.00	64.13	3.79	3.20

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Horse Feeds—Concluded.										
2995	*Rosebro.* Rosenbaum Bros., Chicago, Ill.	*Stratford:* M. Blakely	8.78	7.60	10.13	10.00	12.45	15.00	58.31	2.73	2.00
2979	*Derby.* Tioga Mill & Elevator Co., Waverly, N. Y.	*Bethel:* Morrison & Dunham	8.40	5.38	11.00	10.00	12.25	12.00	59.25	3.72	3.00
2286	*Ground Corn and Oats, ½ & ½.* United Flour & Feed Co., Albany, N. Y.	*Winsted:* Chas. R. Hawley	10.93	2.29	11.19	10.00	5.80	7.00	65.69	4.10	4.00
	Dairy Feeds.										
2954	*Advanced Registry.* Arcady Farms Milling Co., Chicago, Ill.	*Simsbury:* Woods-Chandler Co.	7.30	6.76	26.00	25.00	9.48	10.00	44.76	5.70	5.00
2953	*Peerless.* Arcady Farms Milling Co., Chicago, Ill.	*Simsbury:* Woods-Chandler Co.	7.78	7.42	20.81	20.00	11.94	12.00	46.41	5.64	4.00
3183	*Capitol.* E. W. Bailey & Co., Swanton, Vt.	*New London:* B. J. McCarthy	8.98	5.33	24.50	24.00	6.95	9.00	48.69	5.55	5.00
2825	*Favorite.* E. W. Bailey & Co., Swanton, Vt.	*Merrow:* I. F. Wilcox	10.13	4.35	20.06	20.00	6.70	9.00	53.98	4.78	5.00
2205	*Beers Dairy Ration.* Ira W. Beers, Hamden	*Hamden:* Ira W. Beers	10.60	4.78	20.44	19.00	7.63	8.00	51.67	5.48	3.75

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Continued.										
2820	*Success Dairy Ration.* Amos D. Bridges Sons, Inc., Hazardville, Conn.	*Hazardville:* Amos D. Bridges Sons, Inc.	8.83	4.16	21.38	20.00	8.70	9.30	51.85	5.08	5.20
2826	*No-Botheration Dairy Ration.* C. W. Campbell Co., Westerly, R. I.	*Westerly:* C. W. Campbell Co.	9.50	4.41	20.63	20.00	6.20	8.00	53.82	5.44	5.00
2294	*Ajax Dairy Ration.* Chapin & Co., Chicago, Ill.	*West Cheshire:* G. W. Thorpe	7.83	6.87	22.00	20.00	9.23	12.00	48.32	5.75	4.50
2295	*Unicorn Dairy Ration.* Chapin & Co., Chicago, Ill.	*West Cheshire:* G. W. Thorpe	7.63	7.24	24.75	24.00	8.55	10.00	46.16	5.67	5.00
3147	*Conkey's Dairy Ration.* G. E. Conkey Co., Cleveland, Ohio	Mfr's. Sample	6.44	5.48	23.56	24.00	7.80	9.00	51.77	4.95	5.00
3146	*Gecco Dairy Ration.* G. E. Conkey Co., Cleveland, Ohio	Mfr's. Sample	6.55	5.84	21.19	20.00	7.15	9.00	54.09	5.18	4.50
3145	*Red Seal Dairy Ration.* G. E. Conkey Co., Cleveland, Ohio	Mfr's. Sample	6.57	12.20	17.19	16.00	7.80	10.00	51.96	4.28	3.50
2212	*Cowles' Dairy Ration.* C. A. Cowles, Plantsville, Conn.	*Plantsville:* C. A. Cowles	8.73	4.85	26.56	24.00	8.30	10.00	45.82	5.74	6.00
3151	*Crosby's Balanced Ration.* Crosby Milling Co., Brattleboro, Vt.	*Shelton:* Wolf Savitsky	8.78	5.41	27.56	25.00	8.52	11.00	44.14	5.59	5.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Continued.										
3331	*Crosby's 22 Dairy Feed.* Crosby Milling Co., Brattleboro, Vt. ..	*Shelton:* Wolf Savitsky	8.23	6.27	22.69	22.00	10.64	14.00	47.21	4.96	4.00
3332	*Crosby's Ready Ration.* Crosby Milling Corp., Brattleboro, Vt.	*Shelton:* Wolf Savitsky	9.60	5.70	22.06	20.00	7.75	10.00	49.74	5.15	5.00
2945	*King Dairy Ration.* The Cutler Co., No. Wilbraham, Mass. ..	*Willimantic:* Willimantic Grain Co.	7.75	7.58	22.38	22.00	9.20	12.00	49.09	4.00	5.00
3192	*King Dairy Ration.* The Cutler Co., No. Wilbraham, Mass. ..	*Norwich:* Norwich Grain Co. ..	8.44	8.13	22.88	22.00	8.78	12.00	47.24	4.53	5.00
2200	*Basic Dairy Ration.* R. G. Davis & Sons, New Haven	*Shelton:* Shelton Feed Co.	9.58	4.98	19.81	20.00	8.30	9.00	52.38	4.95	5.00
3009	*Delaware Dairy Feed.* Delaware Mills, Inc., Deposit, N. Y.	*Southington:* Southington Lumber & Feed Co.	8.35	5.18	22.50	23.00	9.20	10.00	49.12	5.65	5.00
3105	*Devon Dairy Ration.* Devon Coal & Ice Co., Devon, Conn.	*Devon:* Devon Coal & Ice Co...	7.89	5.42	19.25	20.00	9.99	8.00[1]	52.26	5.19	5.00
2835	*Full Pail Dairy Ration.* Eastern States Farmers' Exchange, Springfield, Mass.	*Seymour:* John Swan	8.38	6.23	22.44	20.00	7.13	9.00	50.98	4.84	4.00

[1] Minimum. Law requires maximum to be given.

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Continued.										
2858	*Fitting Dairy Ration.* Eastern States Farmers' Exchange, Springfield, Mass.	*Putnam:* Calvin Poore.........	8.38	3.90	13.50	12.00	6.23	8.00	63.14	4.85	3.50
2856	*Milkmore Dairy Ration.* Eastern States Farmers' Exchange, Springfield, Mass.	*Putnam:* Calvin Poore	8.53	6.02	25.44	24.00	7.93	9.00	46.93	5.15	4.50
2254	*Elmore Milk Grains.* Elmore Milling Co., Oneonta, N. Y. ..	*Torrington:* Litchfield County Co-op. Assoc.	8.43	5.41	25.50	25.00	9.44	11.00	46.09	5.13	6.00
3125	*Elmore Milk Grains.* Elmore Milling Co., Oneonta, N. Y. ..	*Kensington:* S. F. Labieniec ...	8.44	4.79	25.00	25.00	9.08	11.00	47.50	5.19	6.00
2202	*Eshelman's Lancaster 20 Dairy Feed.* John W. Eshelman & Sons, Lancaster, Penn.	*Seymour:* Seymour Grain & Coal Co.	10.10	6.51	19.50	20.00	10.15	10.00	48.51	5.23	4.00
2816	*Eshelman's Susquehanna Dairy Feed.* John W. Eshelman & Sons, Lancaster, Penn.	*Plainville:* F. B. Newton	9.29	5.18	20.19	20.00	9.66	12.00	50.47	5.21	3.00
3100	*Eshelman's Red Rose Dairy Feed.* John W. Eshelman & Sons, Lancaster, Penn.	*Greenwich:* Johnson's Feed Store	7.41	6.87	23.50	24.00	10.05	10.00	46.32	5.85	4.00
2843	Dairy Ration. A. W. Forbes, East Haven	*East Haven:* A. W. Forbes	8.78	5.30	21.69	19.00	10.00	9.00	50.38	3.85	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Continued.										
3325	Dairy Ration. A. W. Forbes, East Haven	*East Haven:* A. W. Forbes	9.50	4.78	22.63	19.00	7.67	9.00	51.32	4.10	4.00
2855	*Grandin's 12 Twin Six.* D. H. Grandin Milling Co., Jamestown, N. Y.	*Willimantic:* Willimantic Grain Co.	8.75	5.34	22.81	22.00	7.99	12.00	49.77	5.34	5.00
2859	*Grandin's 24% Balanced Dairy Ration.* D. H. Grandin Milling Co., Jamestown, N. Y.	*Norwich:* Norwich Grain Co.	9.03	5.14	24.13	24.00	8.15	10.00	48.25	5.30	5.00
2234	*Larro*—The Ready Ration for Dairy Cows. Larrowe Milling Co., Detroit, Mich.	*Plantsville:* C. A. Cowles	8.83	5.54	20.31	20.00	10.51	12.00	50.53	4.28	4.00
3013	*Nabob Dairy Feed.* Francis H. Leggett Co., Stamford, Conn.	*Stamford:* Francis H. Leggett Co.	7.75	7.45	22.06	18.00	11.03	10.00	46.79	4.92	4.50
3336	*Nabob Dairy Feed.* Francis H. Leggett Co., Stamford, Conn.	*Stamford:* Francis H. Leggett Co.	9.32	6.80	19.81	18.00	10.48	10.00	48.34	5.25	3.50
3004	*Premier Dairy Feed.* Francis H. Leggett Co., Stamford, Conn.	*Stamford:* Francis H. Leggett Co.	8.38	5.34	26.38	25.00	8.49	10.00	45.75	5.66	5.50
3568	*Uniform Brand Dairy Ration.* C. W. Lines Co., New Britain	*New Britain:* C. W. Lines Co.	8.85	1.67	26.13	24.00	6.98	10.00	50.87	5.50	5.50
2257	*Red Star Dairy Feed.* E. Manchester & Son, Winsted, Conn.	*Winsted:* E. Manchester & Sons	8.45	6.22	24.38	23.00	7.88	10.00	46.32	6.75	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Continued.										
2260	*Red Star Special Dairy Feed.* E. Manchester & Son, Winsted	*Winsted:* E. Manchester & Sons	8.25	6.15	21.50	22.00	8.73	10.00	48.79	6.58	4.50
3042	*Armour's 24% Dairy Feed.* Mapl-Flake Mills, Chicago, Ill.	*Danbury:* C. S. Barnum & Son.	7.44	7.84	23.88	24.00	11.13	12.00	45.08	4.63	5.00
3046	*Iroquois 20% Dairy Feed.* Mapl-Flake Mills, Chicago, Ill.	*Danbury:* H. E. Meeker	7.70	9.46	19.63	20.00	11.42	11.00	47.11	4.68	4.00
2249	*Bull Brand Dairy Ration.* Maritime Milling Co., Buffalo, N. Y.	*Thomaston:* Cunningham & Wallace	9.58	7.21	23.75	24.00	10.27	12.00	43.81	5.38	6.00
3121	*Bull Brand Dairy Ration.* Maritime Milling Co., Buffalo, N. Y.	*Weatogue:* R. B. Eno	8.68	7.56	24.00	24.00	10.00	12.00	43.58	6.18	6.00
2840	*Hi Test Dairy Feed.* Maritime Milling Co., Buffalo, N. Y.	*North Haven:* Wm. L. Thorpe	7.83	7.43	20.50	20.00	12.82	14.00	46.24	5.18	5.00
3530	*Red Wing Special Dairy Ration* (without Brewers' Grains). Meech & Stoddard, Inc., Middletown	*Middletown:* Meech & Stoddard, Inc.	6.98	6.20	24.25	24.00	8.15	9.00	48.82	5.60	5.50
3531	*Red Wing Dairy Ration* (without Brewers' Grains). Meech & Stoddard, Inc., Middletown	*Meriden:* Meriden Grain & Coal Co.	6.60	6.25	22.13	20.00	8.23	9.00	51.34	5.45	5.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25: Found	Protein N x 6.25: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
			Pounds per Hundred								
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Continued.										
3574	*Red Wing Dairy Ration 20%.* Meech & Stoddard, Inc., Middletown	*East Hartford:* Meech Grain Co.	9.13	5.43	23.38	20.00	8.85	9.00	47.66	5.55	5.50
3573	*Red Wing Dairy Ration 24%.* Meech & Stoddard, Inc., Middletown	*East Hartford:* Meech Grain Co.	8.75	6.04	24.19	24.00	8.85	9.00	45.29	6.88	5.50
2848	*Old Mill Dairy Ration.* Fred C. Morse, Guilford, Conn.	*Guilford:* Fred C. Morse	8.78	6.52	23.75	20.00	7.60	10.00	47.40	5.95	5.00
3179	*Domino Butterine Dairy Feed.* Nowak Milling Corp., Hammond, Ind.	*Waterville:* Wooster Feed Store	7.74	12.11	18.13	17.00	10.18	15.00	46.34	5.50	3.50
3161	*Domino 24½ Dairy Feed.* Nowak Milling Corp., Hammond, Ind.	*Higganum:* Felix A. Petrofsky	8.65	8.30	24.81	24.50	7.50	10.00	45.79	4.95	4.50
3178	*Fidelity Dairy Feed.* Nowak Milling Corp., Hammond, Ind.	*Waterville:* Wooster Feed Store	8.95	7.13	20.25	20.00	8.75	11.00	50.38	4.54	4.00
3094	*Hammond Dairy Feed.* Nowak Milling Corp., Hammond, Ind.	*Higganum:* Felix A. Petrofsky	8.13	11.67	17.88	16.50	10.30	13.50	46.02	6.00	4.00
3177	*Marathon Dairy Feed.* Nowak Milling Corp., Hammond, Ind.	*Waterville:* Wooster Feed Store	7.83	7.23	22.00	22.00	9.15	12.00	48.35	5.44	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25: Found	Protein N x 6.25: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
			Pounds per Hundred								
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Continued.										
2773	*Uncle John's 24% Cream Pot Ration.* Ontario Milling Co., Oswego, N. Y.	*New Milford:* W. L. Richmond & Son	9.03	5.48	23.38	24.00	7.42	9.00	48.70	5.99	5.50
2910	*Economy Feed.* Park & Pollard Co., Buffalo, N. Y.	*West Stafford:* C. P. Bradway & Son	8.85	7.19	19.50	20.00	7.55	10.00	52.56	4.35	5.00
3136	*Economy Feed.* Park & Pollard Co., Buffalo, N. Y.	*Moosup:* T. E. Maine & Sons	7.83	8.50	19.69	20.00	8.88	10.00	47.22	7.88	5.00
3062	*Milk Maid 24% Dairy Ration.* Park & Pollard Co., Buffalo, N. Y.	*Putnam:* Bosworth Bros.	7.18	7.86	24.50	24.00	10.79	11.00	44.64	5.03	5.00
2225	*Steven's "44" Sweetened Dairy Ration.* Park & Pollard Co., Buffalo, N. Y.	*Waterbury:* Spencer Grain Co.	8.85	7.33	25.31	24.00	7.22	14.00	45.89	5.40	5.00
2229	*Steven's Milkade Calf Meal.* Park & Pollard Co., Buffalo, N. Y.	*Waterbury:* Spencer Grain Co.	8.28	7.98	23.69	20.00	5.19	7.50	47.06	7.80	8.00
2914	*Universal Ration.* Park & Pollard Co., Buffalo, N. Y.	*Moosup:* T. E. Maine & Sons Co.	9.03	9.50	18.31	16.00	9.75	12.00	45.83	7.58	6.00
2269	Dairy Ration. Pillsbury Mills, Minneapolis, Minn.	*Torrington:* Litchfield County Co-op. Assoc.	8.73	6.71	20.63	20.00	9.03	12.00	50.07	4.83	5.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Continued.										
3536	*Burt's Cereal Feed.* Postum Cereal Co., Battle Creek, Mich.	*Weatogue:* R. B. Eno	4.98	4.51	20.31	17.00	14.85	20.00	51.10	4.25	3.00
3119	*Burt's Dairy Ration.* Postum Cereal Co., Battle Creek, Mich.	*Weatogue:* R. B. Eno	7.01	5.94	24.63	24.00	6.20	9.00	51.59	4.63	5.00
2791	*Producer Dairy Feed.* H. C. Puffer Co., Springfield, Mass..	*Simsbury:* Woods-Chandler Co.	9.39	5.79	23.13	24.00	6.99	8.50	49.52	5.18	4.00
3122	*Producer Dairy Feed.* H. C. Puffer Co., Springfield, Mass..	*Bloomfield:* Bloomfield Farmers' Exchange	9.18	5.67	25.00	24.00	6.85	8.50	48.74	4.56	4.00
3103	*Big Q Dairy Ration.* Quaker Oats Co., Chicago, Ill.	*Highwood:* T. C. Hadden & Co.,	6.92	7.36	20.63	20.00	11.50	12.00	49.39	4.20	3.25
2898	*Boss Dairy Ration.* Quaker Oats Co., Chicago, Ill.	*New Milford:* W. L. Richmond & Son	8.38	6.96	24.25	24.00	8.88	10.50	46.70	4.83	4.00
3091	*Protena Dairy Feed.* Ralston Purina Mills, St. Louis, Mo...	*Hartford:* Olds & Whipple, Inc.	7.18	7.76	17.81	16.50	12.93	12.00	50.39	3.93	3.50
3000	*Purina Cow Chow Feed.* Ralston Purina Mills, St. Louis, Mo...	*Stamford:* W. L. Crabb	7.20	6.62	25.69	24.00	10.00	12.00	45.96	4.53	4.30
2873	*Purina Legume Cow Chow.* Ralston Purina Mills, St. Louis, Mo.	*Litchfield:* Wadhams Co.	8.94	5.21	21.81	20.00	6.55	8.00	52.28	5.21	3.80

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Continued.										
2908	*Advance Dairy Feed.* Rosenbaum Bros., Chicago, Ill.	*Stafford Springs:* Dennis Grain Mill	8.81	8.99	16.31	16.00	11.20	14.00	46.79	7.90	3.50
2996	*Vitality Dairy Feed.* Rosenbaum Bros., Chicago, Ill.	*East Bridgeport:* Kaplan Feed Co.	7.60	7.61	25.81	24.00	8.63	10.00	45.17	5.18	5.00
2997	*Will Pay Dairy Ration.* Rosenbaum Bros., Chicago, Ill.	*East Bridgeport:* Kaplan Feed Co.	8.38	7.89	23.25	20.00	8.70	9.00	46.30	5.48	5.00
3096	*Homespun Dairy Ration.* The Paty Schwartz Co., New London	*New London:* Paty Schwartz Co.	7.84	6.51	23.06	22.00	10 50	10.00	48.02	4.07	5.00
2788	*Mill Stream Boomerang Dairy Feed.* Winchell Smith, Inc., Farmington, Conn.	*Farmington:* Winchell Smith, Inc.	9.49	4.23	24.00	24.00	6.65	10.00	50.28	5.35	6.00
2787	*Mill Stream Twenty Per Cent Dairy Ration.* Winchell Smith, Inc., Farmington, Conn.	*Farmington:* Winchell Smith, Inc.	9.36	5.06	23.06	20.00	8.00	8.00	49.34	5.18	5.00
2890	*"See-More" Milk Dairy Ration.* Seymour Grain & Coal Co., Seymour, Conn.	*Seymour:* Seymour Grain & Coal Co.	9.03	6.45	21.25	20.00	8.18	9.00	49.96	5.13	4.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein N x 6.25: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Continued.										
2264	*Paragon Dairy Feed.* St. Albans Grain Co., St. Albans, Vt.	*Thomaston:* Cunningham & Wallace	8.83	6.36	20.31	22.00	10.63	12.00	49.08	4.79	4.00
3181	*Paragon Dairy Feed.* St. Albans Grain Co., St. Albans, Vt.	*Newtown:* R. H. Holcomb & Co.	8.05	7.26	22.00	22.00	10.95	12.00	46.73	5.01	4.00
2277	*Wirthmore Balanced Ration* for Dairy Cows. St. Albans Grain Co., St. Albans, Vt.	*Lakeville:* E. W. Spurr Co.	8.15	6.72	24.38	25.00	8.58	9.00	46.21	5.96	5.50
2263	*Wirthmore 20% Dairy Feed.* St. Albans Grain Co., St. Albans, Vt.	*Watertown:* Watertown Coöp. Assoc.	9.66	5.72	23.00	20.00	7.23	9.00	49.01	5.38	5.00
2288	*Syragold Milk Ration.* Syracuse Milling Co., Syracuse, N. Y...	*Norfolk:* Aug. P. Curtis	9.34	5.00	19.94	20.00	8.95	12.00	51.93	4.84	4.00
2279	*Syragold Dairy Feed.* Syracuse Milling Co., N. Y.	*Torrington:* F. W. Wadhams ..	8.40	5.17	24.75	24.00	9.35	12.00	46.98	5.35	4.50
2803	*Red Brand Tioga Dairy Feed.* Tioga Mill & Elevator Co., Waverly, N. Y.	*New Milford:* Geo. T. Soule ...	8.50	6.49	26.00	24.00	8.53	10.00	44.58	5.90	4.50
2941	*Union Grains Biles Ready Dairy Ration.* Ubiko Milling Co., Cincinnati, Ohio	*Hartford:* C. A. Pease	8.20	6.18	24.00	24.00	8.68	10.00	47.26	5.68	5.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein N x 6.25: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Dairy Feeds—Concluded.										
2285	*United Dairy Ration.* United Flour & Feed Co., Albany, N. Y.	*Winsted:* Chas. R. Hawley	9.20	5.80	23.38	24.00	8.44	11.00	47.98	5.20	5.00
3120	*United Dairy Ration.* United Flour & Feed Co., Albany, N. Y.	*Weatogue:* R. B. Eno	8.65	5.19	24.13	24.00	9.00	11.00	47.63	5.40	5.00
2912	*Big Y Dairy Ration.* Yantic Grain & Products Co., Norwich, Conn.	*Willimantic:* Boston Grain Co...	8 53	5.85	25.25	25.00	7.24	10.00	47.59	5.54	5.00
2972	*Echo Dairy Feed.* Yantic Grain & Products Co., Norwich, Conn.	*Norwich:* Yantic Grain & Products Co.	7.18	7.14	24.88	24.00	11.29	12.00	44.53	4.98	4.50
2975	*Perfection Dairy Feed.* Yantic Grain & Products Co., Norwich, Conn.	*Norwich:* Yantic Grain & Products Co.	7.18	7.05	22.50	22.00	12.52	13.00	45.33	5.42	4.50
2970	*Uncas Dairy Feed.* Yantic Grain & Products Co., Norwich, Conn.	*Moosup:* Moosup Grain Co.	8.48	5.65	21.00	20.00	6.83	9.00	52.89	5.15	5.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
					Protein N x 6.25		Fiber			Fat	
			Water	Ash	Found	Guaranteed, not less than	Found	Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Stock Feeds.										
2822	*Pennant Stock Feed.* E. W. Bailey & Co., Swanton, Vt. ..	*Mansfield Depot:* Martin M. Hansen	8.97	4.51	9.13	9.00	10.31	10.00	62.64	4.44	5.00
2828	*No-Botheration Stock Feed.* C. W. Campbell Co., Westerly, R. I.	*Westerly:* C. W. Campbell Co...	8.56	5.57	14.25	12.00	9.08	10.00	57.61	4.93	4.00
3150	*Crosby's Stock Food.* Crosby Milling Co., Brattleboro, Vt...	*Shelton:* Wolf Savitsky	8.90	4.21	10.25	9.00	9.69	12.00	62.68	4.27	4.00
3016	*Davis Stock Feed.* R. G. Davis & Sons, New Haven	*Glenbrook:* Davis-Scofield Co...	8.35	4.91	11.63	10.00	10.43	14.00	61.04	3.64	2.00
3008	*Delaware Stock Feed.* Delaware Mills, Inc., Deposit, N. Y.	*Southington:* Southington Lumber & Feed Co.	8.36	4.85	10.06	9.00	11.60	12.00	60.50	4.63	3.00
3107	*Devon Sweet Stock Feed.* Devon Coal & Ice Co., Devon, Conn..	*Devon:* Devon Coal & Ice Co...	8.08	5.02	10.00	8.00	13.40	12.00	59.81	3.69	2.50
3099	*Eshelman's Stock Feed.* John W. Eshelman & Sons, Lancaster, Penn.	*Greenwich:* Johnson's Feed Store	7.02	3.70	9.63	10.00	10.73	10.00	63.19	5.73	3.00
2841	*Eshelman's Sugared Stock Feed.* John W. Eshelman & Sons, Lancaster, Penn.	*So. Manchester:* Smith Bros. ..	8.43	5.35	11.50	10.00	13.72	11.00	57.52	3.48	3.25

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
					Protein N x 6.25		Fiber			Fat	
			Water	Ash	Found	Guaranteed, not less than	Found	Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Stock Feeds—Continued.										
3065	*Globe Cow Feed.* Flory Milling Co., Bangor, Penn.	*Bridgeport:* Connecticut Feed Co.	5.65	5.47	18.94	20.00	8.13	11.00	57.40	4.41	4.00
2842	*Flory's Special Stock Feed.* Flory Milling Co., Bangor, Penn.	*Bloomfield:* Bloomfield Farmers' Exch.	8.27	6.10	8.06	8.00	16.50	14.00	58.57	2.50	3.00
3138	*Flory's Stock Feed.* Flory Milling Co., Bangor, Penn.	*Fairfield:* Samp Mortar Mills ..	7.34	5.60	8.50	8.00	16.25	14.00	58.88	3.43	3.00
2854	*Grandin's Stock Feed.* D. H. Grandin Milling Co., Jamestown, N. Y.	*Willimantic:* Willimantic Grain Co.	9.83	3.40	9.75	9.00	8.36	12.00	63.73	4.93	5.00
3012	*Algrane Milk Feed.* Hecker H. O. Company, Inc., Buffalo, N. Y.	*So. Norwalk:* Roodner Feed Co.	7.48	6.42	16.00	16.00	11.33	15.00	55.04	3.73	4.00
3335	*Algrane Milk Feed.* Hecker H. O. Company, Inc., Buffalo, N. Y.	*So. Norwalk:* Roodner Feed Co.	7.80	6.45	17.63	16.00	12.60	15.00	51.49	4.03	4.00
2861	*Algrane New England Stock Feed.* Hecker H. O. Co., Buffalo, N. Y.	*Westerly:* C. W. Campbell Co...	8.58	5.34	12.13	9.50	9.70	9.75	60.07	4.18	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Stock Feeds—Continued.										
3071	*Badger Stock Feed.* Chas. A. Kraus Milling Co., Milwaukee, Wis.	*Stamford:* Francis H. Leggett Co.	6.13	6.66	10.50	10.00	17.74	12.00	55.02	3.95	3.00
3014	*Nabob Stock Feed.* Francis H. Leggett Co., Stamford, Conn.	*Stamford:* Francis H. Leggett Co.	8.20	3.93	9.75	10.00	10.85	10.00	63.59	3.68	3.00
3043	*Iroquois Chop Feed.* Mapl-Flake Mills, Chicago, Ill.	*Danbury:* C. S. Barnum & Son.	8.69	5.34	9.00	8.00	10.63	12.00	62.04	4.30	4.00
3080	*Iroquois Stock Feed.* Mapl-Flake Mills, Inc., Chicago, Ill.	*New Milford:* Geo. E. Ackley Co.	7.41	6.38	12.88	10.00	12.65	13.00	56.43	4.25	4.00
2783	*Red Wing Special Stock.* Meech & Stoddard, Inc., Middletown, Conn.	*Meriden:* Meriden Grain & Coal Co.	8.28	6.02	9.75	9.00	9.54	12.00	62.41	4.00	3.00
2782	*Red Wing Stock Feed.* Meech & Stoddard, Inc., Middletown, Conn.	*Middletown:* Meech & Stoddard, Inc.	8.44	5.73	9.31	9.00	9.10	12.00	63.64	3.78	3.00
3030	*Fidelity Stock Feed.* Nowak Milling Corp., Hammond, Ind.	*Higganum:* Felix A. Petrofsky.	8.61	3.97	8.19	8.00	11.40	12.00	64.25	3.58	3.00
2227	*Park & Pollard Co. Stock Feed.* Park & Pollard Co., Buffalo, N. Y.	*Waterbury:* Spencer Grain Co.	9.03	6.38	8.94	8.00	9.44	12.00	62.27	3.94	2.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Stock Feeds—Continued										
3038	*Pratt's Supreme Stock Feed.* Pratt's Food Co., Philadelphia, Penn.	*New Britain:* S. P. Strople	8.90	3.35	9.50	9.00	8.97	12.00	65.59	3.69	3.00
3090	*Purina Steer Fatena Feed.* Ralston Purina Mills, St. Louis, Mo.	*Hartford:* Olds & Whipple, Inc.	7.40	7.95	13.75	12.00	7.54	7.50	59.86	3.50	2.00
2877	*Richford White Diamond Stock Feed.* Quaker Oats Co., Chicago, Ill.	*So. Manchester:* Smith Bros.	7.75	5.60	8.75	9.00	12.98	14.00	60.27	4.65	3.00
2896	*Sugared Schumachers Feed.* Quaker Oats Co., Chicago, Ill.	*Waterbury:* H. S. Coe & Co., Inc.	8.10	6.74	11.31	10.00	10.22	12.00	59.85	3.78	3.25
2904	*77 Stock Feed.* Rosenbaum Bros., Chicago, Ill.	*Stafford Springs:* Dennis Grain Mill	8.13	7.07	9.50	9.00	13.08	15.00	58.24	3.98	3.50
3566	*Vitality Stock Feed.* Rosenbaum Bros., Chicago, Ill.	*New Britain:* S. P. Strople	9.58	12.51	9.00	9.00	10.75	12.00	54.46	3.70	3.00
2924	*Homespun Stock Feed.* Paty Schwartz Co., New London	*New London:* Paty Schwartz Co.	6.93	5.44	9.19	9.00	12.10	10.00	61.56	4.78	4.00
2968	*Charlestock Feed.* St. Albans Grain Co., St. Albans, Vt.	*Danielson:* Quinebaug Mills	8.60	3.87	9.50	9.00	11.50	14.00	62.80	3.73	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25 Found	Protein N x 6.25 Guaranteed, not less than	Fiber Found	Fiber Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat Found	Fat Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Stock Feeds—Concluded.										
2276	*Wirthmore Stock Feed.* St. Albans Grain Co., St. Albans, Vt.	*Lakeville:* E. W. Spurr Co.	8.51	3.78	9.63	9.00	8.73	9.50	63.61	5.74	4.00
2806	*Syragold Stock Feed.* Syracuse Milling Co., Syracuse, N. Y.	*Granby:* E. H. Rollins	8.90	4.49	10.44	9.00	10.68	12.00	61.20	4.29	3.00
2944	*Gold Medal Stock Feed.* Washburn-Crosby Co., Minneapolis, Minn.	*West Stafford:* C. P. Bradway & Sons	7.68	6.58	10.75	12.00	12.53	12.00	57.58	4.88	3.00
	Calf Feed, etc.										
2262	*Blatchford's Calf Meal.* Blatchford's Calf Meal Co., Waukegan, Ill.	*Lakeville:* E. W. Spurr Co.	9.80	7.89	24.31	24.00	5.45	6.75	47.02	5.53	5.00
2255	*Elmore Calf Meal.* Elmore Milling Co., Oneonta, N. Y.	*Torrington:* Litchfield County Coöp. Assoc.	9.49	4.91	25.50	24.00	4.19	4.00	51.69	4.22	4.00
3092	*Purina Calf Feed.* Ralston Purina Mills, St. Louis, Mo.	*Middletown:* H. G. Wadhams	9.00	4.97	27.75	27.00	3.60	4.50	51.11	3.57	3.20
2889	*Purina Pig Chow.* Ralston Purina Mills, St. Louis, Mo.	*Derby:* Peterson-Hendee Co.	9.23	8.35	21.50	20.00	6.23	7.00	51.05	3.64	3.20

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25 Found	Protein N x 6.25 Guaranteed, not less than	Fiber Found	Fiber Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat Found	Fat Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feed.										
3184	*Pennant Scratch Feed.* E. W. Bailey & Co., Swanton, Vt.	*New London:* B. J. McCarthy	12.11	1.60	11.00	10.00	3.53	6.50	68.38	3.38	3.00
3139	*No. 455 Scratch Grains.* Basic Feeds Co. Lockport, Ill.	*Stamford:* W. L. Crabb	9.70	1.51	12.88	12.00	1.64	3.00	70.44	3.83	4.00
2938	*Beacon Egg Mash.* Beacon Milling Co., Inc., Cayuga, N. Y.	*New Milford:* W. L. Richmond & Son	8.40	9.64	22.00	22.00	4.95	7.00	49.35	5.66	4.50
3101	*Beacon Laying Mash.* Beacon Milling Co., Cayuga, N. Y.	*Danbury:* C. S. Barnum & Son.	7.30	10.22	21.63	20.00	6.70	8.00	47.21	6.94	5.00
2206	*Beers' Laying Mash.* Ira W. Beers, Hamden, Conn.	*Hamden:* Ira W. Beers	10.25	8.59	22.19	22.00	5.90	7.00	47.27	5.80	6.00
2207	*Beers' Scratch Feed.* Ira W. Beers, Hamden, Conn.	*Hamden:* Ira W. Beers	12.38	1.76	10.31	9.00	3.50	4.00	68.85	3.20	4.00
3148	*Beers' Scratch Feed.* Ira W. Beers, Hamden, Conn.	*Hamden:* Ira W. Beers	12.23	1.75	10.94	9.00	2.93	4.00	68.90	3.25	4.00
2911	*Bidwell Dry Mash.* Black Rock Milling Corp., Black Rock, N. Y.	*West Stafford:* C. P. Bradway & Son.	8.83	9.52	21.00	18.00	5.94	12.00	50.87	3.84	1.50
2217	*Bidwell Scratch Feed.* Black Rock Milling Corp., Black Rock, N. Y.	*Shelton:* Shelton Feed Co.	11.50	1.62	10.13	10.00	2.83	5.00	70.62	3.30	1.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25 Found	Protein Guaranteed, not less than	Fiber Found	Fiber Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat Found	Fat Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feed—Continued.										
3011	*Buckingham's Dry Mash.* C. Buckingham & Co., Southport, Conn.	*Southport:* C. Buckingham & Co.	8.81	8.78	19.00	19.00	5.78	8.00	51.49	6.14	5.00
2827	*Egg-O Scratch Feed.* C. W. Campbell Co., Westerly, R. I.	*Westerly:* C. W. Campbell Co.	11.35	1.54	10.69	10.00	2.58	5.00	71.34	2.50	3.00
3187	*Egg-O Scratch Feed.* C. W. Campbell Co., Westerly, R. I.	*Westerly:* C. W. Campbell Co.	11.81	1.44	10.38	10.00	2.60	5.00	71.02	2.75	3.00
2829	*Egg-O Dry Mash.* C. W. Campbell Co., Westerly, R. I.	*Westerly:* C. W. Campbell Co.	8.62	10.77	20.06	18.00	7.10	10.00	47.42	6.03	3.00
3338	*Albert Angell Jr.'s Growing Mash.* Coles Co., Middletown	*Middletown:* Coles Co.	8.50	6.17	17.19	15.00	4.50	6.00	58.21	5.43	5.00
3339	*Albert Angell Jr.'s Egg Mash.* Coles Co., Middletown	*Middletown:* Coles Co.	8.48	10.12	21.13	20.00	5.04	8.00	49.28	5.95	4.00
3526	*Albert Angell Jr.'s Chick Starter.* Coles Co., Middletown	*New Milford:* W. L. Richmond & Son	6.75	12.36	16.88	15.00	4.73	5.00	54.00	5.28	5.00
3018	*Conkey's Buttermilk Meat and Bone Growing Mash.* G. E. Conkey Co., Cleveland, Ohio	*New Canaan:* Clapboard Hill Farms	7.98	9.74	18.63	18.00	4.90	5.00	53.27	5.48	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25 Found	Protein Guaranteed, not less than	Fiber Found	Fiber Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat Found	Fat Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feed—Continued.										
3019	*Conkey's Buttermilk Meat, Grain and Bone Laying Mash.* G. E. Conkey Co., Cleveland, Ohio	*New Canaan:* Clapboard Hill Farms	9.18	8.71	20.25	20.00	5.58	6.00	50.60	5.68	5.00
3021	*Conkey's Buttermilk, Grain and Bone Starting Feed.* G. E. Conkey Co., Cleveland, Ohio	*Ridgefield:* Ridgefield Lumber Co.	9.23	5.82	12.69	12.00	3.61	4.00	63.20	5.45	3.00
3020	*Conkey's Scratch Grains.* G. E. Conkey Co., Cleveland, Ohio	*Ridgefield:* Ridgefield Lumber Co.	11.64	1.61	11.06	9.75	2.53	3.00	70.38	2.78	1.75
2214	*C. A. Blue Seal Mash.* C. A. Cowles, Plantsville, Conn.	*Plantsville:* C. A. Cowles	9.60	9.24	20.13	18.00	4.60	6.00	50.75	5.68	4.00
2213	*C. A. Meato Mash.* C. A. Cowles, Plantsville, Conn.	*Plantsville:* C. A. Cowles	9.80	7.12	24.19	20.00	4.65	4.50	48.34	5.90	4.00
3152	*Crosby's Egg Mash.* Crosby Milling Co., Brattleboro, Vt.	*Shelton:* Wolf Savitsky	9.02	11.45	22.69	18.00	5.48	8.50	45.98	5.38	4.00
3149	*Crosby's Scratch Feed.* Crosby Milling Co., Brattleboro, Vt.	*Shelton:* Wolf Savitsky	11.92	1.55	10.50	11.00	3.28	5.00	69.53	3.22	3.00
2946	*King Mash Feed.* The Cutler Co., No. Wilbraham, Mass.	*Willimantic:* Willimantic Grain Co.	8.23	8.49	20.69	20.00	6.93	10.00	49.76	5.90	3.00
2947	*King Scratch Feed.* The Cutler Co., No. Wilbraham, Mass.	*Willimantic:* Willimantic Grain Co.	10.81	1.46	10.38	10.00	2.49	6.00	71.87	2.99	2.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feed—Continued.										
2201	*Davis Mash Feed.* R. G. Davis & Sons, New Haven, Conn.	*Ansonia:* Ansonia Flour & Feed Co.	9.48	6.16	18.13	18.00	6.50	7.00	53.75	5.98	5.00
3084	*Davis Scratch Feed.* R. G. Davis & Sons, New Haven, Conn.	*New Haven:* R. G. Davis & Sons	10.88	1.64	10.00	10.00	2.26	5.00	71.91	3.31	2.00
3007	*Delaware Chick Starting Mash.* Delaware Mills, Inc., Deposit, N. Y.	*Southington:* Southington Lumber & Feed Co.	8.75	8.79	21.88	15.00	4.48	5.00	49.65	6.45	4.00
2952	*Delaware Intermediate Chick Grains.* Delaware Mills, Inc., Deposit, N. Y.	*Southington:* Southington Lumber & Feed Co.	12.30	1.39	9.81	10.00	1.80	5.00	72.17	2.53	2.00
2951	*Delaware Scratch Grains.* Delaware Mills, Inc., Deposit, N. Y.	*Southington:* Southington Lumber & Feed Co.	11.85	1.35	10.25	10.00	2.68	5.00	71.19	2.68	2.50
3106	*Devon Laying Mash.* Devon Coal & Ice Co., Devon, Conn.	*Devon:* Devon Coal & Ice Co.	8.51	8.23	21.00	18.00	4.88	7.00	52.28	5.10	5.00
2837	*Eastern States Scratch Grains* Eastern States Farmers' Exchange, Springfield, Mass.	*Seymour:* John Swan	10.60	1.69	11.06	10.00	2.83	4.50	70.72	3.10	3.00
2857	*Egg Mash.* Eastern States Farmers' Exchange, Springfield, Mass.	*Putnam:* Calvin Poore	8.75	7.72	22.38	20.00	6.35	7.00	49.77	5.03	3.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feed—Continued.										
2818	*Elmore Scratch Feed.* Elmore Milling Co., Oneonta, N. Y.	*Thompsonville:* Geo. S. Phelps & Co.	11.79	1.33	10.13	10.00	2.65	5.00	71.35	2.75	3.50
2253	*Eshelman's Laying Mash.* John W. Eshelman & Son, Lancaster, Penn.	*Torrington:* D. L. Talcott	9.46	6.74	22.19	20.00	5.16	7.00	49.60	6.85	5.00
2244	*Eshelman's Scratch Feed.* John W. Eshelman & Son, Lancaster, Penn.	*Torrington:* D. L. Talcott	12.00	1.40	10.19	10.00	2.78	4.00	70.90	2.73	3.00
2819	*Imperial Scratch Feed.* John W. Eshelman & Son, Lancaster, Penn.	*Manchester:* W. A. Strant	11.50	1.39	9.94	9.00	2.53	4.00	71.93	2.71	3.00
3197	*Imperial Scratch Feed.* John W. Eshelman & Son, Lancaster, Penn.	*Hartford:* N. Y. Feed & Grain Co.	12.78	0.97	9.69	9.00	2.70	4.00	71.01	2.85	3.00
3123	*Flory's Superior Egg Mash.* Flory Milling Co., Bangor, Penn.	*Bloomfield:* Bloomfield Farmers' Exchange	8.98	6.41	19.50	20.00	7.93	8.00	51.64	5.54	5.50
3066	*Golden Egg Laying Mash.* Flory Milling Co., Bangor, Penn.	*Bridgeport:* Connecticut Feed Co.	8.13	6.95	18.50	18.00	9.54	10.00	51.68	5.20	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feed—Continued.										
3155	*Golden Egg Scratch Feed.* Flory Milling Co., Bangor, Penn.	*Thomaston:* I. Levy	11.76	1.72	10.56	10.00	3.08	5.00	69.57	3.31	3.00
2821	*Sunray Scratch Feed.* Flory Milling Co., Bangor, Penn.	*Bloomfield:* Bloomfield Farmers' Exchange	11.73	1.46	10.13	10.00	2.50	5.00	71.53	2.65	3.00
2844	Laying Mash. A. W. Forbes, East Haven, Conn.	*East Haven:* A. W. Forbes	8.75	8.88	25.00	20.00	4.94	6.00	46.60	5.83	5.00
2845	*R. Own Scratch Feed.* A. W. Forbes, East Haven, Conn.	*East Haven:* A. W. Forbes	11.48	1.67	9.75	10.00	2.94	5.00	70.86	3.30	3.00
3194	*Grandin's Baby Chick Feed.* D. H. Grandin Milling Co., Jamestown, N. Y.	*Willimantic:* Willimantic Grain Co.	11.83	1.45	11.06	10.00	1.40	5.00	70.88	3.38	2.50
3195	*Grandin's Baby Chick Starter with Buttermilk.* D. H. Grandin Milling Co., Jamestown, N. Y.	*Willimantic:* Willimantic Grain Co.	9.45	4.43	14.75	12.00	3.13	5.00	62.78	5.46	4.00
2853	*Grandin's Laying Mash with Buttermilk.* D. H. Grandin Milling Co., Jamestown, N. Y.	*Willimantic:* Willimantic Grain Co.	8.98	11.63	20.75	20.00	6.20	8.00	47.41	5.03	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feed—Continued.										
2852	*Grandin's Screened Scratch Feed.* D. H. Grandin Milling Co., Jamestown, N. Y.	*Merrow:* I. F. Wilcox	11.73	1.55	10.44	10.00	2.73	5.00	70.11	3.44	2.50
3097	*Red Comb Egg Mash with Dried Buttermilk.* Hales & Hunter Co., Chicago, Ill.	*New Britain:* Stanley-Svea Grain Co.	8.33	12.10	21.88	20.00	4.27	7.00	48.99	4.43	4.50
3102	*Red Comb Growing Mash.* Hales & Hunter Co., Chicago, Ill.	*Highwood:* T. C. Hadden & Co.	8.25	5.86	17.38	18.00	5.00	5.00	58.63	4.88	4.00
3575	*Hudson's Laying Mash.* L. W. Hudson, Windsor	*Windsor:* L. W. Hudson	9.78	10.87	19.19	19.79	6.30	6.95	48.11	5.75	5.62
3576	*Hudson's 50-50 Scratch.* L. W. Hudson, Windsor	*Windsor:* L. W. Hudson	11.15	1.60	11.00	11.38	2.75	3.48	70.37	3.13	3.35
3010	*Ingersoll's Special Egg Mash.* Z. C. Ingersoll, Stratford, Conn.	*Stratford:* Z. C. Ingersoll	7.75	10.99	17.00	18.31	8.48	8.44	49.42	6.36	6.45
3333	*Ingersoll's Special Egg Mash.* Z. C. Ingersoll, Stratford, Conn.	*Stratford:* Z. C. Ingersoll	8.73	10.50	17.88	18.31	8.16	8.44	48.65	6.08	6.45
3167	*Larro Egg Mash.* Larrowe Milling Co., Detroit, Mich.	*Bristol:* D. J. Minor	8.35	12.02	20.75	19.00	5.49	8.00	47.93	5.46	5.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25: Found	Protein N x 6.25: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feed—Continued.										
3164	*Larro Scratch Grains.* Larrowe Milling Co., Detroit, Mich. ...	*Bristol:* D. J. Minor	12.56	1.57	10.56	10.00	2.60	4.00	69.80	2.91	2.50
3002	*Nabob Scratch Feed.* Francis H. Leggett Co., Stamford, Conn..	*Stamford:* Francis H. Leggett Co.	11.30	1.67	10.50	9.00	3.15	4.00	70.04	3.34	3.00
3005	*Premier Growing Mash.* Francis H. Leggett Co., Stamford, Conn.	*Stamford:* Francis H. Leggett Co.	8.70	8.65	18.94	15.00	5.42	4.50	52.45	5.84	4.50
3337	*Premier Growing Mash.* Francis H. Leggett Co., Stamford, Conn.	*Stamford:* Francis H. Leggett Co. Co.	9.33	8.72	19.44	15.00	5.53	4.50	51.23	5.75	4.50
3006	*Premier Laying Mash.* Francis H. Leggett Co., Stamford. Conn.	*Stamford:* Francis H. Leggett Co.	8.50	11.43	23.38	20.00	5.10	8.50	46.11	5.48	4.00
3003	*Premier Scratch Feed.* Francis H. Leggett Co., Stamford, Conn.	*Stamford:* Francis H. Leggett Co.	10.46	1.64	10.88	9.00	3.13	4.00	70.93	2.96	3.00
3570	*Homestead Dry Mash.* The C. W. Lines Co., New Britain	*New Britain:* The C. W. Lines Co.	9.38	8.41	21.00	18.00	5.80	7.00	49.43	5.98	4.00
3569	*Homestead Scratch Feed.* The C. W. Lines Co., New Britain	*New Britain:* The C. W. Lines Co.	12.25	8.42	10.19	9.00	2.53	5.00	62.38	4.23	2.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25: Found	Protein N x 6.25: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feed—Continued.										
2258	*Red Star Egg Mash.* E. Manchester & Sons, Winsted	*Winsted:* E. Manchester & Sons	8.30	11.02	19.56	18.00	6.43	8.00	48.11	6.58	4.00
3078	*Red Star Buttermilk Growing Mash.* E. Manchester & Sons, Winsted	*Winsted:* E. Manchester & Sons	7.72	6.16	16.44	20.00	3.90	6.00	59.63	6.15	4.00
3079	*Armour's Cak-Cak Laying Mash.* Mapl-Flake Mills, Inc., Chicago, Ill.	*New Milford:* Geo. E. Ackley Co.	7.53	7.78	21.88	20.00	5.90	6.00	50.14	6.77	3.00
3044	*Iroquois Poultry Mash.* Mapl-Flake Mills, Inc., Chicago, Ill.	*Danbury:* C. S. Barnum & Son.	9.44	5.89	16.88	15.00	6.58	6.00	55.77	5.44	4.00
3045	*Iroquois Scratching Grains.* Mapl-Flake Mills, Inc., Chicago, Ill.	*Danbury:* C. S. Barnum & Son.	12.25	1.48	10.13	10.00	2.98	5.00	70.32	2.84	3.00
2776	*Bull Brand Laying Mash with Dried Buttermilk.* Maritime Milling Co., Buffalo, N. Y. ...	*New Milford:* Geo. E. Ackley Co.	8.35	11.36	19.75	20.00	5.35	8.00	48.97	6.22	5.00
2775	*Red E Mixt Scratch Feed.* Maritime Milling Co., Buffalo. N. Y.	*New Milford:* Geo. E. Ackley Co.	10.80	1.47	10.31	10.00	2.48	4.00	71.85	3.09	2.50
3520	*Red Wing Scratch Feed.* Meech & Stoddard, Inc., Middletown	*Hamden:* Ira W. Beers	9.20	1.60	11.00	10.00	2.48	5.00	73.02	2.70	3.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feed—Continued.										
3580	*Red Wing Special Buttermilk Chick Starter.* Meech & Stoddard, Inc., Middletown	*Middletown:* Meech & Stoddard, Inc.	11.95	7.55	19.75	13.00	4.85	5.00	49.85	6.05	4.00
3528	*Red Wing Special Buttermilk Growing Feed.* Meech & Stoddard, Inc., Middletown	*East Hartford:* Meech Grain Co.	6.88	17.34	20.13	17.00	5.18	8.00	44.84	5.63	5.50
3571	*Red Wing Special Buttermilk Laying Mash.* Meech & Stoddard, Inc., Middletown	*East Hartford:* Meech Grain Co.	10.55	7.04	19.00	17.00	6.50	8.00	51.23	5.68	5.50
3577	*Red Wing Special Chick Feed.* Meech & Stoddard, Inc., Middletown, Conn.	*Middletown:* Meech & Stoddard, Inc.	12.15	1.53	10.44	10.00	1.75	5.00	70.65	3.48	3.00
2779	*Red Wing Special Dry Mash.* Meech & Stoddard, Inc., Middletown, Conn.	*East Hartford:* Meech Grain Co.	8.88	7.41	18.31	17.00	6.28	7.00	53.82	5.30	5.50
3578	*Red Wing Special Intermediate Chick Feed.* Meech & Stoddard Inc., Middletown	*Middletown:* Meech & Stoddard, Inc.	14.15	1.60	10.19	10.00	2.85	5.00	67.53	3.68	3.00
2250	*No. 1 Scratch Feed.* Miner-Hillard Milling Co., Wilkes-Barre, Penn.	*Torrington:* F. W. Wadhams	12.08	1.55	10.50	8.00	2.84	4.00	69.65	3.38	2.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
3524	*Moon's Special A Scratch Feed.* Geo. O. Moon & Co., Binghamton, N. Y.	*Thomaston:* Cunningham & Wallace	9.90	1.59	10.31	10.00	3.33	5.00	71.82	3.05	2.00
3027	*C-B Mash.* Moran-Patton Co., New Haven, Conn.	*New Haven:* Moran-Patton Co.	9.10	7.83	20.88	18.00	6.65	7.00	50.09	5.45	4.00
2847	*Old Mill Buttermilk Laying Mash.* Fred C. Morse, Guilford, Conn.	*Guilford:* Fred C. Morse	9.58	7.43	20.50	18.00	5.90	8.00	50.84	5.75	4.00
2846	*Old Mill Mash Feed.* Fred C. Morse, Guilford, Conn.	*Guilford:* Fred C. Morse	9.41	8.31	21.31	18.00	6.05	8.00	48.97	5.95	4.00
2850	*Old Mill Scratch Feed.* Fred C. Morse, Guilford, Conn.	*Guilford:* Fred C. Morse	11.18	1.51	10.25	10.00	2.55	4.00	71.34	3.17	3.00
2875	*Genesee Scratching Grains.* Mystic Milling & Feed Co., Rochester, N. Y.	*Plainville:* W. S. Eaton	11.38	1.53	10.69	10.00	2.75	3.00	70.97	2.68	2.50
3170	*Domino Crate Fattener with Buttermilk.* Nowak Milling Corp., Hammond, Ind.	*Waterville:* Wooster Feed Store	8.33	2.61	15.75	14.00	5.13	7.00	61.55	6.63	4.50
3340	*Domino Developing Feed.* Nowak Milling Corp., Hammond, Ind.	*Manchester:* I. P. Campbell	10.78	1.52	10.25	10.00	2.12	5.00	72.20	3.13	3.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25 Found	Protein N x 6.25 Guaranteed, not less than	Fiber Found	Fiber Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat Found	Fat Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
3172	*Domino Laying Mash with Buttermilk.* Nowak Milling Corp., Hammond, Ind.	*Waterville:* Wooster Feed Store	9.79	7.77	19.31	18.00	4.58	7.00	53.55	5.00	3.50
3171	*Domino Pigeon Feed.* Nowak Milling Corp., Hammond, Ind.	*Waterville:* Wooster Feed Store	11.42	1.68	12.63	10.00	2.78	5.00	69.14	2.35	3.00
3168	*Domino Scratch Feed.* Nowak Milling Corp., Hammond, Ind.	*Waterville:* Wooster Feed Store	12.35	1.67	11.31	10.00	2.53	5.00	68.99	3.15	3.00
3029	*Fidelity Scratch Feed.* Nowak Milling Corp., Hammond, Ind.	*Higganum:* Felix A. Petrofsky	11.25	1.48	10.56	10.00	2.79	5.00	71.06	2.86	3.00
3180	*Marathon Chick Feed.* Nowak Milling Corp., Hammond, Ind.	*Waterville:* Wooster Feed Store	11.18	1.58	10.50	11.00	1.60	5.00	71.64	3.50	2.00
3124	*Marathon Laying Mash with Buttermilk.* Nowak Milling Corp., Hammond, Ind.	*Manchester:* I. P. Campbell	8.88	7.23	21.63	20.00	6.55	9.00	50.10	5.61	4.50
3176	*Marathon Scratch Feed.* Nowak Milling Corp., Hammond, Ind.	*Waterville:* Wooster Feed Store	12.45	1.53	10.06	10.00	2.83	5.00	67.94	5.19	3.00
2883	*Osborn Mash.* S. V. Osborn Estate, Branford, Conn.	*Branford:* S. V. Osborn Estate	9.53	3.21	15.75	12.00	6.33	8.00	61.25	3.93	3.00
2884	*Osborn Scratch.* S. V. Osborn Estate, Branford, Conn.	*Branford:* S. V. Osborn Estate	11.33	1.87	10.50	10.00	2.95	5.00	69.50	3.85	2.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Water	Ash	Protein N x 6.25 Found	Protein N x 6.25 Guaranteed, not less than	Fiber Found	Fiber Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat Found	Fat Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
2275	*Baby Buster Chick Feed.* Park & Pollard Co., Buffalo, N. Y.	*Canaan:* Ives & Pierce	10.83	1.75	11.13	10.00	1.88	5.00	71.67	2.74	2.00
3572	*Bonnie Booster.* Park & Pollard Co., Buffalo, N. Y.	*East Hartford:* Meech Grain Co.	11.30	5.30	15.50	12.00	3.58	3.00	60.47	3.85	3.00
2273	*Growing Feed.* Park & Pollard Co., Buffalo, N. Y.	*Canaan:* Ives & Pierce	9.95	8.89	15.13	14.00	4.55	8.00	57.43	4.05	1.50
2274	*Intermediate Chick Feed.* Park & Pollard Co., Buffalo, N. Y.	*Canaan:* Ives & Pierce	11.23	1.51	10.25	10.00	2.43	5.00	71.48	3.10	1.50
2226	*Lay or Bust Dry Mash.* Park & Pollard Co., Buffalo, N. Y.	*Waterbury:* Spencer Grain Co.	9.90	9.16	18.75	18.00	6.10	12.00	51.34	4.75	1.50
2265	*Leghorn Special Dry Mash.* Park & Pollard Co., Buffalo, N. Y.	*Torrington:* F. W. Wadhams	9.33	11.32	21.88	21.00	5.80	10.00	46.72	4.95	1.50
2960	*Pigeon Feed.* Park & Pollard Co., Buffalo, N. Y.	*Westerly:* C. W. Campbell Co.	10.93	1.82	13.50	10.00	2.48	5.00	68.94	2.33	1.50
2222	*Red Ribbon Scratch Feed.* Park & Pollard Co., Buffalo, N. Y.	*Ansonia:* Ansonia Flour & Feed Co.	12.15	1.49	10.19	10.00	2.70	5.00	70.49	2.98	1.50
2215	*P-H Mash.* Peterson-Hendee Co., Derby, Conn.	*Derby:* Peterson-Hendee Co.	10.43	6.92	15.63	17.00	4.13	7.00	58.41	4.48	4.00
2216	*P-H Scratch Feed.* Peterson-Hendee Co., Derby, Conn.	*Derby:* Peterson-Hendee Co.	11.85	1.75	10.38	10.00	2.88	5.00	70.26	2.88	2.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
3085	*Platco Laying Mash.* Frank S. Platt Co., New Haven, Conn..	*New Haven:* Frank S. Platt Co.	6.88	13.60	21.81	20.00	6.06	7.00	44.42	7.23	5.50
3025	*Platco Perfection Grain Mixture.* Frank S. Platt Co., New Haven, Conn.	*New Haven:* Frank S. Platt Co.	11.91	1.59	10.75	10.50	2.70	4.50	69.80	3.25	3.50
3026	*Platt's Pigeon Mixture.* Frank S. Platt Co., New Haven, Conn..	*New Haven:* Frank S. Platt Co.	11.48	1.84	13.00	13.00	3.65	5.00	65.25	4.78	4.50
3039	*Pratt's Supreme Pigeon Feed with Corn.,* Pratt's Food Co., Philadelphia, Penn.	*New Britain:* S. P. Strople	11.07	1.64	13.56	10.00	2.48	5.00	68.57	2.68	2.50
3037	*Pratt's Victory Laying Mash.* Pratt Food Co., Philadelphia, Penn.	*New Britain:* S. P. Strople	8.89	6.94	18.44	18.00	6.68	9.00	53.57	5.48	4.00
3040	*Pratt's Victory Large Scratch Feed.* Pratt's Food Co., Philadelphia, Penn.	*New Britain:* S. P. Strople	10.85	1.44	10.38	10.00	2.33	5.00	72.25	2.75	2.50
2793	*Egg-Em-On Laying Mash.* H. C. Puffer, Springfield, Mass.	*Suffield:* Spencer Bros.	9.33	8.80	21.50	20.00	6.50	9.00	49.13	4.74	4.00
2792	*Egg-Em-On Scratch Grains.* H. C. Puffer, Springfield, Mass.	*Suffield:* Spencer Bros.	11.63	1.40	9.63	10.00	2.34	5.00	72.02	2.98	1.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
2893	*Ful-O-Pep Egg Mash.* Quaker Oats Co., Chicago, Ill.	*Hamden:* Ira W. Beers	7.73	12.08	20.81	20.00	6.95	8.00	46.85	5.58	4.00
2876	*Schumacher's Scratch Grains, No Grit.* Quaker Oats Co., Chicago, Ill.	*Thompsonville:* Geo. S. Phelps & Co.	11.40	1.65	10.94	10.00	2.90	3.50	70.13	2.98	2.00
3088	*Purina Baby Chick Chow Feed.* Ralston Purina Mills, St. Louis, Mo.	*New Haven:* Moran-Patton Co..	10.80	1.57	11.06	10.00	1.90	4.00	72.38	2.29	2.00
2874	*Purina Chicken Chowder Feed.* Ralston Purina Mills, St. Louis, Mo.	*Torrington:* F. W. Wadhams ..	8.68	7.77	19.94	19.00	6.97	7.00	51.84	4.80	4.00
3093	*Purina Chicken Fat Chow Feed.* Ralston Purina Mills, St. Louis, Mo.	*Middletown:* H. G. Wadhams ..	8.44	4.80	16.00	15.50	3.73	4.50	62.14	4.89	4.60
3087	*Purina Chicken Fatena Feed.* Ralston Purina Mills, St. Louis, Mo.	*New Haven:* Moran-Patton Co..	8.30	3.47	14.69	12.00	5.93	6.60	62.56	5.05	4.60
2888	*Purina Chick Startena Feed.* Ralston Purina Mills, St. Louis, Mo.	*Derby:* Peterson-Hendee Co. ...	8.53	7.00	19.44	17.00	6.15	7.50	52.47	6.41	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
2878	*Purina Hen Chow Feed.* Ralston Purina Mills, St. Louis, Mo...	*Rockville:* Rockville Grain & Coal Co.	12.10	1.52	10.50	10.00	2.75	4.00	69.91	3.22	2.50
3326	*Purina Intermediate Hen Chow Feed.* Ralston Purina Mills, St. Louis, Mo.	*New Haven:* Moran-Patton Co..	11.64	1.30	10.13	10.00	2.09	4.00	71.87	2.97	2.50
3001	*Purina Pigeon Chow Feed.* Ralston Purina Mills, St. Louis, Mo.	*Stamford:* W. L. Crabb	11.83	2.05	14.75	12.00	2.85	4.00	66.06	2.46	2.00
3143	*Winner Scratch Feed.* Ralston Purina Co., St Louis, Mo.	*Middletown:* H. G. Wadhams ..	11.43	1.42	10.38	10.00	2.38	5.00	71.64	2.75	2.00
2794	*Diamond Scratch Feed.* Rockville Grain & Coal Co., Rockville, Conn.	*Rockville:* Rockville Grain & Coal Co.	11.85	1.51	10.69	10.00	2.64	4.00	70.66	2.65	3.00
2907	*Advance Egg Mash.* Rosenbaum Bros., Chicago, Ill.	*Stafford Springs:* Dennis Grain Mill	8.58	11.13	18.75	18.00	5.90	8.00	48.36	7.28	4.00
2905	*77 Scratch Feed, No Grit.* Rosenbaum Bros., Chicago, Ill.	*Stafford Springs:* Dennis Grain Mill	11.23	1.72	10.69	10.00	2.98	5.00	70.03	3.35	2.00
3567	*Vitality Chick Starter.* Rosenbaum Bros., Chicago, Ill.	*New Britain:* S. P. Strople	10.70	6.21	17.06	15.00	4.65	6.00	56.65	4.73	5.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
2231	*Vitality Egg Mash without Buttermilk.* Rosenbaum Bros., Chicago, Ill.	*Hamden:* Ira W. Beers	9.28	12.13	22.69	20.00	7.05	10.00	41.54	7.31	3.00
2906	*Vitality Egg Mash with Buttermilk.* Rosenbaum Bros., Chicago, Ill.	*Stafford Springs:* Dennis Grain Mill	9.03	9.75	20.63	20.00	5.58	8.00	48.66	6.35	4.00
3565	*Vitality Fine Chick Scratch.* Rosenbaum Bros., Chicago, Ill.	*New Britain:* S. P. Strople	12.28	6.12	11.31	10.00	1.28	3.00	63.13	5.88	3.50
2909	*Vitality Growing Mash.* Rosenbaum Bros., Chicago, Ill.	*Stafford Springs:* Dennis Grain Mill	9.28	5.72	16.44	15.00	5.53	6.00	57.28	5.75	5.00
2230	*Vitality Scratch, No Grit.* Rosenbaum Bros., Chicago, Ill.	*Hamden:* Ira W. Beers	12.28	1.57	10.38	10.00	2.60	5.00	70.19	2.98	2.50
2923	*Homespun Laying Mash.* Paty Schwartz Co., New London, Conn.	*New London:* Paty Schwartz Co.	8.46	6.30	15.00	20.00	8.50	10.00	55.99	5.75	4.00
3064	*Homespun Scratch Grains.* Paty Schwartz Co., New London, Conn.	*New London:* Paty Schwartz Co.	11.30	1.50	10.00	10.00	2.88	5.00	71.26	3.06	1.50
2891	*"See-More Egg" Buttermilk Mash.* Seymour Grain & Coal Co., Seymour, Conn.	*Seymour:* Seymour Grain & Coal Co.	9.32	9.55	21.69	18.00	4.40	8.00	49.54	5.50	4.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25 Found	Protein N x 6.25 Guaranteed, not less than	Fiber Found	Fiber Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat Found	Fat Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
2892	*"See-More Egg" Scratch Feed.* Seymour Grain & Coal Co., Seymour, Conn.	*Seymour:* Seymour Grain & Coal Co.	10.94	1.44	9.81	10.00	2.98	6.00	71.88	2.95	3.00
2220	*Nelson Mixed Chicken Feed.* Shelton Feed Co., Shelton, Conn.	*Shelton:* Shelton Feed Co.	11.83	2.65	10.31	10.00	2.83	5.00	69.64	2.74	1.50
2219	*Nelson Laying Mash.* Shelton Feed Co., Shelton, Conn.	*Shelton:* Shelton Feed Co.	9.93	8.78	18.06	16.00	5.43	8.00	52.65	5.15	4.00
2805	*"Mill Streams" Fortune Hunter Scratch Grains.* Winchell Smith Inc., Farmington, Conn.	*Farmington:* Winchell Smith, Inc.	11.88	1.59	10.50	10.00	3.18	3.00	69.45	3.40	2.50
2789	*"Mill Streams" Lightnin Laying Mash.* Winchell Smith, Inc., Farmington, Conn.	*Farmington:* Winchell Smith, Inc.	9.30	10.19	20.38	16.00	5.78	7.00	49.10	5.25	3.00
2238	*Wirthmore Buttermilk Mash Feed with Fish and Meat Scraps.* St. Albans Grain Co., St. Albans, Vt.	*Hamden:* Ira W. Beers	9.52	8.82	20.81	20.00	5.49	7.00	49.77	5.59	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25 Found	Protein N x 6.25 Guaranteed, not less than	Fiber Found	Fiber Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat Found	Fat Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
2802	*Wirthmore Growing Feed with Dried Buttermilk and Beef Scraps.* St. Albans Grain Co., St. Albans, Vt.	*New Milford:* Geo. T. Soule	9.53	8.44	17.06	15.00	5.25	4.50	54.07	5.65	4.50
2235	*Wirthmore Intermediate Chick Feed.* St. Albans Grain Co., St. Albans, Vt.	*Seymour:* Seymour Grain & Coal Co.	10.78	1.36	10.44	10.00	2.39	3.50	72.49	2.54	3.00
2239	*Wirthmore Scratch Feed.* St. Albans Grain Co., St. Albans, Vt.	*West Cheshire:* G. W. Thorpe	11.78	1.54	10.69	10.00	2.97	5.00	70.29	2.73	3.00
2287	*Onondaga Scratch Grains.* Syracuse Milling Co., Syracuse, N. Y.	*Norfolk:* Aug. P. Curtis	12.90	1.57	10.44	10.00	2.50	5.00	69.84	2.75	3.00
2998	*Syragold Chick Feed.* Syracuse Milling Co., Syracuse, N. Y.	*Southport:* C. Buckingham & Co.	11.30	1.77	11.25	10.00	1.33	5.00	70.35	4.00	2.50
2999	*Syragold Chick Starter.* Syracuse Milling Co., Syracuse, N. Y.	*Southport:* C. Buckingham & Co.	10.00	6.57	16.81	18.00	2.01	4.00	60.26	4.35	3.50
3334	*Syragold Chick Starter.* Syracuse Milling Co., Syracuse, N. Y.	*Southport:* C. Buckingham & Co.	10.75	7.15	17.00	18.00	1.83	4.00	59.64	3.63	3.50

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
2280	*Syragold Egg Mash.* Syracuse Milling Co., Syracuse, N. Y.	*Torrington:* F. U. Wadhams	9.09	7.54	20.31	18.00	5.90	8.00	51.32	5.84	3.00
2281	*Syragold Growing Mash.* Syracuse Milling Co., Syracuse, N. Y.	*Torrington:* F. U. Wadhams	9.83	4.79	16.56	16.00	3.44	7.00	60.64	4.74	4.00
2271	*Syragold Scratch Grains.* Syracuse Milling Co., Syracuse, N. Y.	*Torrington:* F. L. Wadhams	11.20	1.38	10.63	10.00	2.63	5.00	71.36	2.80	3.00
2978	*Derby Scratch Feed.* Tioga Mill & Elevator Co., Waverly, N. Y.	*Hawleyville:* W. A. Honan	11.48	1.57	9.88	9.00	3.55	4.50	70.72	2.80	2.04
2804	*Egatine.* Tioga Mill & Elevator Co., Waverly, N. Y.	*North Haven:* Wm. L. Thorpe	8.88	9.06	25.81	23.00	4.47	6.00	47.31	4.47	2.50
2928	*Tioga Laying Food.* Tioga Mill & Elevator Co., Waverly, N. Y.	*Hawleyville:* W. A. Honan	9.53	7.44	20.31	17.00	4.98	6.00	51.86	5.88	2.50
2283	*Rex Scratch Feed.* United Flour & Feed Co., Inc., Albany, N. Y.	*Winsted:* Chas. R. Hawley	11.70	1.51	10.13	10.00	2.40	5.00	71.36	2.90	3.00
2282	*United Laying Mash* (Storrs Formula). United Flour & Feed Co., Inc., Albany, N. Y.	*Winsted:* Chas. R. Hawley	9.57	8.75	20.50	20.00	5.32	7.00	50.41	5.45	4.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
2808	*United Scratch Feed.* United Flour & Feed Co., Albany, N. Y.	*Thompsonville:* Geo. S. Phelps & Co.	11.40	1.46	10.31	10.00	2.75	4.00	70.95	3.13	3.00
2284	*Waldorf Milk Grains.* United Flour & Feed Co., Albany, N. Y.	*Winsted:* Chas. R. Hawley	9.72	4.79	21.88	20.00	7.83	10.00	51.13	4.65	3.50
2801	*Eventually Gold Medal Vitamin Egg Mash.* Washburn-Crosby Co., Minneapolis, Minn.	*New Milford:* W. L. Richmond & Son	8.23	7.66	21.19	20.00	6.95	8.50	50.56	5.41	5.50
2974	*Big Y Growing Feed.* Yantic Grain & Products Co., Norwich, Conn.	*Norwich:* Yantic Grain & Products Co.	8.15	7.45	20.13	17.00	6.76	6.00	51.11	6.40	4.00
2913	*Big Y Laying Mash.* Yantic Grain & Products Co., Norwich, Conn.	*Willimantic:* Boston Grain Co.	8.63	8.28	21.81	20.00	6.64	7.00	48.51	6.13	4.00
2971	*Uncas Scratch Feed.* Yantic Grain & Products Co., Norwich, Conn.	*Norwich:* Yantic Grain & Products Co.	11.00	1.62	10.19	11.00	3.03	5.00	70.83	3.33	3.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
	Beef Scrap, etc.										
2831	*Beach Star Brand Beef Scrap.* Beach Soap Co., Lawrence, Mass.	*Mystic:* J. L. Manning & Co.	5.55	3.73	38.00	35.00	1.59	2.50	37.74	13.39	10.00
2209	*Collis Process Pure Dried Buttermilk.* Collis Products Co., Clinton, Iowa	*Hamden:* Ira W. Beers	10.45	10.56	30.50	30.00	....	....	41.79	6.70	5.00
3190	*Cooked Meat Scrap.* Conn. Fat Rendering & Fertilizer Corp., New Haven, Conn.	*Guilford:* F. H. Rolf	6.38	21.82	57.81	50.00	....	....	1.96	12.03	10.00
2204	*Meat Scrap for Poultry.* Conn. Fat Rendering & Fertilizer Corp., New Haven, Conn.	*Waterbury:* Spencer Grain Co.	5.60	30.52	50.31	40.00	....	....	2.19	11.38	10.00
3117	*Red W. Brand Meat Scraps.* Eastern States Farmers' Exchange, Springfield, Mass.	*New Canaan:* Clapboard Hill Farms	4.71	28.80	55.25	55.00	1.78	3.00	1.86	7.60	6.00
3154	*Fairmont's Better Pure Flake Buttermilk.* Fairmont Creamery Co., Omaha, Neb.	*Plantsville:* C. A. Cowles	8.53	9.74	35.13	32.00	....	....	40.45	6.15	6.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
			Water	Ash	Protein N x 6.25		Fiber		Nitrogen-free extract (starch, gum, etc.)	Fat	
					Found	Guaranteed, not less than	Found	Guaranteed, not more than		Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
	Beef Scrap, etc.—Continued.										
2948	*Frisbie's Bone Meal 20-25% Protein* (For Cattle & Poultry). L. T. Frisbie Co., New Haven, Conn.	*New Haven:* L. T. Frisbie Co.	4.90	64.31	26.31	20.00	...	....	1.83	2.65	5.00
2256	*Frisbie's Bone and Meat Meal 35-45% Protein.* L. T. Frisbie Co., New Haven, Conn.	*Winsted:* Chas. R. Hawley	3.40	45.95	29.94	35.00	....	....	6.07	14.64	8.00
3142	*Frisbie's Bone and Meat Meal 35-45% Protein.* L. T. Frisbie Co., New Haven, Conn.	*New Haven:* L. T. Frisbie Co.	3.25	42.96	33.56	35.00	....	....	6.67	13.56	8.00
3329	*Frisbie's Bone and Meat Meal 35-45% Protein.* L. T. Frisbie Co., New Haven, Conn.	*New Haven:* L. T. Frisbie Co.	5.13	35.17	38.69	35.00	....	....	8.96	12.05	8.00
2246	*Frisbie's Poultry Feed 45-55% Protein.* L. T. Frisbie Co., New Haven, Conn.	*Torrington:* D. L. Talcott	4.78	37.80	39.06	45.00	....	....	7.43	10.93	8.00
3137	*Frisbie's Pultry Feed 45-55% Protein.* L. T. Frisbie Co., New Haven, Conn.	*Hawleyville:* W. A. Honan	4.55	36.41	40.63	45.00	....	....	7.53	10.88	8.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
	Beef Scrap, etc.—Continued.										
3327	*Frisbie's Poultry Feed 45-55% Protein.* L. T. Frisbie Co., New Haven, Conn.	*New Haven:* L. T. Frisbie Co...	5.10	27.78	49.44	45.00	....	....	3.90	13.78	8.00
2243	*Frisbie's Poultry Feed 55-65% Protein.* L. T. Frisbie Co., New Haven, Conn.	*Litchfield:* Wadhams Co.	8.20	24.61	53.94	55.00	....	....	1.57	11.68	8.00
3141	*Frisbie's Poultry Feed 55-65% Protein.* L. T. Frisbie Co., New Haven, Conn.	*New Haven:* L. T. Frisbie Co...	4.75	25.58	53.56	55.00	....	....	3.71	12.40	8.00
3328	*Frisbie's Poultry Feed 55-65% Protein.* L. T. Frisbie Co., New Haven, Conn.	*New Haven:* L. T. Frisbie Co...	6.55	21.36	56.88	55.00	....	....	3.76	11.45	8.00
2932	*Frisbie's Cracked Bone.* L. T. Frisbie Co., New Haven, Conn.	*New Haven:* L. T. Frisbie Co...	3.83	63.21	24.25	20.00	....	....	3.61	5.10	5.00
3196	*H. J. Selected Meat Scrap.* Henry James & Son, Worcester, Mass.	*Abington:* O. A. Weeks	6.23	31.58	46.88	42.00	1.18	6.00	2.95	11.18	10.00

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred: Water	Ash	Protein N x 6.25: Found	Protein: Guaranteed, not less than	Fiber: Found	Fiber: Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Fat: Found	Fat: Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Continued.*										
	Poultry Feeds—Continued.										
	Beef Scrap, etc.—Continued.										
2851	*Cooked Meat and Bone Scrap.* A. G. Markham, Springfield, Mass.	*Merrow:* I. F. Wilcox	7.17	29.86	50.31	45.00	....	....	2.78	9.88	8.00
3185	*Marsh's Pure Ground Scraps for Poultry.* Geo. E. Marsh Co., Lynn, Mass.	*Mystic:* Mystic Grain Co.	6.35	33.27	41.00	40.00	....	....	7.53	11.85	8.00
3076	*Blue Seal Meat Scraps.* New England By-Products Co., Lawrence, Mass.	*Plantsville:* C. A. Cowles	5.88	30.03	50.56	50.00	1.45	3.00	1.81	10.27	5.00
3074	*White Seal Meat Scraps.* New England By-Products Co., Lawrence, Mass.	*Derby:* Peterson-Hendee Co. ...	5.27	44.93	36.75	40.00	1.34	4.00	4.07	7.64	5.00
3521	*Norton's Meat and Bone Poultry Food.* Norton Tallow Co., Somerville, Mass.	*Watertown:* Watertown Coöp. Assoc.	4.15	35.80	40.63	45.00	....	....	5.92	13.50	8.00
3163[1]	*Rauh's Meato.* E. Rauh & Sons, Indianapolis, Ind.	*Plantsville:* C. A. Cowles	1.53	7.14	80.50	75.00	....	....	....	10.83	10.00
3533	*Reardon's Beef Scrap.* John Reardon & Sons Co., Cambridge, Mass.	*Westerly:* C. W. Campbell Co...	5.05	28.27	55.50	55.00	....	....	2.83	8.35	6.00

[1] Wire tags, illegal.

TABLE I. ANALYSES OF COMMERCIAL FEEDS, INSPECTION OF 1925—*Continued.*

Station No.	Manufacturer and Brand	Retail Dealer	Pounds per Hundred								
					Protein N x 6.25		Fiber			Fat	
			Water	Ash	Found	Guaranteed, not less than	Found	Guaranteed, not more than	Nitrogen-free extract (starch, gum, etc.)	Found	Guaranteed, not less than
	PROPRIETARY MIXED FEEDS—*Concluded.*										
	Poultry Feeds—Concluded.										
	Beef Scrap, etc.—Concluded.										
3534	*Reardon's Beef Scrap.* John Reardon & Sons Co., Cambridge, Mass.	*Westerly:* C. W. Campbell Co.	4.65	39.07	44.81	45.00	....	....	3.39	8.08	6.00
2785	*Chic-Chuck.* Russia Cement Co., Gloucester, Mass.	*Plantsville:* C. A. Cowles	6.10	33.33	55.50	45.00	0.69	1.00	3.25	1.13	0.10
2807	*Springfield Ground Meat Scraps.* Springfield Rendering Co., Springfield, Mass.	*Suffield:* Spencer Bros.	6.51	36.35	45.31	45.00	....	....	2.03	9.80	7.00
2798	*Stanley's 45% to 50% Protein Meat Scrap.* John T. Stanley Co., Inc., New York City	*Derby:* Peterson-Hendee Co.	5.24	35.58	43.81	45.00	1.45	3.00	2.68	11.24	10.00
3127	*Stanley's 45% to 50% Protein Meat Scrap.* John T. Stanley Co., Inc., New York City	*Middletown:* Meech & Stoddard, Inc.	6.83	29.51	46.31	45.00	2.28	3.00	4.54	10.53	10.00
2899	*Vico Meat Scrap.* Van Iderstine Co., Long Island City, N. Y.	*New Milford:* Geo. T. Soule	7.63	21.26	57.50	55.00	1.90	3.00	0.46	11.25	5.00
2922	*P. W. Bone Meal.* Worcester Rendering Co., Auburn, Mass.	*New London:* Paty Schwartz Co.	3.58	59.51	20.38	20.00	....	....	4.30	12.23	5.00
2955	*P. W. Meat Scrap.* Worcester Rendering Co., Auburn, Mass.	*Mansfield Depot:* Martin M. Hansen	6.58	29.20	51.75	45.00	1.54	6.00	1.28	9.65	8.00
2956	*P. W. Special Meat Scrap.* Worcester Rendering Co., Auburn, Mass.	*Merrow:* I. F. Wilcox	6.25	25.04	55.13	55.00	1.43	5.00	0.57	11.58	8.00

MISCELLANEOUS.

In Table II are given analyses of samples submitted by individuals or taken by the Station agent upon request. Here are included also various materials which have been examined for poisonous or injurious substances. Such comments as are required are noted in the tabulated statement.

TABLE II. ANALYSES OF FEEDING STUFFS SUBMITTED BY INDIVIDUALS.

Station No.	Material	Submitted by	Pounds per Hundred: Water	Ash	Protein (N x 6.25)	Fiber	Nitrogen-free extract (starch, gum, etc.)	Ether extract (crude fat)	Remarks
	COTTONSEED PRODUCTS.								
1827	Danish. Cottonseed Feed	*Middletown:* The Coles Co.	....	....	35.94	....	....	....	
2566	Danish. Cottonseed Meal	The Coles Co.	....	....	39.50	....	....	....	
	RYE PRODUCTS.								
2575	Rye Middlings No. 1	*Waterbury:* Scoville Mfg. Co. ..	11.35	4.38	15.19	5.79	60.22	3.07	
2576	Rye Middlings No. 2	Scoville Mfg. Co.	12.12	3.75	15.63	3.71	61.68	3.11	
	PROPRIETARY MIXED FEEDS.								
	Dairy Rations, etc.								
2901	Eshelman's Red Rose Dairy Feed	*Rockville:* E. E. Tucker	7.53	6.57	24.00	10.43	45.87	5.60	Guaranty: 24-10-4.
1197	Red Wing Junior Dairy Ration.	*Newington:* Thomas Holt	....	5.87	19.44	8.15	....	....	Contains 1.05% Salt (NaCl).
1198	Red Wing Junior Dairy Ration.	Thomas Holt	....	4.47	20.63	9.48	....	....	Contains trace of chlorine.
2832	Red Brand Dairy Feed	*New Britain:* Stanley-Svea Grain & Coal Co.	7.58	6.57	25.63	8.61	45.23	6.38	Guaranty: 24-10-4.5.
1230	Dairy Ration	*Amston:* R. F. Porter	....	....	22.81	10.53	....	5.45	
2984	Dairy Feed	*Middletown:* Sidney Edwards ..	8.01	5.18	20.75	8.05	54.11	3.90	
1541	Dairy Ration	*Guilford:* Fred C. Morse	10.60	6.75	21.56	8.71	47.36	5.02	
2669	Old Mill Dairy Ration	Fred C. Morse	11.68	....	23.00	8.78	....	5.23	
1564	Dairy Ration No. 1	*Middletown:* Meech & Stoddard, Inc.	6.74	....	25.56	8.02	....	6.39	

TABLE II. ANALYSES OF FEEDING STUFFS SUBMITTED BY INDIVIDUALS—*Continued.*

Station No.	Material	Submitted by	Pounds per Hundred: Water	Ash	Protein (N x 6.25)	Fiber	Nitrogen-free extract (starch, gum, etc.)	Ether extract (crude fat)	Remarks
	PROPRIETARY MIXED FEEDS—*Continued.*								
	Dairy Rations, etc.—Concluded.								
1665	Dairy Ration No. 2	Meech & Stoddard, Inc.	7.25	....	20.56	7.89	....	6.46	
2814	Basic Dairy Ration	*New Haven:* R. G. Davis & Sons	8.10	5.25	23.50	7.35	51.32	4.48	Guaranty: 20-9-5.
3548	Dairy Ration	*Gaylordsville:* W. D. Conn	7.13	1.45	25.13	10.25	50.19	5.85	
	Horse Feed.								
2663	Horse Feed	*Bridgeport:* Bridgeport Ice Delivery Co.	15.23	....	8.63	19.83	....	0.38	
2670	Old Mill Provender	*Guilford:* Fred C. Morse	13.38	....	9.75	5.00	....	3.80	
	Stock Feed.								
2599	Grain, Sample No. 1	*Somers:* C. S. Beaumont	11.47	4.94	26.06	10.51	42.42	4.60	
2600	Grain, Sample No. 2	C. S. Beaumont	11.85	6.31	24.00	19.09	35.60	3.15	
	Poultry Feeds.								
1115	Meat Scrap No. 1	*New Haven:* Conn. Fat Rendering Co.	6.78	....	56.19	2.38	....	11.43	
1116	Meat Scrap No. 2	Conn. Fat Rendering Co.	4.90	....	52.06	1.78	....	11.13	
1117	Meat Scrap No. 3	Conn. Fat Rendering Co.	6.35	....	62.00	3.73	....	12.35	
2902	Bone Meal for Poultry	*Winsted:* A. J. Beckman	....	64.55	24.88	....	....	....	
2903	Bone Meal for Poultry	A. J. Beckman	....	86.00	5.13	....	....	....	

TABLE II. ANALYSES OF FEEDING STUFFS SUBMITTED BY INDIVIDUALS—*Continued.*

Station No.	Material	Submitted by	Pounds per Hundred						Remarks
			Water	Ash	Protein (N x 6.25)	Fiber	Nitrogen-free extract (starch, gum, etc.)	Ether extract (crude fat)	
	PROPRIETARY MIXED FEEDS—*Concluded.*								
	Poultry Feeds—Concluded.								
3055	Edible Steamed Bone Meal	*Norwich:* Yantic Grain & Products Co.	....	....	13.81	....	....	....	
1762	Beef Scrap No. 1	*Middletown:* Sidney A. Edwards	....	....	39.50	....	....	....	Contains 14.68% Phosphoric Acid (P_2O_5).
1763	Beef Scrap No. 2	Sidney A. Edwards	....	....	45.31	....	....	....	Contains 12.23% Phosphoric Acid (P_2O_5).
3304	Beef Scrap	*Gilead:* Joseph A. Barrasso	6.28	26.85	53.88	....	....	9.39	
2597	Ingersoll Special Egg Mash	*Stratford:* Z. C. Ingersoll	11.51	10.31	18.31	8.44	44.98	6.45	
3158	Scratch Feed	*New Britain:* C. W. Lines Co. ..	10.54	1.39	10.00	2.29	72.88	2.90	
2667	Scratch Feed	*Guilford:* Fred C. Morse	14.00	....	10.56	3.88	....	2.73	
2668	Old Mill Mash Feed	Fred C. Morse...............	11.90	....	22 25	6.73	....	5.80	
2598	Poultry Mash	*Rockville:* Rockville Grain & Coal Co.	9.82	17.58	23.06	8.68	36.01	4.85	Ash contains charcoal.
2664	Poultry Mash No. 1	*Guilford:* Fred H. Rolf	10.13	....	16.88	4.40	....	4.95	
2665	Poultry Mash No. 2	Fred H. Rolf	10.48	....	21.75	5.00	....	4.03	
2666	Poultry Mash No. 3	Fred H. Rolf	11.05	....	16.25	5.15	....	3.10	
2740	Purina Hen Chowder	*Little River:* Walnut Crest Poultry Farm	8.65	....	21.25	8.26	....	4.68	

TABLE II. ANALYSES OF FEEDING STUFFS SUBMITTED BY INDIVIDUALS—*Continued.*

Station No.	Material	Submitted by	Pounds per Hundred						Remarks
			Water	Ash	Protein (N x 6.25)	Fiber	Nitrogen-free extract (starch, gum, etc.)	Ether extract (crude fat)	
	MISCELLANEOUS.								
2194	Alfalfa Leaf Meal, Sample A ..	*Unionville:* F. D. Lawton & Son	....	....	21.44	15.88	....	....	
2195	Alfalfa Leaf Meal, Sample B ..	F. D. Lawton & Son	....	....	24.38	13.07	....	....	
1202	Beet Pulp	*Bridgeport:* Mitchell Dairy Co..	74.88	1.19	4.29	3.55	15.97	0.12	Soaked in skim milk.
1352	Dried Buttermilk	*Guilford:* Fred H. Rolf	7.51	8.77	34.32	....	42.15	7.25	Protein N x 6.38.
3072	Feed	*Torrington:* Ralph H. Alcott ..	....	....	24.69	....	....	....	
1201	Ground Screenings	*Southport:* Daniel H. Morgan..	8.65	5.03	14.50	11.85	50.32	9.65	
2596	Hemp Seed	*New Haven:* Frank S. Platt Co.	10.00	5.46	21.75	8.34	24.83	29.62	
1203	Mixed Feed	*Hartford:* H. O. Daniels	8.63	5.30	22.13	9.50	49.41	5.03	
1424	Corn, Flint	Dept. of Plant Breeding	7.60	....	....	....	....	....	
1425	Corn, Dent	Dept. of Plant Breeding	6.95	....	....	....	....	....	
1483	Corn, shelled corn	Dept. of Plant Breeding	5.50	2.58	13.88	3.09	35.36	10.68	
3359	Corn, Dent	Dept. of Plant Breeding	5.75	....	....	....	....	....	
3360	Corn, Flint	Dept. of Plant Breeding	6.65	....	....	....	....	....	
3419	Red Wheat	*Willimantic:* Reuben Fishbein ..	....	....	....	....	....	....	Wheat 87%; Oats 9.80%; Barley 2.70%; Weed 0.50%; Corn, trace.
2697	Mash	*Long Ridge:* Louis Draghi	....	....	....	....	....	....	Consisted chiefly of corn, oats and middlings. No cockle found. Feeding developed no unfavorable symptoms in animals fed.

TABLE II. ANALYSES OF FEEDING STUFFS SUBMITTED BY INDIVIDUALS—*Continued.*

Station No.	Material	Submitted by	Pounds per Hundred: Water	Ash	Protein (N x 6.25)	Fiber	Nitrogen-free extract (starch, gum, etc.)	Ether extract (crude fat)	Remarks
	MISCELLANEOUS—*Continued.*								
2017	Scratch Feed	*E. Granby:* B. A. Krick	....	....	....	....	....	....	Consisted of cracked corn, barley, wheat, oats, weed seeds. Slight musty odor. Feeding tests developed no unfavorable symptoms in animals fed.
2607	Unknown Salt. (Found in pasture)	*Hartford:* Commissioner on Domestic Animals	....	....	....	....	....	....	Identified as potassium nitrate or saltpeter.
2399 2400	Mash Beef Scrap }	*Pleasant Village:* Birchwood Farm Co., Inc.	....	....	....	....	....	....	No alkaloids or mineral poisons detected. White rats and chicks fed with both mash and scrap for period of three days developed no unfavorable symptoms.
2167 2168	Mixed Grain Mash }	*West Cheshire:* Reno Swift	....	....	....	....	....	....	Feeds clean and wholesome apparently. No indication of salt. Feeding tests developed no unfavorable symptoms in animals fed.

TABLE II. ANALYSES OF FEEDING STUFFS SUBMITTED BY INDIVIDUALS—*Concluded.*

Station No.	Material	Submitted by	Pounds per Hundred: Water	Ash	Protein (N x 6.25)	Fiber	Nitrogen-free extract (starch, gum, etc.)	Ether extract (crude fat)	Remarks
	MISCELLANEOUS—*Concluded.*								
1476	Calf Meal	*So. Norwalk:* Sam'l Roodner ..	....	....	....	....	....	....	No poisons indicated by chemical tests or by feeding trials.
1410	(1) Portion of cow's stomach; (2) Stomach contents, (3) mixed feed; (4) cottonseed meal	*Hartford:* Commissioner on Domestic Animals	....	....	....	....	....	....	Nitrate indicated in the inflamed stomach tissue. Arsenic, mercury, lead, barium, copper, phosphorus and cyanide not detected. Alkaloids not found. No evidence of poison except the possible presence of nitrates.
1689	Stock Salt	*Rockfall:* D. Howard Birdsey..	....	....	....	....	....	....	Not common salt but magnesium sulphate (Epsom salt).

Tonics, Conditioners, Remedies, etc.

3352. *Mineral Mixture* for use in feeds. Sample submitted by Mulberry Shell Co. Composed of salt, sulphur, charcoal, shell and gravel. Salt, sulphur and charcoal did not correspond to the formula used in mixing, due, probably, to the difficulty in mixing such materials and the tendency to stratify upon handling afterwards.

3353. *Coot Shell Clam,* screened. Submitted by the company named above. Consisted of approximately 66 per cent of shell and 29 per cent of sand, gravel, etc.

3354. *Coot Shell Clam,* unscreened. Submitted by the company named above. Consisted of approximately 76 per cent of shell and 18 per cent of sand, gravel, etc.

3160. *Zip Stock Conditioner.* Zip Products Co., Tiffin, Ohio. Sample submitted by John Robb, Middletown. Ingredients claimed to be present are sulphur, quassia, copperas, Glauber's salt, fenugreek, sodium chloride, palmo meal and charcoal. A substance resembling palm nut meal was present and all of the other materials claimed were identified.

915. *Bowman's Abortion Remedy.* Erick Bowman Remedy Co., Inc., Owatonna, Minn. This remedy was called to our attention by a dairyman whose herd was infected with contagious abortion by reason of which he had sustained serious losses in the past few years. While not too sanguine of the efficacy of any advertised "specific," preliminary trials appeared to have produced favorable results and a substantial supply of the remedy was procured at a considerable cost. The disease was not eliminated from his herd, however, and at the time of submitting the sample the purchaser was in doubt as to the value of the treatment.

Examination of the remedy showed that it consisted of some ordinary feeding material, probably bran, with about 85 per cent of brown sugar, and chlorides, calculated as sodium chloride, equivalent to 0.71 per cent. The analysis further indicated the presence of some vegetable extractive or other medicament. The proximate analysis accounted for about 99 per cent of the sample but active medicaments, if present, were not identified.

So far as we are aware, the only progress which has been made in controlling this disease is by the method of strict isolation of infected animals; the efficacy of specifics given by mouth, or otherwise, has not been demonstrated by adequate acceptable evidence.

21664. *Lictonic.* Lambert Lictonic Co., St. Louis, Mo. This preparation, in the form of a black compressed cake, is said to contain practically all the drugs, herbs, and mineral substances which have been recommended from time to time by various authorities as desirable adjuncts to the rations of farm animals. Reference is made in accompanying literature to official and other feeding tests which appear to substantiate the claims made for the product.

We have no first-hand information about this preparation from the standpoint of actual feeding experience, but a sample submitted to us showed on analysis substantially the following composition:

Moisture 2.50 per cent; organic matter (loss on ignition less moisture and free sulphur), 13.83 per cent; nitrogen 0.27 per cent; sodium chloride 50.24 per cent; calcium sulphate 15.10 per cent; calcium carbonate 9.21 per cent; magnesium carbonate 1.07 per cent; iron and aluminum oxides 2.85 per cent; silicon dioxide 2.71 per cent; undetermined, including phosphorus if present, 0.57 per cent; free sulphur 1.92 per cent.

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Connecticut Agricultural Experiment Station

New Haven, Connecticut

A Chemical Investigation of Some Standard Spray Mixtures

R. E. ANDREW AND PHILIP GARMAN

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to other applicants as far as the editions permit.

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

A Chemical Investigation of Some Standard Spray Mixtures

R. E. Andrew* and Philip Garman

Modern spray practices have become complicated procedures. The necessity of attaining maximum efficiency with a minimum of labor has led in the case of fruit growing to the use of high powered outfits which apply spray mixtures at a rapid rate and to the combination of sprays in order to avoid separate applications. In the combination of sprays there has been much uncertainty of results and failure to explain certain phenomena which have not been well understood, at least from a chemical standpoint. For instance, we know that the ingredients of a certain spray formula mixed in a certain order give a definitely colored mixture, whereas an entirely different order of combination may give a different appearance. What goes on under these conditions as regards the ingredients themselves has only been conjectured by the entomologist, and it is in an attempt to throw some further light on what happens when various insecticides and fungicides are put together that the present work was undertaken.

Historical Summary

Probably the earliest studies of spray mixtures from a chemical standpoint were made by Bradley[2] and Bradley and Tartar[3], who found that there was a distinct chemical reaction between lime-sulphur and lead arsenate resulting in the formation of soluble arsenic. The latter undesirable condition was found to be greatly helped by the addition of lime to the mixture. Robinson[15], following this clue, described the beneficial action of lime upon the standard spray mixture and came to the conclusion that lime prevents the reaction between lime-sulphur and lead arsenate and does not lower the polysulphide sulphur in the lime-sulphur to a harmful extent. Ruth[17] made an extensive investigation of spray mixtures from a chemical standpoint, reaching the general conclusion that when these two components are mixed, a thioarsenate of some kind is formed which holds it insoluble in lime-sulphur solution, and that thiosulphates and sulphites are increased, possibly accounting for the improved fungicidal properties of the mixture. More recently Thatcher and Streeter[22] have investigated the addition of casein, gelatin,

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nicotine and other preparations to the combined lead arsenate, lime-sulphur sprays, finding that casein-lime and nicotine exert a beneficial action upon the spray mixture. Still more recently, with the use of somewhat different methods, Goodwin and Martin[10] reached somewhat different conclusions, stating that casein and gelatin do not always protect lead arsenate from harmful reactions with lime-sulphur and in fact give an increased amount of soluble arsenic, contrary to the conclusions of Thatcher and Streeter. They found furthermore that lime decreased the amount of sulphur in solution in the spray mixture, thereby reducing its fungicidal value, but that lime, if carbonated, exerted little or no effect upon the mixture.

Plan of Study and Methods Employed

All of the work thus far described was done with double or triple combinations of spray materials but the possible effect upon the composition of the mixture due to the sequence in which the separate ingredients were added was not considered. The work herein reported began with a study of the effect of different orders of mixing upon the composition of a mixture containing four ingredients, but as the work progressed it seemed advisable to extend its scope to include all possible double and triple combinations as well.

In preparing the experimental mixtures the conditions obtaining in practical spraying operations were followed as closely as possible. Thus, the materials used were market products of standard grades, and the proportions in which they were mixed, and the method of mixing, are fairly representative of field practice. It will be seen that the period of agitation was one hour, which is about the maximum time required to apply a two hundred gallon tank of spray mixture, using one gun or two rods. With many outfits much less time than this would be required so that this agitation period is probably nearer the maximum than the minimum for the average spray rig.

FORMULA

The complete formula used and its equivalent in actual spraying practice are as follows:

	Experimental Mixture	Corresponding Field Practice
(1) Arsenate of lead (acid)	2.4 grams	4.0 pounds
(2) Nicotine sulphate	0.6 cc	0.96 pint
(3) Casein-lime	0.55 grams	0.917 pounds
(4) Lime-sulphur	14.5 cc	2.6 gallons
(5) Water (distilled), to make	500.0 cc	100.0 gallons

PREPARATION OF EXPERIMENTAL MIXTURES

In mixing the ingredients, whatever the number chosen, the final volume was brought to 500 cc and the manipulation was uniformly as follows:

Place about 485 cc of water in a 500 cc graduated shaking flask. Add the ingredients separately, in the amounts indicated by the formula, shaking by hand for two minutes after each addition. Stopper the flask securely, place in a shaking machine of the revolving type and agitate the mixture for one hour. Remove the flask from the shaking device and allow the mixture to stand for one hour. Filter on a 9 cm filter paper using a Buchner funnel with gentle suction, transferring as much of the insoluble material as possible to the filter. Do not rinse the flask or wash the residue upon the filter. Transfer the yellow filtrate (A), to a suitable flask, stopper, and hold for analysis.

Return the filter with the insoluble residue to the original graduated shaking flask and wash into the flask also any of the insoluble residue which may have adhered to the funnel. Fill the flask to the 500 cc mark, stopper securely, place in the shaking machine and agitate the contents for one hour. Remove the flask from the shaking device and allow to stand for one hour, after which filter through a large filter. Do not wash the residue. Reserve the filtrate, solution (B), for analysis.

EXAMINATION OF MIXTURES

The various experimental mixtures were examined with reference to certain physical characteristics and to chemical composition, the latter being confined to determinations of total sulphur in the lime-sulphur solution (filtrate A), and of total arsenic, as arsenic pentoxide (As_2O_5), both in filtrate A and filtrate B. The results obtained for total sulphur are of interest as an index to the extent of chemical change which has taken place in the mixture so far, at least, as the sulphur originally present has been converted into insoluble forms. Foliage injury, in part, results from excessive amounts of soluble arsenic in the lime-sulphur solution; and it seems not improbable that the insoluble arsenic-containing residue which is deposited upon foliage in the process of spraying might become, upon exposure to weather conditions, a potential source of further injury. For this reason the water-soluble arsenic in the insoluble residue was determined.

METHODS OF ANALYSIS

The determination of the small amounts of soluble arsenic involved in preparations made on the scale of these laboratory mixtures presented some difficulty. After some preliminary trials, the method used by Bradley[2] and by others whereby sulphur is oxidized by means of hydrogen peroxide and arsenic finally titrated with dilute iodine solution appeared to be promising. The results, however, were not satisfactory and the method is objectionable chiefly for the following reasons: it requires large quantities of a relatively expensive reagent (hydrogen peroxide); the evaporation of a large volume of liquid is time consuming; the filtration of the large amount of sediment which forms during the evaporation, and the necessary washing, introduce potential errors; and finally, the iodine titration does not give a sharply defined end point.

About this time Cox[5] published a critical review of certain methods for the determination of small quantities of arsenic, citing particularly the methods of Bang and Ramberg, his experience favoring the last named. As pointed out by Cox, neither method involves any new principle, but, on trial, the Ramberg method was found to be adaptable to our problem. Briefly, the procedure consists in oxidizing the sulphur and destroying organic matter by digestion with nitric and sulphuric acids, removing the excess of nitric acid by means of ammonium oxalate, distilling with hydrochloric acid and titrating the arsenic with potassium bromate solution, using methyl orange (1 : 5000) as as indicator.

The digestion was conducted in a long-neck Kjeldahl flask made to fit a condensing tube with a ground glass joint; thus the digestion and distillation were both made without a transfer of material. Arsenic-free reagents, tested by means of suitable blanks, were used throughout. The standard potassium bromate solution was prepared of such strength that 1 cc was equivalent to 0.0005 gm. of arsenic pentoxide (As_2O_5).

The procedure in detail as used by us is as follows:

Arsenic in lime-sulphur solution (*Solution A*). Transfer 100 cc of the solution to the digestion-distillation flask, add a few glass beads, 50 cc of concentrated nitric acid and evaporate over a low flame until the volume is reduced to about 25 cc. Cool, add 25 cc of concentrated sulphuric acid and heat until fumes of sulphuric acid appear. From a suitable dropping device add 50 cc of concentrated nitric acid dropwise, meanwhile boiling the solution very gently. Continue the boiling until sulphuric acid fumes appear. Cool, add 25 cc of saturated ammonium oxalate solution and again boil until fumes of sulphuric acid are noticed. Cool, rinse the neck of the flask with 20 cc of water and then add 2 grams of ferrous sulphate, 50 cc of concentrated hydrochloric acid and 0.1 gram of potassium bromide. (If any yellow or brown color appears at this point nitrogen acids are present and the experiment must be rejected.) Connect the flask with the condensing tube, adjust a receiving flask containing 150 cc of water, and allow the condenser to dip about 1 cm. below the surface of the liquid therein. Distill at such a rate that 20 to 25 cc of distillate are obtained in about 10 minutes. Heat the distillate to 50° C., add three drops of methyl orange and titrate at once with standard potassium bromate solution, adding this reagent very slowly as the end point is approached. The end point is reached when the red color of the indicator is discharged. Each cc of potassium bromate used corresponds to 0.0005 gram of As_2O_5.

Arsenic in Solution B. Transfer 50 cc of the solution to the digestion-distillation flask, add 50 cc of concentrated nitric acid and evaporate over a low flame until the volume is reduced to about 25 cc. Cool, add 25 cc of concentrated sulphuric acid and boil until sulphuric acid fumes appear. Cool, add 10 cc of concentrated nitric acid and again heat until fumes of sulphuric acid are noted. Cool, add 25 cc of saturated ammonium oxalate solution and from this point proceed as directed in the previous paragraph.

Total sulphur in Solution A. Total sulphur was determined substantially according to the official procedure[1] except that oxidation of sulphur was effected by means of hydrogen peroxide in alkaline solution as allowed by a former optional method.[13]

Transfer 10 cc of solution A to a 250 cc beaker containing 10 cc of a 10 per cent solution of sodium hydroxide, 50 cc of water and 50 cc of hydrogen peroxide. Cover the beaker with a watch glass and heat for one hour on a steam bath. Cool, acidify with dilute hydrochloric acid (1 to 1), and precipitate the sulphur as barium sulphate. Calculate the percentage of sulphur from the weight of barium sulphate, using the factor 0.1374.

PRELIMINARY EXPERIMENTS

The adaptability of the method for the determination of arsenic as described may be illustrated by the following experiments. Blanks on the reagents, in the amounts used in the method, showed titerable substances equivalent to 0.3 cc of standard potassium bromate and this correction was uniformly made in all determinations.

Material	Arsenic, as As_2O_5 Present gm.	Added gm.	Total gm.	Recovered gm.
100 cc water+1 gm. sugar	......	0.01160	0.01160	0.01160
100 cc water+1 gm. sugar	......	0.01160	0.01160	0.01160
Lime-sulphur-Lead arsenate	0.00613	0.01160	0.01773	0.01775
		0.01160	0.01773	0.01773

INTERPRETATION OF RESULTS

In the analytical data herein reported total sulphur is expressed in terms of grams per 100 cc of the lime-sulphur solution. Arsenic is expressed in percentages of As_2O_5 based on the amount of lead arsenate, 2.4 grams, present in the mixture.

In the tables also abbreviations are necessary and the following are used: L.A. = Lead arsenate; L.S. = Lime-sulphur; N. S. = Nicotine sulphate; C.L. = Casein-Lime; L. = Lime; Blk. = Black; G. = Grey; G.B. = Greyish-black.

TABLE 1. EFFECT OF COMBINING LIME-SULPHUR WITH LEAD ARSENATE

Exp. No.	Order of Mixing 1	2	3	4	Physical Characteristics: Color of finished mixture	Color of sediment	Filtered solution	Arsenic, As_2O_5, per cent. Based on amount of lead arsenate used: In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur In Lime-Sulphur solution gm/100 cc
A-1	L. A.	....	....	....	....	....	....	....	0.05	0.05	....
A-2	L. S.	....	....	....	....	....	....	....	....	....	.923
B-1	L. A.	L. S.	....	....	....	....	....	0.98	5.48	6.46	.907
B-2	L. S.	L. A.	....	....	....	....	....	1.49	5.72	7.21	.890

TABLE 2. EFFECT OF ADDING LIME-SULPHUR TO LEAD ARSENATE AND NICOTINE SULPHATE ALREADY IN COMBINATION AND OF COMBINING IT WITH THESE INGREDIENTS IN OTHER WAYS

Exp. No.	Order of Mixing 1	2	3	4	Color of finished mixture	Color of sediment	Filtered solution	In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur In Lime-Sulphur solution gm/100 cc
B-3	L. A.	N. S.	....	....	....	....	....	....	0.06	0.06	....
B-4	N. S.	L. A.	....	....	....	....	....	....	0.03	0.03	....
C-2	L. A.	N. S.	L. S.	....	Light	G. B.	Clear	1.03	4.20	5.23	.890
C-1	L. A.	L. S.	N. S.	....	Light	Blk.	Clear	1.74	0.52	2.26	.604
C-3	L. S.	L. A.	N. S.	....	Light	Blk.	Clear	1.28	0.30	1.58	.611
C-4	L. S.	N. S.	L. A.	....	Light	G. B.	Clear	1.77	4.63	6.40	.820
C-5	N. S.	L. S.	L. A.	....	Light	G. B.	Clear	1.06	4.40	5.46	.884
C-6	N. S.	L. A.	L. S.	....	Light	G. B.	Clear	1.06	3.78	4.84	.873

TABLE 3. EFFECT OF ADDING LIME-SULPHUR TO LEAD ARSENATE, NICOTINE SULPHATE AND CASEIN-LIME ALREADY IN COMBINATION, AND OF COMBINING IT WITH THESE INGREDIENTS IN OTHER WAYS

Exp. No.	Order of Mixing 1	2	3	4	Physical Characteristics: Color of finished mixture	Color of sediment	Filtered solution	Arsenic, As_2O_5, per cent. Based on amount of lead arsenate used: In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur In Lime-Sulphur solution gm/100 cc
C-14	L. A.	N. S.	C. L.	....	....	....	Turbid	0.20	0.48	0.68	....
1	L. A.	N. S.	C. L.	L. S.	Light	G. B.	Clear	0.40	2.55	2.95	.930
12	L. S.	L. A.	N. S.	C. L.	Light	Blk.	Clear	0.90	0.41	1.31	.678
C-13	L. A.	C. L.	N. S.	....	....	....	Turbid	0.30	0.60	0.90	....
2	L. A.	C. L.	N. S.	L. S.	Dark	G. B.	Clear	0.47	2.83	3.30	.925
9	L. S.	L. A.	C. L.	N. S.	Light	G. B.	Turbid	0.47	0.98	1.45	.907
C-15	C. L.	L. A.	N. S.	....	....	....	Turbid	0.31	0.56	0.87	....
8	C. L.	L. A.	N. S.	L. S.	Dark	G. B.	Clear	0.60	2.65	3.25	.916
15	L. S.	C. L.	L. A.	N. S.	Dark	G. B.	Turbid	0.55	1.35	1.90	.912
C-16	N. S.	L. A.	C. L.	....	....	....	Turbid	0.23	0.40	0.63	....
7	N. S.	L. A.	C. L.	L. S.	Light	G. B.	Clear	0.39	2.55	2.94	.919
16	L. S.	N. S.	L. A.	C. L.	Light	Dark	Clear	0.65	2.40	3.05	.838
C-17	N. S.	C. L.	L. A.	....	....	....	Turbid	0.25	0.94	1.19	....
17	N. S.	C. L.	L. A.	L. S.	Light	G. B.	Clear	0.41	2.56	2.97	.906
23	L. S.	N. S.	C. L.	L. A.	Light	G. B.	Turbid	0.39	1.40	1.79	.907
C-18	C. L.	N. S.	L. A.	....	....	....	Clear	0.30	1.20	1.50	....
14	C. L.	N. S.	L. A.	L. S.	Dark	G. B.	Turbid	0.33	2.77	3.10	.920
21	L. S.	C. L.	N. S.	L. A.	Dark	G. B.	Clear	0.48	1.71	2.19	.916

Discussion

Effect of Adding Lime-Sulphur to Different Ingredients Separately and Combined (Tables 1 to 3)

It will be seen that addition of lime-sulphur to lead arsenate brings about a tremendous increase in soluble arsenic,—nearly 136 times the original content of the lead arsenate alone. When lime-sulphur is added to nicotine sulphate and lead arsenate in combination there is likewise a great increase,—34 to 140 times, while in the complete quadruple combination the increase is not so great, due probably to addition of casein-lime in the mixture. It is thus evident that there is an important reaction between lime-sulphur and lead arsenate, but that this is not increased by nicotine sulphate, and is lessened when casein-lime is added.

Table 4. Effect of Combining Nicotine Sulphate with Lead Arsenate and Lime-Sulphur

Exp. No.	Order of Mixing 1	2	3	4	Physical Characteristics: Color of finished mixture	Color of sediment	Filtered solution	Arsenic, As_2O_5, per cent. Based on amount of lead arsenate used: In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur In Lime-Sulphur solution gm/100 cc
A-1	L. A.	....	....	....	....	....	....	....	0.05	0.05	....
B-3	L. A.	N. S.	....	....	....	....	....	....	0.06	0.06	....
B-4	N. S.	L. A.	....	....	....	....	....	....	0.03	0.03	....
A-2	L. S.	....	....	....	....	....	....	....	....	....	.923
B-7	L. S.	N. S.	....	....	....	....	....	....	....	....	.933
B-8	N. S.	L. S.	....	....	....	....	....	....	....	....	.928
Table 5. Effect of Adding Nicotine Sulphate to Lime-Sulphur and Casein-Lime Already in Combination and of Combining It with These Ingredients in Other Ways											
B-9	L. S.	C. L.	....	....	....	....	....	....	....	....	.916
B-10	C. L.	L. S.	....	....	Light	....	....	....	....	....	.905
C-20	L. S.	C. L.	N. S.	....	....	....	....	....	....	....	.930
C-22	C. L.	L. S.	N. S.	....	....	....	....	....	....	....	.936
Table 6. Effect of Adding Nicotine Sulphate to Lead Arsenate and Casein-Lime Already in Combination and of Combining It with These Ingredients in Other Ways											
B-5	L. A.	C. L.	....	....	....	....	....	....	0.28	0.28	....
B-6	C. L.	L. A.	....	....	....	....	....	....	0.28	0.28	....
C-13	L. A.	C. L.	N. S.	....	....	....	....	0.30*	0.60	0.90	....
C-15	C. L.	L. A.	N. S.	....	....	....	....	0.31*	0.56	0.87	....

* Soluble in water.

TABLE 7. EFFECT OF ADDING NICOTINE SULPHATE TO LEAD ARSENATE AND LIME-SULPHUR ALREADY IN COMBINATION AND OF COMBINING IT WITH THESE INGREDIENTS IN OTHER WAYS

Exp. No.	Order of Mixing 1	2	3	4	Physical Characteristics: Color of finished mixture	Color of sediment	Filtered solution	Arsenic, As_2O_5, per cent. Based on amount of lead arsenate used: In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur In Lime-Sulphur solution gm/100 cc
B-1	L. A.	L. S.	....	....	Light	G. B.	Clear	0.98	5.48	6.46	.907
B-2	L. S.	L. A.	....	....	Light	G. B.	Clear	1.49	5.72	7.21	.890
C-1	L. A.	L. S.	N. S.	....	Light	Blk.	Clear	1.74	0.52	2.26	.604
C-3	L. S.	L. A.	N. S.	....	Light	Blk.	Clear	1.28	0.30	1.58	.611
C-5	N. S.	L. S.	L. A.	....	Light	G. B.	Clear	1.06	4.40	5.46	.884
C-6	N. S.	L. A.	L. S.	....	Light	G. B.	Clear	1.06	3.78	4.84	.873
C-4	L. S.	N. S.	L. A.	....	Light	G. B.	Clear	1.77	4.63	6.40	.820
C-2	L. A.	N. S.	L. S.	....	Light	G. B.	Clear	1.03	4.20	5.23	.890
TABLE 8. EFFECT OF ADDING NICOTINE SULPHATE TO LEAD ARSENATE, CASEIN-LIME AND LIME-SULPHUR ALREADY IN COMBINATION AND OF COMBINING IT WITH THESE INGREDIENTS IN OTHER WAYS											
C-7	L. A.	C. L.	L. S.	....	Light	G. B.	Turbid	0.41	2.58	2.99	.915
6	L. A.	C. L.	L. S.	N. S.	Dark	G. B.	Turbid	0.50	2.33	2.83	.916
7	N. S.	L. A.	C. L.	L. S.	Light	G. B.	Clear	0.39	2.55	2.94	.919
C-8	L. A.	L. S.	C. L.	....	Light	G. B.	Turbid	0.35	1.56	1.91	.916
3	L. A.	L. S.	C. L.	N. S.	Light	G. B.	Turbid	0.43	1.19	1.62	.915
10	N. S.	L. A.	L. S.	C. L.	Light	G. B.	Turbid	0.29	1.33	1.62	.912
C-9	C. L.	L. A.	L. S.	....	Dark	L. G.	Clear	0.40	2.56	2.96	.928
11	C. L.	L. A.	L. S.	N. S.	Dark	G. B.	Clear	0.69	2.60	3.29	.918
17	N. S.	C. L.	L. A.	L. S.	Light	G. B.	Clear	0.41	2.56	2.97	.906
C-10	L. S.	L. A.	C. L.	....	Light	G. B.	Turbid	0.40	1.93	2.33	.920
9	L. S.	L. A.	C. L.	N. S.	Light	G. B.	Turbid	0.47	0.98	1.45	.907
13	N. S.	L. S.	L. A.	C. L.	Light	Blk.	Clear	0.55	2.31	2.86	.800
C-11	L. S.	C. L.	L. A.	....	Light	G. B.	Turbid	0.46	1.91	2.37	.920
15	L. S.	C. L.	L. A.	N. S.	Dark	G. B.	Turbid	0.55	1.35	1.90	.912
19	N. S.	L. S.	C. L.	L. A.	Light	G. B.	Turbid	0.40	1.06	1.46	.907
C-12	C. L.	L. S.	L. A.	....	Light	G. B.	Turbid	0.45	2.52	2.97	.922
18	C. L.	L. S.	L. A.	N. S.	Dark	G. B.	Turbid	0.50	2.80	3.30	.922
24	N. S.	C. L.	L. S.	L. A.	Dark	G. B.	Clear	0.48	2.73	3.21	.916

EFFECT OF ADDING NICOTINE SULPHATE TO DIFFERENT INGREDIENTS SEPARATELY AND COMBINED

(TABLES 4 TO 8)

A study of Tables 4 to 8 shows that there is a negligible action when nicotine sulphate and lime-sulphur are mixed together as regards total sulphur in solution. There is likewise little or no action when nicotine sulphate and lead arsenate are mixed together. When nicotine sulphate is added to lime-sulphur and casein-lime in combination, not so much sulphur is precipitated from the solution although the difference is small and of doubtful importance. When added to lead arsenate and casein-lime there is a distinct increase in soluble arsenic and when nicotine sulphate is added to lead arsenate and lime-sulphur in combination there is a decrease in soluble arsenic, and also a decrease in the amount of sulphur in solution. Added to triple combinations as in Table 8, there are variable results. The sulphur content of the filtrate is only slightly altered and the soluble arsenic is decreased in 8 cases but increased in 4.

TABLE 9. EFFECT OF COMBINING CASEIN-LIME WITH LEAD ARSENATE AND LIME-SULPHUR

Exp. No.	Order of Mixing 1	2	3	4	Physical Characteristics: Color of finished mixture	Color of sediment	Filtered solution	Arsenic, As_2O_5, per cent. Based on amount of lead arsenate used: In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur In Lime-Sulphur solution gm/100 cc
A-1	L. A.	....	....	....	....	....	....	....	0.05	0.05	....
B-5	L. A.	C. L.	....	....	....	....	....	....	0.28	0.28	....
B-6	C. L.	L. A.	....	....	....	....	....	....	0.28	0.28	....
A-2	L. S.	....	....	....	....	....	....	....	....	....	.923
B-9	L. S.	C. L.	....	....	....	....	....	....	....	....	.916
B-10	C. L.	L. S.	....	....	Light	....	....	....	....	....	.905

TABLE 10. EFFECT OF ADDING CASEIN-LIME TO LEAD ARSENATE AND LIME-SULPHUR ALREADY IN COMBINATION AND OF COMBINING IT WITH THESE INGREDIENTS IN OTHER WAYS

Exp. No.	1	2	3	4	Color of finished mixture	Color of sediment	Filtered solution	In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur gm/100 cc
B-1	L. A.	L. S.	....	....	Light	G. B.	Clear	0.98	5.48	6.46	.907
B-2	L. S.	L. A.	....	....	Light	G. B.	Clear	1.49	5.72	7.21	.890
C-8	L. A.	L. S.	C. L.	....	Light	G. B.	Turbid	0.35	1.56	1.91	.916
C-10	L. S.	L. A.	C. L.	....	Light	G. B.	Turbid	0.40	1.93	2.33	.920
C-7	L. A.	C. L.	L. S.	....	Light	G. B.	Turbid	0.41	2.58	2.99	.915
C-9	C. L.	L. A.	L. S.	....	Dark	L. G.	Clear	0.40	2.56	2.96	.928
C-11	L. S.	C. L.	L. A.	....	Light	G. B.	Turbid	0.46	1.91	2.37	.920
C-12	C. L.	L. S.	L. A.	....	Light	G. B.	Turbid	0.45	2.52	2.97	.922

TABLE 11. EFFECT OF ADDING CASEIN-LIME TO LEAD ARSENATE AND NICOTINE SULPHATE ALREADY IN COMBINATION AND OF COMBINING IT WITH THESE INGREDIENTS IN OTHER WAYS

Exp. No.	1	2	3	4	Color of finished mixture	Color of sediment	Filtered solution	In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur gm/100 cc
B-3	L. A.	N. S.	....	....	....	....	....	....	0.06	0.06	....
B-4	N. S.	L. A.	....	....	....	....	....	....	0.03	0.03	....
C-14	L. A.	N. S.	C. L.	....	....	....	Turbid	0.20	0.48	0.68	....
C-16	N. S.	L. A.	C. L.	....	Clear	....	Turbid	0.23	0.40	0.63	....
C-13	L. A.	C. L.	N. S.	....	Clear	....	Turbid	0.30	0.60	0.90	....
C-15	C. L.	L. A.	N. S.	....	Clear	....	Turbid	0.31	0.56	0.87	....
C-17	N. S.	C. L.	L. A.	....	Clear	....	Turbid	0.25	0.94	1.19	....
C-18	C. L.	N. S.	L. A.	....	Clear	....	Clear	0.30	1.20	1.50	....

TABLE 12. EFFECT OF ADDING CASEIN-LIME TO LIME-SULPHUR AND NICOTINE SULPHATE IN COMBINATION AND OF COMBINING IT WITH THESE INGREDIENTS IN OTHER WAYS

Exp. No.	Order of Mixing 1	2	3	4	Physical Characteristics: Color of finished mixture	Color of sediment	Filtered solution	Arsenic, As_2O_5, per cent. Based on amount of lead arsenate used: In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur In Lime-Sulphur solution gm/100 cc
B-7	L. S.	N. S.	....	....	....	....	....	....	....	....	.933
B-8	N. S.	L. S.	....	....	....	....	....	....	....	....	.928
C-19	L. S.	N. S.	C. L.	....	Dark	....	....	....	....	....	.925
C-21	N. S.	L. S.	C. L.	....	Dark	....	....	....	....	....	.930
C-20	L. S.	C. L.	N. S.	....	....	....	....	....	....	....	.930
C-22	C. L.	L. S.	N. S.	....	....	....	....	....	....	....	.936
C-23	N. S.	C. L.	L. S.	....	....	....	....	....	....	....	.934
C-24	C. L.	N. S.	L. S.	....	....	....	....	....	....	....	.935

TABLE 13. EFFECT OF ADDING CASEIN-LIME TO LEAD ARSENATE, NICOTINE SULPHATE AND LIME-SULPHUR IN COMBINATION AND OF COMBINING IT WITH THESE INGREDIENTS IN OTHER WAYS

Exp. No.	1	2	3	4	Color of finished mixture	Color of sediment	Filtered solution	In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur gm/100 cc
C-1	L. A.	L. S.	N. S.	....	Light	Blk.	Clear	1.74	0.52	2.26	.604
4	L. A.	L. S.	N. S.	C. L.	Light	Blk.	Turbid	0.71	1.62	2.33	.827
11	C. L.	L. A.	L. S.	N. S.	Dark	G. B.	Clear	0.69	2.60	3.29	.918
C-2	L. A.	N. S.	L. S.	....	Light	G. B.	Clear	1.03	4.20	5.23	.890
5	L. A.	N. S.	L. S.	C. L.	Light	Blk.	Clear	0.81	0.29	1.10	.716
8	C. L.	L. A.	N. S.	L. S.	Dark	G. B.	Clear	0.60	2.65	3.25	.916
C-3	L. S.	L. A.	N. S.	....	Light	Blk.	Clear	1.28	0.30	1.58	.611
12	L. S.	L. A.	N. S.	C. L.	Light	Blk.	Clear	0.90	0.41	1.31	.678
18	C. L.	L. S.	L. A.	N. S.	Dark	G. B.	Turbid	0.50	2.80	3.30	.922
C-4	L. S.	N. S.	L. A.	....	Light	G. B.	Clear	1.77	4.63	6.40	.820
16	L. S.	N. S.	L. A.	C. L.	Light	Dark	Clear	0.65	2.40	3.05	.838
20	C. L.	L. S.	N. S.	L. A.	Dark	G. B.	Clear	0.50	2.69	3.19	.906
C-5	N. S.	L. S.	L. A.	....	Light	G. B.	Clear	1.06	4.40	5.46	.884
13	N. S.	L. S.	L. A.	C. L.	Light	Blk.	Clear	0.55	2.31	2.86	.800
22	C. L.	N. S.	L. S.	L. A.	Dark	G. B.	Clear	0.41	2.54	2.95	.913
C-6	N. S.	L. A.	L. S.	....	Light	G. B.	Clear	1.06	3.78	4.84	.873
10	N. S.	L. A.	L. S.	C. L.	Light	G. B.	Turbid	0.29	1.33	1.62	.912
14	C. L.	N. S.	L. A.	L. S.	Dark	G. B.	Turbid	0.33	2.77	3.10	.920

Effect of Adding Casein-Lime to Different Ingredients Separately and Combined

(Tables 9 to 13)

It will be seen from Table 9 that the addition of casein-lime increased the soluble arsenic and reduced the sulphur when mixed with lead arsenate and lime-sulphur alone. When added to lead arsenate and lime-sulphur in combination, the amount of soluble arsenic is greatly reduced and the sulphur in solution is increased. When added to nicotine sulphate and lead arsenate in combination the soluble arsenic is distinctly increased, but when added to lime-sulphur and nicotine sulphate the sulphur content of the solution is not greatly altered. In quadruple mixtures, Table 13, there seems to be, in general, an increase of sulphur in solution where casein-lime is used over mixtures where this material is omitted; and, in general, the soluble arsenic is reduced, but it may sometimes be increased.

Effect of Replacing Casein-Lime with Pure Lime (Table 14)

In order to find out whether the casein or lime of the casein-lime mixture was responsible for the results noted in Tables 9 to 13, a quantity of pure lime (CaO), equivalent to the amount used in the casein-lime, was substituted (D1). This amount was then doubled (D2). It will be seen that the amount of soluble arsenic is decreased as much or more by lime alone as by casein-lime (Exp. No. 2); also that the amount of sulphur in solution is not greatly reduced by the additional lime.

Effect of Different Orders of Mixing on Quadruple Mixtures (Table 15)

It is easily demonstrated that different orders of mixing produce differently colored mixtures, but to determine if possible the value of this criterion for judging spray mixtures Table 15 was prepared. It will be seen that some of the mixtures are dark in color while others are light. It was noted in the course of the work that some of the blackness of the resulting spray was due to the mixture of lime-sulphur and nicotine sulphate as well as the formation of lead sulphide as noted by others. The actual color of the sediment does not vary greatly, but there is a considerable variation in the turbidity of the filtrate, certain ones remaining clear, while others produce a decided murkiness. The turbid filtrates were tested by chemical means and found to be due to a very finely divided sulphur and not to lead, calcium or

Table 14. Effect of Replacing Casein-Lime with Pure Lime, Equal in Amount and Double the Original Content of the Casein-Lime

Exp. No.	Order of Mixing 1	2	3	4	Physical Characteristics: Color of finished mixture	Color of sediment	Filtered solution	Arsenic, As_2O_5, per cent. Based on amount of lead arsenate used: In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur In Lime-Sulphur solution gm/100 cc
C-2	L. A.	N. S.	L. S.	....	Light	G. B.	Clear	1.03	4.20	5.24	.890
D-1	L. A.	L.*	N. S.	L. S.	Light	G.	Clear	0.31	1.21	1.52	.921
D-2	L. A.	L.**	N. S.	L. S.	Light	G.	Clear	0.25	0.27	0.52	.915
2	L. A.	C. L.	N. S.	L. S.	Dark	G. B.	Clear	0.47	2.83	3.30	.925

*0.3 gm.
**0.6 gm.

Table 15. Effect of Different Orders of Mixing on Quadruple Mixtures

Exp. No.	Order of Mixing 1	2	3	4	Color of finished mixture	Color of sediment	Filtered solution	In L.-S. solution %	Water-soluble in sediment %	Total soluble %	Total Sulphur gm/100 cc
1	L. A.	N. S.	C. L.	L. S.	Light	G. B.	Clear	0.40	2.55	2.95	.930
2	L. A.	C. L.	N. S.	L. S.	Dark	G. B.	Clear	0.47	2.83	3.30	.925
3	L. A.	L. S.	C. L.	N. S.	Light	G. B.	Turbid	0.43	1.19	1.62	.915
4	L. A.	L. S.	N. S.	C. L.	Light	Blk.	Turbid	0.71	1.62	2.33	.827
5	L. A.	N. S.	L. S.	C. L.	Light	Blk.	Clear	0.81	0.29	1.10	.716
6	L. A.	C. L.	L. S.	N. S.	Dark	G. B.	Turbid	0.50	2.33	2.83	.916
7	N. S.	L. A.	C. L.	L. S.	Light	G. B.	Clear	0.39	2.55	2.94	.919
8	C. L.	L. A.	N. S.	L. S.	Dark	G. B.	Clear	0.60	2.65	3.25	.916
9	L. S.	L. A.	C. L.	N. S.	Light	G. B.	Turbid	0.47	0.98	1.45	.907
10	N. S.	L. A.	L. S.	C. L.	Light	G. B.	Turbid	0.29	1.33	1.62	.912
11	C. L.	L. A.	L. S.	N. S.	Dark	G. B.	Clear	0.69	2.60	3.29	.918
12	L. S.	L. A.	N. S.	C. L.	Light	Blk.	Clear	0.90	0.41	1.31	.678
13	N. S.	L. S.	L. A.	C. L.	Light	Blk.	Clear	0.55	2.31	2.86	.800
14	C. L.	N. S.	L. A.	L. S.	Dark	G. B.	Turbid	0.33	2.77	3.10	.920
15	L. S.	C. L.	L. A.	N. S.	Dark	G. B.	Turbid	0.55	1.35	1.90	.912
16	L. S.	N. S.	L. A.	C. L.	Light	Blk.	Clear	0.65	2.40	3.05	.838
17	N. S.	C. L.	L. A.	L. S.	Light	G. B.	Clear	0.41	2.56	2.97	.906
18	C. L.	L. S.	L. A.	N. S.	Dark	G. B.	Turbid	0.50	2.80	3.30	.922
19	N. S.	L. S.	C. L.	L. A.	Light	G. B.	Turbid	0.40	1.06	1.46	.907
20	C. L.	L. S.	N. S.	L. A.	Dark	G. B.	Clear	0.50	2.69	3.19	.906
21	L. S.	C. L.	N. S.	L. A.	Dark	G. B.	Clear	0.48	1.71	2.19	.916
22	C. L.	N. S.	L. S.	L. A.	Dark	G. B.	Clear	0.41	2.54	2.95	.913
23	L. S.	N. S.	C. L.	L. A.	Light	G. B.	Turbid	0.39	1.40	1.79	.907
24	N. S.	C. L.	L. S.	L. A.	Dark	G. B.	Clear	0.48	2.73	3.21	.916

nicotine. This fact is of some significance in spraying practices since it has been demonstrated that colloidal sulphurs are important fungicides.[28] Whether such combinations as these, however, contain enough colloidal sulphur to affect the efficiency of the spray has not been determined.

It will be noted that combinations showing the lowest arsenic in solution (Nos. 5 and 12) are both extremely low in soluble sulphur and that both filtrates are clear. It would probably not be wise to select merely on the basis of soluble arsenic and sulphur content alone, although we know from the work of Saffro[19] that spray injury may be caused by calcium polysulphides and to a less extent by calcium thiosulphate (p. 32). An attempt to avoid spray injury would, therefore, include selection of mixtures low in sulphur and arsenic in solution, but these would probably be reduced in fungicidal action since the filtrates are clear and the total sulphur, supposedly the active forms, is reduced 25% or more (Nos. 5 and 12). It is important to note that in all cases the greater part of the soluble arsenic is found in the residue which emphasizes the necessity of cleaning the spray tank frequently, in order to avoid accumulation of sludge from previous tanks, and the importance of ample agitation to avoid this difficulty.

General Conclusions

(1) The Bramberg method of determining small amounts of arsenic has been found adaptable to the determination of soluble arsenic in spray mixtures.

(2) *Lime-sulphur* reacts strongly with lead arsenate* giving increased soluble arsenic and decreased sulphur in solution. It reacts similarly with lead arsenate and nicotine sulphate in combination and with lead arsenate and casein-lime but the reaction is not as great in the latter case.

(3) *Nicotine sulphate* does not react with lead arsenate or with lime-sulphur so far as indicated by the chemical data; a color change is noted, the significance of which is not explained. When added to lead arsenate and casein-lime together the soluble arsenic is increased; added to lead arsenate and lime-sulphur together there is a marked decrease in soluble arsenic and also a decrease in the amount of sulphur in solution. When added to triple combinations of lead arsenate, casein-lime and lime-sulphur, variable results are noted.

(4) *Casein-lime* increases the soluble arsenic content of lead arsenate when mixed with it alone. When mixed with lime-sulphur alone the amount of sulphur in solution is somewhat reduced. When added to nicotine sulphate and lead arsenate the soluble arsenic is distinctly increased, but when added to lime-sulphur and nicotine sulphate the sulphur content of the solution is not greatly altered. In quadruple mixtures there is, in general, an increase of sulphur in solution due to the casein-lime and there is in general a decrease in soluble arsenic. The latter, however, may sometimes be increased.

(5) The lime in casein-lime is largely responsible for the decrease in soluble arsenic where this material is used.

(6) Different orders of mixing quadruple mixtures give different results, but so many factors are involved and the variations are so small that the selection of improved mixtures seems an impossibility.

(7) Colloidal sulphur is sometimes formed in the spray mixtures.

(8) The color of the resulting mixture is not a satisfactory means of judging a spray solution.

* Acid lead arsenate is implied wherever lead arsenate is mentioned.

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The Genetics and Morphology of Some Endosperm Characters in Maize

P. C. MANGELSDORF

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

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PART III

PART IV

The Genetics and Morphology of Some Endosperm Characters in Maize*

P. C. MANGELSDORF

INTRODUCTION

When Nawaschin in 1898 discovered the phenomenon of double fertilization in *Lilium* it was generally believed by botanists that such a peculiar mechanism was confined to this species and perhaps a few closely related ones. Later investigations have shown that it is widely distributed and that the endosperm of angiosperms, with perhaps a few exceptions, is the product of a sexual fusion, quite apart from that which gives rise to the embryo, and differing from the latter in that one male nucleus combines with two or more female nuclei, while the embryo results from a fusion in which both parents contribute equally.

Thus the endosperm of angiosperms is unique in several respects. It resembles its near relative, the embryo, in its sexual origin, but differs from the latter in structure, in capacity for continued development, and in ability to reproduce.

This unique sporophyte, if indeed, it may be called a sporophyte, achieves its highest development in the cereals, in which it constitutes the part which makes these plants of such great economic importance, and in which it gives evidence of its sexual origin by the expression of the hereditary factors which it receives from its two parents.

Mendelian characters which have their expression in the endosperm have been found in wheat, rye, barley, rice and maize. They are apparently most numerous in maize and a number of characters which affect the color of the endosperm or aleurone layer and the texture of the endosperm tissue of this species have long been familiar, and have played an important part in the researches leading up to the re-discovery of Mendel's Law

* Parts I-IV of a thesis submitted to the Faculty of the Bussey Institution of Harvard University in partial fulfillment of the requirements for the degree of Doctor of Science, June, 1925. Part V, on "Genetic Factors Which Affect the Development of the Gametophyte and Their Relation to Some Endosperm Characters," has been combined with researches by Dr. D. F. Jones on the same subject and will appear in Genetics, Vol. XI, under the title "The Expression of Mendelian Factors in the Gametophyte of Maize."

in 1900 and in the accumulation of a vast amount of genetic evidence since its re-discovery.

The endosperm characters of maize are of unusual value to the geneticist because, like all endosperm characters, they are visible sooner than those which affect other parts of the plant, and because they are readily studied in large numbers without the necessity of devoting a great amount of land or labor to the purpose. The average ear of maize bears from several hundred to a thousand seeds and one pollination on a single plant produces a large population which is readily classified because the environment has been remarkably alike for all its members.

In recent years the widespread application of a new method of corn improvement which involves the extensive inbreeding of this crop by artificial self-pollination, has brought to light many new characters which influence the development of the endosperm. Because of their possible phylogenetic significance, and because they represent new material which may prove of value in charting the germplasm of this important species, these characters merit a thorough study. The following pages are devoted to the preliminary investigations of a number of these new characters, their breeding behavior, morphology, effect upon development, and their relation to each other and to other characters.

DEFINITIONS

Two terms are used so frequently throughout the pages which follow that they deserve to be defined and limited.

The *endosperm generation* is the period beginning with fertilization and ending with the disappearance of the endosperm through absorption or digestion. In the cereals, the endosperm persists until the germination of the seed but in some plants it is almost completely lost in the early stages of development. This period has also been termed the *xenia* generation by some writers. In crosses the F_2 endosperm generation is borne on F_1 plants.

An *endosperm character* is any character which has its expression in the endosperm generation. The term does not imply that the character in question affects only the endosperm, in fact some of the endosperm characters produce their major effect upon the embryo.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to Dr. E. M. East, under whose supervision this investigation was made and these pages written, for his helpful advice and kindly criticism. A word of appreciation is due the Connecticut Agricultural Experiment Station for an arrangement enabling the writer to complete these studies while a member of its staff, and particularly to Dr. D. F.

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PART I

Defective Seeds

Defective seeds are lethal or semi-lethal characters which affect the development of the endosperm and embryo between the time of fertilization and maturity. These characters were first reported by Jones (1920) who described them as "aborted seeds with either entirely empty pericarps or badly shrivelled seeds, completely lethal in some cases and partially so in others," He found these characters to be inherited as simple Mendelian recessives.

Previous to 1920 aborted seeds had frequently been noted on open-pollinated ears of maize but had generally been regarded as due to imperfect pollination or other external factors.

Self-pollinated ears in which approximately one fourth of the seeds were aborted, had also undoubtedly appeared in the cultures of many investigators before 1920 but these lethal characters were not noted or were not regarded as heritable.

In an early edition of Bailey's "Plant Breeding" appears a photograph of two ears grown shortly after the re-discovery of Mendel's Law, illustrating the alternative inheritance of the starchy and sugary conditions of the endosperm. One of these ears is clearly segregating for defective seeds in addition to the other two characters. The segregation is so well defined that the normal and aborted seeds on three of the rows of grain can be counted from the photograph. Seventy-five normal and 23 defective seeds are noted. The investigator who pollinated these ears to prove or disprove to his own satisfaction the newly re-discovered Law of Mendel, had more evidence of its correctness than he probably realized.

Richey (1923) found several defective seeds on an ear of maize, believed to be many centuries old, unearthed from an Indian graveyard in Peru. He concludes from this discovery that defective seeds are characters of considerable antiquity. Although his conclusion is probably correct, it is scarcely justified from this evidence alone, since it is equally possible that the few aborted seed on this ancient ear are of the non-hereditary types described in Part II.

In the past few years many experiment stations in this country, Canada, South America and Europe have undertaken projects for the improvement of corn by the method outlined by East and Jones (1919) and by Jones (1920) and known as "Selection in Self-fertilized Lines." Thousands of self-pollinations in many varieties have been made every year, and this extensive inbreeding of a naturally cross-fertilized species has brought to light many recessive variations previously covered up by the remarkable heterozygosity which exists in the average variety of maize.

Among these variations have been a large number of defective seed types.

The writer (Mangelsdorf, 1923) has noted defective seeds in self-pollinated ears of more than 30 representative American varieties as well as several from Spain, Italy, China and Peru. Since 1920, defective seeds have been reported under various names by numerous investigators. Lindstrom (1920, 1923) has described "abortive," "flint defectives," and "sweet defectives." Demerec (1923) has reported a condition which he calls "germless," Eyster (1922) a peculiar defect to which he gives the term

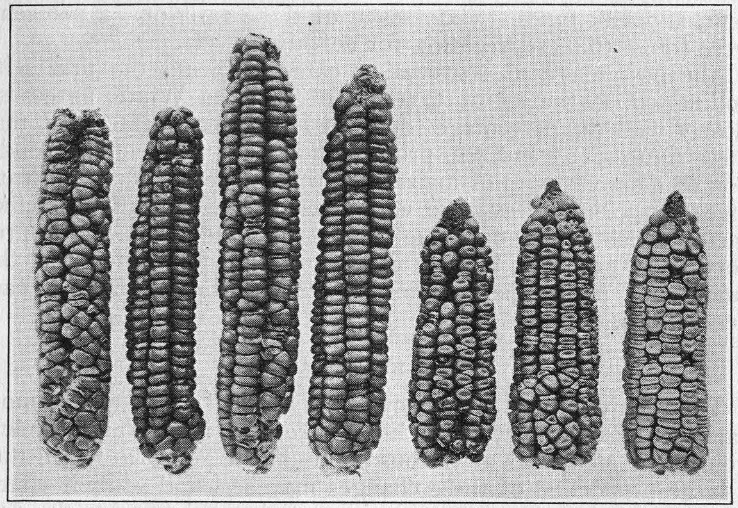

Fig. 51.—Self-pollinated ears of three New England varieties which are segregating for defective seeds. The third, sixth and seventh ears from the left represent the original ears of stocks de_1, de_3 and de_8 respectively.

"scarred" and Wentz (1924) a type known as "miniature germ." Garber and Wade (1924) report a semi-lethal type of defective seed in their cultures.

All of these characters may be considered as variations of the "defective" condition since all of them represent a seed development considerably below normal and most of them are lethal or semi-lethal in a homozygous condition.

WIDESPREAD DISTRIBUTION IN GERMPLASM

Some conception of the frequency with which defective seeds occur may be gained from the following figures taken from self-pollinations made in typical American varieties.

Defective seeds were first noted in a lot of 86 self-pollinated ears of four New England varieties. Thirteen of these ears, or 15.0 per cent, were segregating.

In 1922, 575 self-pollinated ears of six regional strains of Sanford White Flint were examined for these variations. Nineteen of these ears, or 3.3 per cent, were found to be segregating.

Hutchison (1922), in making a systematic search for variations of all sorts, self-pollinated 2,110 ears representing 468 different lots of seed which had been obtained from seed companies and experiment stations. These lots contained most of the varieties commonly grown in the Northern states and included sweet, pop, dent, and flint types. Sixty-seven of these ears, or 3.2 per cent, were found to be segregating for defective seeds.

The percentage of segregating ears, following the first self-pollination, in the lot of 575 ears of Sanford White, agrees so closely with the percentage found in Hutchison's 2,110 ears, that these figures, 3.3 and 3.2, probably represent the average condition of most varieties of maize. In other words, about one plant in every 30 in the average variety is heterozygous for a lethal factor which causes defective seeds. In some varieties this proportion is probably higher, depending to some extent on the amount of natural self-pollination which has occurred in past generations.

ORIGIN BY MUTATION

The relatively high frequency of these lethal characters in most varieties suggests that maize, like *Drosophila,* is constantly undergoing factor changes at various points in the germplasm and that a large proportion of these changes may be lethal in their effect. Muller and Altenburg (1919), in a study to determine the frequency of mutation in the X chromosome of *Drosophila,* find that characters which are lethal or semi-lethal are the most frequent to occur. They estimate that the X chromosome in *Drosophila* produces a new lethal, on the average, about once in every 100 generations. Recent evidence from homozygous inbred strains of maize indicates that the frequency of lethal mutations in this species may be as high or perhaps considerably higher.

In 1921 an inbred strain of maize which had been self-pollinated for thirteen generations and which was apparently homozygous for its genetic factors, as demonstrated by a test made by Jones (1924), began to segregate for defective seeds. The sudden appearance of this new character was clearly due to a germinal change since nothing of this kind had previously been noted, although a careful search for new variations in all inbred strains had been constantly maintained. Nor could this new character have been the result of a segregation following accidental crossing since outcrossing with unrelated stocks is immediately apparent

by the increased vigor and productiveness of the hybrid plants. With the exception of the segregation for defective seeds, the mutant stock differed in no detail from the original inbred strain.

This new character originating by mutation in a homozygous stock is a typical defective seed, is completely lethal in its effect

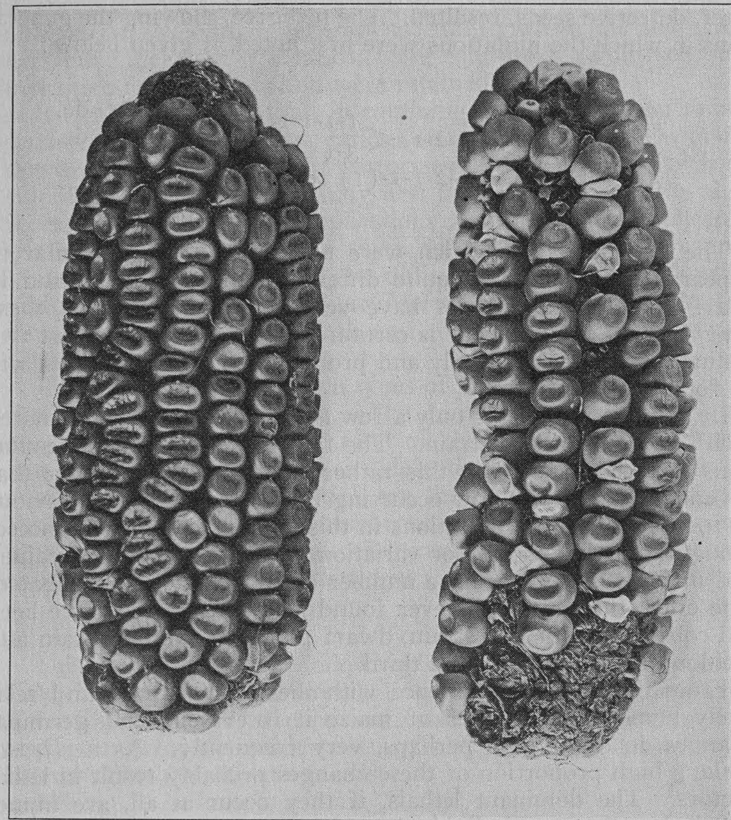

FIG. 52.—Ears of a strain of Leaming which mutated to defective seeds after thirteen generations of inbreeding. The ear at the right is segregating for the mutant character.

and is inherited as a simple Mendelian recessive. Ears of this inbred strain which are segregating for defective seeds are shown in Fig. 52.

A sister strain separated from this one after seven generations of inbreeding also showed defective seeds in the thirteenth generation when grown by H. A. Wallace at Des Moines, Iowa. This same strain, though of slightly different pedigree, produced defective seeds on two ears in 1924 after 17 generations of inbreeding. The parental ears of both segregating progenies were normal in 1923 so two separate mutations must have occurred. In other words, four separate mutations have appeared in the germplasm of this strain in the past four years and each time a lethal character, defective seeds, resulted. The pedigree, showing the generations in which the mutations were first noted, is given below:

```
                                       1-1-1-1-1-1 <  (1) seg. de.
                         4-4-2-1  <                   (2) seg. de.
1-6-1-3-4-4-4-2  <                     3-(1) seg. de.
                         5-5-2-1-1-(1) seg. de.
```

The two defectives which were noted in 1924 are similar in appearance but both are quite different from the one found in 1921. Though no crosses have yet been made between these four separate mutations, it is certain that they are of at least two distinct types phenotypically and probably genetic differences will be found as well.

In the past four years only a few ears have been self-pollinated each season from this strain. The fact that four separate mutations have been noted in this rather small sample indicates that germinal changes are now occurring rather frequently. Previous to 1921, however, no mutations in this stock had ever been noted, though an active search for variations was constantly maintained and in some seasons a large number of ears were self-pollinated. The only other mutations ever found in inbred strains have been red cobs in a white cob strain, dwarf plants in another strain and a chlorophyll deficiency in a third.

From the limited experience with these long-inbred and relatively homozygous strains of maize it is evident that germinal changes do occur and, perhaps, very frequently. As in *Drosophila,* a high proportion of these changes probably result in lethal factors. The dominant lethals, if they occur at all, are immediately lost, because individuals which carry them do not live to reproduce. The recessive factors, unless they have a marked deleterious effect in the heterozygous condition, may be carried along for generations. It is not at all surprising, therefore, to find these lethal factors in almost every variety of maize. Inbreeding brings them to light and demonstrates that about one plant in every thirty is heterozygous for one or more of them. How many genetically distinct lethal seed factors there are in maize can not be estimated at the present time, but some indication of the enormous number which probably exists may be gained from the following pages.

SOURCE OF MATERIAL

As already mentioned, defective seeds were noted by the writer in more than 30 varieties of maize. It soon became evident, that in order to make a thorough investigation it would be impossible to study the breeding behavior of more than half this number. Accordingly only those stocks in which defective seeds had appeared at least two successive generations, and in which the segregating ears gave clear-cut 3:1 ratios, were continued. Fourteen stocks met these requirements and were retained.

It is almost certain that, in confining the investigation to those strains in which simple 3:1 ratios were obtained, lethals which are due to duplicate or triplicate factors were eliminated. It was considered best, however, to study first the inheritance of the simple recessives without the complications brought in by duplicate or triplicate factors, especially since defectives which segregate in 15:1 or 63:1 ratios would be difficult to distinguish from the various types of non-hereditary defectives which occur in small numbers on almost every ear and which are discussed in some detail in Part II.

The source of the fourteen types of defective seeds used in this investigation is given below. The *de* numbers under which they are discussed were assigned after all the types had been arranged in a series on the basis of their "defectiveness." Those with high numbers such as de_{13} and de_{14} are the most defective in appearance, while those with low numbers, such as de_1, de_2, and de_3 most nearly approach the normal condition and are only semi-lethal in effect, being sometimes obtained in a homozygous condition.

de_1

This type appeared following the first self-pollination of Gold Nugget, an eight rowed, large-eared, yellow, flint variety. Twenty self-pollinated ears were obtained of which three were segregating for defective seeds. Only one strain has been kept heterozygous for defective seeds.

de_2

This defective was obtained from a self-pollinated ear of an eight-rowed yellow flint type grown by Dr. E. G. Anderson, then at Cornell University. This is probably the same stock in which Lindstrom found his "flint defective" and, if so, was obtained originally from Dr. W. E. Castle of Harvard University.

de_3

Defective seeds appeared on a self-pollinated ear of Century Dent, a many-rowed, medium early, yellow, New England dent variety. Five ears out of 18 which were self-pollinated, segregated for defective seed, but only this and one other, de_8, have been continued.

de_4

This type was first noted in the third generation of inbreeding in two ears of a strain of Beardsley's Leaming, a many-rowed, fairly late, yellow dent variety. No defectives had been noted in this strain in the first two generations and their appearance in the third may have been due to mutation.

de_5

This stock originated from a segregating self-pollinated ear of Reid's Yellow Dent received from Dr. J. R. Holbert of Bloomington, Illinois.

de_6

A self-pollinated ear of Luce's Favorite, a large eared, New England dent variety received from Dr. R. A. Emerson, segregated for defective seeds of this type.

de_7

A mutation in an inbred strain of Chester's Leaming which had been self-pollinated for thirteen successive generations and was apparently homozygous, gave rise to this defective.

de_8

This stock originated from another ear of the same lot of self-pollinated ears of Century Dent as de_3.

de_9

This type was found on a self-pollinated ear of Cornell No. 12, a selection of Funk's 90 Day, obtained from Dr. R. A. Emerson.

de_{10}

This defective appeared in a stock of "fine striped" which had been obtained some years previously from Cornell University.

de_{11}

The source of this stock was a self-pollinated ear of Clarage Dent, a typical Western yellow dent variety received from Professor M. T. Meyers, Ohio University.

de_{12}

Seeds of this type appeared in a self-pollinated ear of Burbank's "Rainbow," a novelty purchased from Peter Henderson Co., New York.

de_{13}

This type was isolated from a cross made by Mr. H. A. Wallace of Des Moines, Iowa. The seed parent was a hybrid combination of four inbred strains; the pollen parent a plant of "Illinois Two Ear" which Mr. Wallace believed to be homozygous for defective seeds.

de_{14}

This defective appeared in the second generation of inbreeding of a strain of Beardsley's Leaming, the same variety which gave rise to de_4. Defective seeds were not noted in this strain in the first generation of inbreeding.

SIMPLE MENDELIAN RECESSIVES

Except for the fact that there is often a slight deficiency of recessives, whereas an excess might be expected because of the regular occurrence of non-hereditary defectives on almost every ear, all of these fourteen types appear to be inherited as simple Mendelian recessives.

CROSSING EXPERIMENTS

The first defectives studied, de_1, de_2, de_3, and de_8, showed slight phenotypical differences, the first three being "partial" defectives; the last a "complete" defective. Crosses of these four strains made by Dr. D. F. Jones, the later generations of which were classified by the writer, indicated that these four defectives were genetically distinct. The next step was to determine the number of factors involved in the remaining ten stocks.

METHOD OF CROSSING

Throughout the investigation the general method of crossing two stocks has been as follows: A number of tassels, five or more, of the strain to be used as pollen parent were bagged. When pollinations were made the pollen from all of the bagged plants was collected, combined and mixed. Theoretically two-thirds of the plants in any segregating stock are heterozygous for the lethal factor and one-third are homozygous for the dominant allelomorph. Half of the pollen grains of the heterozygous plants should carry the lethal factor while the remaining half, as well as all of the pollen from the homozygous plants, should lack the lethal factor. Assuming an equal production of pollen by the heterozygous and homozygous plants, a composite collection of pollen made in this way should contain, on the average, one-third of the pollen grains carrying the lethal factor and two-thirds carrying its dominant allelomorph.

The seed parent of the cross should, like the pollen parent, produce heterozygous and homozygous plants in the proportion of 2:1. When the composite mixture of pollen is applied to homozygous plants, only normal seeds should be produced. When applied to the heterozygous plants, of which half the ovules carry the lethal factor, one-sixth of the seeds should be defective if the two stocks which are crossed are alike in their lethal factors, but all of the seeds should be normal if the lethal factors of the two parental stocks are unlike.

Since on the average two-thirds of the plants of a segregating stock are heterozygous for the lethal factor, the odds against obtaining no heterozygous plants when pollinations are made by this method are as follows:

No. Ears Pollinated	Odds
1	2:1
2	8:1
3	26:1
4	80:1
5	242:1

In order to be reasonably certain of including at least one heterozygous plant in every cross and to allow for failure to secure seed, it was customary to pollinate five ears. The pollen was always collected from five or more plants and it is practically certain that some pollen from heterozygous plants was always included in the mixtures.

This method of making the crosses between stocks, rather than between individual plants, has the advantage of being very rapid, a large number of pollinations being made from a single collection of pollen.

In several cases in which crosses were made between strains which regularly bear two ears, one of the ears was self-fertilized to determine the composition of the plant, the other was crossed. At harvest, only the crosses between known heterozygotes were retained. This method requires so much additional time and labor that its possible advantages are offset by the fact that only a limited number of crosses can be made in a season. The same objections were found to the method used by Demerec (1923) who, in making crosses between white seedling stocks, pollinated the ears with a mixture of own and foreign pollen and separated the selfed and crossed seeds by the effects of xenia. Only stocks which differ in their endosperm color or texture can be crossed by this method.

That the method of crossing at random without determining the composition of the plants used, gives the results which are theoretically expected, is shown by the following experiment, which incidentally shows that these lethal factors retain their genetic identity as do any other Mendelian characters. A stock in which defective seeds had appeared for three successive generations was crossed with another stock originally from the same source, but which had been crossed with an entirely unrelated strain and the defective seeds recovered in the second generation. The pedigree of these two stocks is shown below:

$$105\text{-}9\text{-}7 < \begin{matrix} 1\text{-}1 = \text{Stock A} \\ \text{Cross-}9\text{-}1 = \text{Stock B} \end{matrix}$$

Six ears of Stock A were pollinated by a mixture of pollen collected from six plants of B. Four of the six ears proved to be segregating for defective seeds. A count of the normal and defective seeds on these four segregating ears is shown in Table 1.

TABLE 1. Ratios Resulting when Plants Heterozygous for a Lethal Factor are Pollinated with a Composite Mixture of Pollen from Homozygous and Heterozygous Plants.

Ear No.	Normal	Defective
448	184	22
449	116	32
450	151	32
451	164	43
Total	615	129
Ex. 5:1	620	124
Deviation	5	

The agreement of the actual results with the theoretical expectation is surprisingly good. Exactly two-thirds of the ears proved to be segregating and exactly one-sixth of the seeds on these ears were defective.

RESULTS OF CROSSES

It was believed that the most rapid progress in determining the total number of lethals involved in the fourteen stocks, would be made by crossing the first four, which were apparently all different, with the remaining ten, on the assumption that some of the untested stocks would prove to be carrying the same lethal factors as the first four and these could then be eliminated from further investigation.

Thirty-nine crosses were made in 1922 with the astonishing results that the F_1 seeds were normal in every case. This indicated that not one of the ten stocks carried the same genetic factors for defective seeds as the four original strains by which they had been crossed, The next step was to cross the stocks in all combinations among themselves. This program involved a total of 91 crosses $\frac{n^2-n}{2}$ of which 45 had already been made. Since the remainder could not all be made in a single season, it was decided to cross first only the stocks in which the defective seeds showed some resemblance. In appearance the fourteen types range from complete defectives in which the caryopsis consists of little more than the flattened, transparent, pericarp to the partial defectives in which the recessive seeds are about half the size of normal seeds. Between these two extremes are all gradations and within each type there is a certain amount of variation. Several representative types of defectives are shown in Fig. 53. The fourteen types were arranged in a series on the basis of the average appearance of the recessive seeds. The plan was to cross each type with the two or three others nearest to it in the series. Although it was realized that resemblance in appearance did not necessarily mean genetic relationship, it seemed only reasonable to suppose that types resembling each other phenotypically were more likely to be alike genetically than those which were wholly different in appearance.

Twenty-seven crosses between types close together in the series were made in 1923 and again every cross produced only normal seeds.

Four additional crosses were made in 1924 and eight more in 1925; these, with the six preliminary crosses of 1920 and 1921, bring the total number to 84. Two of the crosses were reciprocals, however, so that the actual number of distinct combinations is only 82. This leaves 9 of the possible 91 crosses which are not yet made.

Of all these crosses, only one, a combination of de_5 and de_{11}, gave defective seeds in F_1. This shows that de_5 and de_{11} are genetically identical, and that the results of any crosses made with one of these stocks applies as well to the other. Taking this fact into consideration only seven combinations remain to be made.

THE F_2 GENERATION

In order to be certain that segregating plants had always been included in making the crosses, and to obtain additional evidence that the two types entering the cross were genetically distinct in each case, F_2 progenies of a large proportion of the crosses have been grown.

Since the heterozygous crossed ears could not be distinguished from the homozygous ones, all of the ears of a cross were combined by counting off an equal number of seeds from each. As

one-third of the pollen grains of a composite collection of pollen are expected to carry the lethal factor of the pollen parent, and

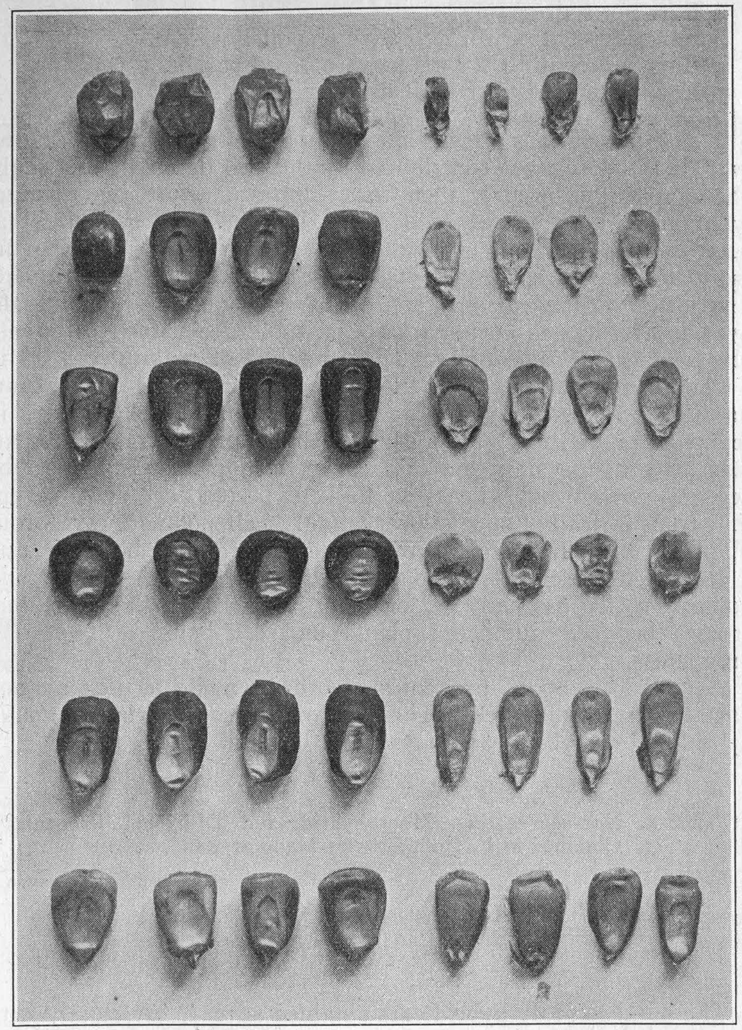

FIG. 53.—Six types of defective seeds showing the gradation from complete to partial defectives. Normal seeds from same ears are shown at left.

one-third of the ovules on a composite collection of ears the lethal factor of the seed parent, then a mixture of seed obtained from such crosses would be expected to give on the average the following F_2 progenies:

4 Ears not segregating.
2 Ears segregating for defective of pollen parent.
2 Ears segregating for defective of seed parent.
1 Ear segregating for both defectives.

The di-hybrid ears are expected only once in nine times. However, if the defectives contributed by the two parents show slight phenotypical difference, then the reappearance of two distinct types in F_2 may be regarded as fairly conclusive evidence that heterozygous plants of both parents were included in making the cross and that the parental types are therefore genetically unlike.

In order to have better than an even chance of obtaining di-hybrid ears, it was customary to self-pollinate fifteen to twenty plants of each cross. Though this method of making crosses in a wholesale manner and self-pollinating F_2 progenies on the same prodigious scale, may appear to entail unnecessary labor, in reality, it proved to be the most economical procedure. It is true that by growing only the crosses between plants known to be heterozygous, di-hybrid ears would be expected once out of every four trials instead of once in every nine. Self-pollinating vigorous F_1 plants on a large scale can be done very rapidly, however, and it has been found easier to make the crosses at random and pollinate twice as many F_2 progenies, than to make individual crosses between numbered plants and self-pollinate fewer F_2 progenies.

A total of 1089 F_2 progenies of crosses made by this method have been self-pollinated. The ratio of non-segregating to mono-hybrid and di-hybrid ears is given in Table 2.

TABLE 2. Non-segregating, Mono-hybrid, and Di-hybrid Progenies Obtained in F_2 from Crosses Made at Random.

	Found	Expected	Deviation
Ears not segregating	428	484	—56
Ears segregating one type	552	484	68
Ears segregating both types	109	121	—12

The number of dy-hybrid ears obtained agrees very closely with the theoretical expectation. There is a significant excess of the mono-hybrid ears, however. These are expected only as frequently as the non-segregating ears, actually they have appeared in considerable excess. A greater production of pollen by the heterozygous plants in some of the stocks, or the occurrence of heterozygous plants more frequently than two out of three, might account for this.

SUMMARY OF CROSSES

The diagram in Fig. 54 gives a picture of the situation with respect to these fourteen stocks.* Squares with vertical cross hatching represent crosses in which the F_1 seeds were normal. Those with horizontal cross hatching represent crosses in which

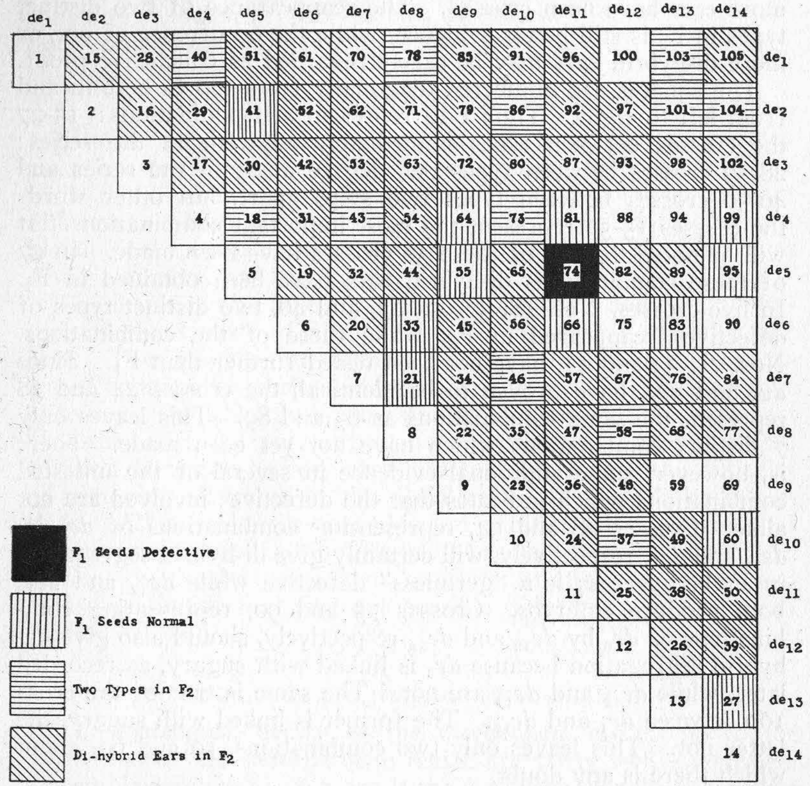

FIG. 54.—Diagram showing the crosses which have been made among the fourteen defective seed stocks. The types were arranged in the order of their "defectiveness."

the F_1 seeds were normal and two distinct types of defectives appeared in F_2 though no di-hybrid ears were obtained. Squares with diagonal cross hatching represent crosses in which the F_1

* For reasons of economy the detailed data showing the segregation in the individual ears of the fourteen parental stocks and their crosses are not included. Any marked deviations from expectation are noted, however, and are discussed in this and other papers.

seeds were normal and one or more di-hybrid ears were obtained in F_2, while the single case in which defective seeds appeared in F_1 is shown by a solid square.

As has already been pointed out, the production of only normal seeds in F_1 is fairly good evidence that the two types entering the cross are genetically distinct providing that three or more ears have been crossed. The reappearance of two distinct types in F_2 is still better evidence, while the occurrence of one or more di-hybrid ears may be safely regarded as conclusive proof.

The squares are numbered diagonally from top to bottom and from left to right. Thus 1-14 represent self-pollinations: 15-27 the crosses between types immediately adjacent in the series; 28-39 crosses between types one degree apart in the series and 40-50 crosses between types two steps apart. In other words the crosses 15-50 represent the most important combinations. It will be noted that all of these 36 crosses have been made. In 27 of these combinations di-hybrid ears have been obtained in F_2. In five crosses, Nos. 18, 37, 40, 43, and 46, two distinct types of defectives reappeared in F_2, while three of the combinations, Nos. 21, 33 and 41, have not been tested further than F_1. Since de_5 and de_{11} have proven to be identical, the crosses 24 and 38 represent the same combinations as 65 and 89. This leaves only 7 distinct combinations which have not yet been made. There is, however, some additional evidence in several of the untested combinations which indicates that the defectives involved are not alike. Crosses 88 and 94, representing combinations of de_4 by de_{12} and de_{13} respectively, will certainly give di-hybrid segregation in F_2 because de_4 is a "germless" defective while de_{12} and de_{13} both produce embryos. Crosses 75 and 90, representing combinations of de_6 by de_{12} and de_{14} respectively, should also give de-hybrid segregation because de_6 is linked with sugary, as recorded later, while de_{12} and de_{14} are not. The same is true of the cross 100 between de_1 and de_{12}. The former is linked with sugary, the latter not. This leaves only two combinations, 59 and 69, about which there is any doubt.

The evidence, then, is almost conclusive in indicating that thirteen distinct genetic factors for defective seeds are involved in the fourteen stocks tested. There is, of course, the possiblity that one of the two doubtful combinations will reveal an additional case of two stocks which are genetically identical, even though these combinations are between defectives which differ decidedly in appearance. It must be remembered that two characters may be genetically identical in one main factor and yet differ phenotypically because of minor modifying factors. This is shown by the cross between de_5 and de_{11} which proved these two defectives to be identical although they were far apart in the arbitrary series which had been arranged on the basis of external appearance.

These results give some indication of the enormous number of distinct defective seed types which probably occur in maize. A sample of fourteen types was taken at random from the grab bag which constitutes the germplasm of maize, and thirteen of these proved to be genetically distinct. The total number of distinct lethal seed factors in the germplasm of this species can only be conjectured, but it probably equals or exceeds the number of distinct varieties of maize which are now grown.

THE MORPHOLOGY OF DEFECTIVE SEEDS

In order to determine the irregularities in development which cause one-fourth of the seeds on a segregating ear to be defective while the remainder are normal, and to find, if possible, constant differences which distinguish some of the types from others, a histological examination of all fourteen types, in various stages of development, has been made.

The material was killed and fixed in Carnoy's solution, a mixture of three parts of absolute alcohol to one of glacial acetic acid. Two other fixing agents, Benda's solution and a concentrated solution of picric acid, were also tried. The former gave excellent results, but was discontinued because of the high cost of osmic acid, its most important constituent. The picric acid solution proved to be very unsatisfactory because of the difficulty of removing all traces of the discoloration from such large sections. All material was imbedded in paraffin, cut in sections of ten microns and stained in Delafield's haematoxylin. Some of the sections were also stained in a dilute solution of iodine and potassium iodide to bring out possible differences in the starch grains.

THE CYTOLOGICAL MECHANISM OF ENDOSPERM FORMATION

The cytological details of the mechanism leading up to the formation of the endosperm in maize are fairly well established. When Nawaschin, in 1898, made the discovery that the endosperm of *Lilium* is the product of a sexual fusion entirely apart from that which gives rise to the embryo, three investigators, DeVries (1899), Correns (1899), and Webber (1900), simultaneously and independently reached the conclusion that this mechanism was probably responsible for the phenomenon of xenia in maize, although it was not until 1901 that Guignard furnished the cytological evidence of double fertilization in this species.

More recently Weatherwax (1919) and Miller (1919) have independently repeated Guignard's researches and both have given detailed descriptions and illustrations of the entire process leading up to fertilization. In most respects the accounts of these two writers agree very well, though Miller believed that all four megaspores functioned while Weatherwax observed the disintegration of three megaspores, with only one persisting. In an earlier paper, however, Weatherwax (1917) also had made the observation that all four megaspores functioned and his discovery that only one persisted was made only after attention was called to the disagreement between his earlier cytological observation and certain well established facts regarding the genetic behavior of the endosperm.

When the pollen tube enters the micropyle, two identical sperm are emptied into the embryo sac. One of these fuses with the egg and an embryo is produced; the other fuses with one of the polar nuclei which lie close together in the embryo sac. Almost immediately the fusing nuclei are joined by the second polar nucleus, this process constituting the "triple fusion" characteristic of many angiosperms. It is of importance to note, in connection with the possible explanation of some of the forms of non-hereditary defectives described later, that both Weatherwax and Miller, in repeated observations, never found the two polar nuclei fusing before fertilization of one of them had occurred.

The endosperm of angiosperms is unique in that it is the product of a fusion in which the two parents do not contribute equally. Two maternal nuclei, with their assortment of chromosomes bearing the hereditary factors, combine with one male nucleus. The female parent, therefore, contributes two sets of chromosomes and a double dose of the assortment of hereditary factors while the pollen parent contributes only one set of chromosomes and a single dose of factors.

This peculiar situation enabled Hayes and East (1915) to demonstrate the fallacy of the "presence and absence" conception of dominant and recessive factors. These writers found that in crosses between flint and flour varieties the inheritance was always apparently maternal, a double dose of the maternal condition being always dominant to a single dose of the alternative condition. In other words, two "absences" were dominant to a single "presence."

DEVELOPMENT AFTER FERTILIZATION

The general features of the development of the endosperm and embryo in the cereals are fairly well established. Details of development which distinguish maize from other grasses are gradually being added as special phases are investigated. True (1893) and Poindexter (1903) studied the general development of the caryopsis. Reed (1904) has investigated the secreting cells of the scutellum of maize. Sargent and Robertson (1905) have made a very thorough study of the anatomy of the scutellum. The aleurone layer has been the subject of cytological studies especially by Lüdtke (1890), Haberlandt (1890) and Groom

(1893). The successive stages in the development of the embryo have been described and figured by Weatherwax (1920).

The general development of the caryopsis in maize is briefly as follows: The endosperm fusion nucleus begins division almost at once and the rapidly growing endosperm soon fills the embryo sac. The embryo nucleus does not divide immediately after fusion and the first division usually does not occur until after the nuclei of the endosperm number 20 or more. (Miller, 1919.) The nucellus soon begins to disintegrate and is partly absorbed, the remainder being compressed into a thin integument between the pericarp and endosperm.

By the time that the early milk stage is reached, the endosperm occupies the entire space within the pericarp and exerts considerable pressure. (See Plate XXI, Fig. 1.) The embryo on the other hand is still rather rudimentary. Fom this point on, the embryo develops more rapidly than the endosperm, the latter undergoing only slight additional increase in size while the former grows rapidly, pushing further and further into the endosperm tissue.

Small starch grains are found in the outer cells of the endosperm in the early milk stage, which in the writer's material occurred at about 15-20 days after pollination. By the time that the late milk stage is reached at about 25 days to four weeks after pollination, the cells in the upper part of the endosperm are completely packed with starch grains, although those in the lower part are still relatively clear. In material fixed after this stage, the contents of the cells drop out in sectioning and in most cases no histological studies of further changes have been made.

The aleurone layer is present in most specimens in the early milk stage, though no color can be detected in this layer in unsectioned material at this period.

DEVELOPMENT OF DEFECTIVE SEEDS

In preliminary experiments of 1922, seeds were fixed at intervals of 1, 2, 4, 7, 10, 20 and 30 days after pollination. The defective seeds could not be distinguished from the normal seeds in the early stages and it was necessary to examine sections from a large number of seeds in order to be certain that defectives were included. In 1923 no material was collected until the normals and defectives on segregating ears could be distinguished from each other. This point was usually reached in the blister or early milk stage, or at about fifteen to twenty days after pollination in most of the types. Some of the partial defectives, however, could not be distinguished from normal seeds on the same ears until later.

Defectives and normal seeds were always removed in pairs for comparison and the seeds were usually taken from the middle of the ear to avoid differences due to unequal development at butts and tips of the ears. Before dropping the seeds into the fixing agent, as much tissue as possible on either side of the embryo was removed to permit a more rapid penetration of the solution.

REGULAR DEVELOPMENT IN EARLY STAGES

The inheritance of all of the defective seed types as simple Mendelian recessives pointed to a regular functioning of the fertilization mechanism and the fusion of male and female gametes. The specimens collected in the early stages bore out this assumption. All of the types of which the early stages after pollination were studied showed the normal beginning of endosperm and embryo formation and no marked differences between normal and defective seeds were noted.

In specimens fixed after the blister or early milk stage, however, the differences between normal and defective seeds were very striking. The various types of defectives differed from each other, however, only in general development and, with the exception of one type, no specific morphological differences, which always distinguish one type from another, have been found. A general account of the development of these various types of aborted seeds follows.

THE PERICARP

No matter how defective the endosperm and embryo may be, the pericarp usually attains a normal or almost normal development. This affords a striking illustration of the complete independence of these two tissues which, though borne on the same plant, represent distinct sporophyte generations. The pericarp is maternal in its origin and with the exception of the stimulus from pollination which sets off its development, it does not appear to be influenced by the hereditary composition of the new sporophyte which it encloses.

In normal seeds, the pericarp is constantly distended by the pressure of the growing endosperm. In the defectives, there is always a space between these tissues. In early stages this space is filled, partly with nucellar tissue and partly with a clear watery solution. In later stages the walls of the ovule are pushed together by the pressure of the normal seeds on either side and the space disappears as shown in Plate XXI, which shows three successive stages in the development of the de_{14} type of defective seeds.

THE NUCELLUS

In normal seeds the nucellus rapidly disintegrates following fertilization. Part of it is probably absorbed while the remainder is compressed into a thin integument between the endosperm and

pericarp and soon loses its identity as a separate tissue. (Plate XXI.) The nucellus, like the pericarp, is of maternal origin and is not influenced by the sporophyte with which it is in constant contact, except that in the absence of a vigorous and rapidly growing endosperm it is permitted to persist as a distinct tissue for longer periods than it does in normal seeds.

THE ENDOSPERM

The endosperm of the defective seeds differs from that of normal seeds in degree rather than in kind. In no case does it attain the size of the normal endosperm, but in details of development no marked differences are noted. With regard to the development of the endosperm, the defectives of these fourteen stocks form a continuous series ranging from the de_{13} and de_{14}

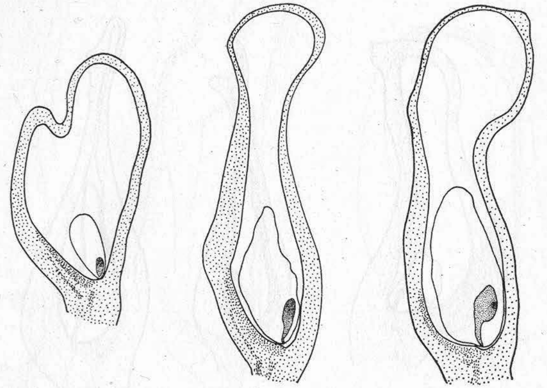

FIG. 55.—Three successive stages of development of defective seeds of de_{10}. No aleurone layer is found at any stage. (Figures 55-58 represent a magnification of approximately 6.5 diameters.)

types in which only a small mass fo tissue is present, to the de_1 and de_3 types, in which the endosperm is fully half size.

With regard to the rate at which the endosperm increases in size from week to week the same gradation is found. In the de_{14} stock, for example, the defective seeds at the early stage have only a small mass of endosperm tissue. At the late milk stage no increase in size is noted, and at the early dough stage the development of the endosperm still remains practically the same, as shown in Plate XXI. In partial defectives, such as those of the de_5 stock, for example, the endosperm gradually increases in size from week to week though its rate of growth is considerably retarded as compared to the endosperm of normal seeds and its final size is considerably less than that of a normal endosperm. (Plate XXII.)

The order of the fourteen stocks of defective seeds on the basis of their endosperm development as shown by these histological studies is not exactly the same as the arrangement made on the basis of external appearance alone. In general, however, the two series agree very well.

STARCH GRAIN FORMATION

The same general differences noted in size of endosperm are also found with regard to the formation of the starch grains. In the defectives at the lower end of the series no starch grains were found at any stage examined. Types further up in the series produce small starch grains in the periphery of the endosperm in later stages, while in the partial defectives, starch grains are found

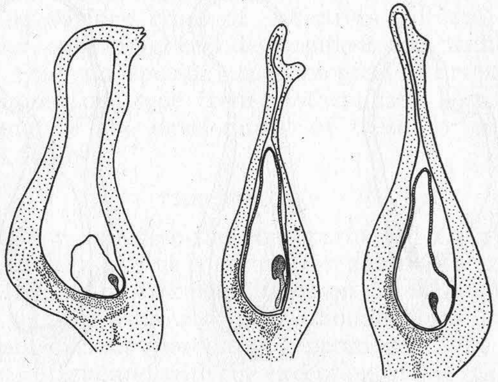

FIG. 56.—Defective seeds of de_{14} at early milk stage; de_7, late milk; de_{12}, late milk.

in every stage examined, and in later stages the cells of the endosperm are packed with starch grains which are apparently normal in size and structure.

No characteristic differences in the structure of starch grains were noted with the exception of the defective seeds of de_4. In the recessive seeds of this strain the starch grains have the appearance of undergoing hydrolosis many of them being completely broken up.

THE ALEURONE LAYER

The defectives at the foot of the series produce no aleurone layer at any stage examined and this might be expected since an aleurone layer is usually formed only in later stages of normal development. Beginning with de_{11}, however, an aleurone layer

is found in the later stages examined. In some cases this layer extends only part way around the endosperm, in others it completely surrounds this structure except, of course, at the base where no aleurone layer is found even in normal seeds. Drawings in which the aleurone layer has been enlarged out of proportion to the other structures are shown in figures 55-58. In defectives higher in the series than de_{10}, an aleurone layer is found in almost all stages examined.

THE EMBRYO

With the exception of de_4 all of the types were found to contain embryos. This type is similar to the "germless" seeds reported by Demerec (1923) which at maturity contain no embryo.

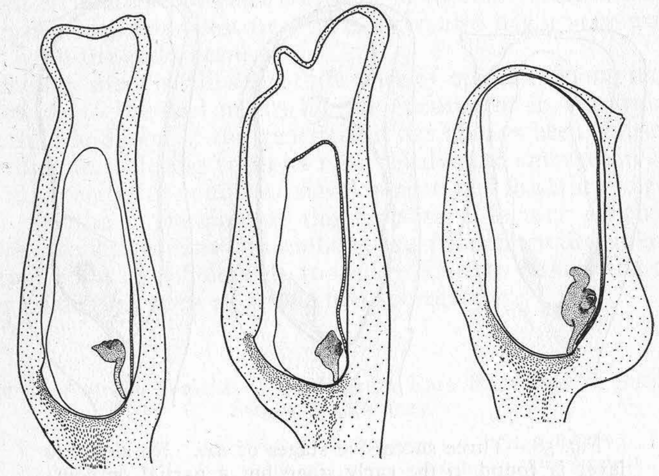

FIG. 57.—Defective seeds of de_{11} de_5 and de_6 at approximately the same stage, showing difference in degree of development of embryo, endosperm, and aleurone layer.

No paraffin sections of this defective were secured because the recessive seeds are distinguishable from the normals only shortly before maturity, at which time the seeds are too corneous to be sectioned by the paraffin method. Free-hand dissection in early stages of seeds from ears later proven to be segregating for this character, showed that an embryo was present in all the seeds. Apparently the embryo is digested and absorbed later. The cavity which remains on the germinal side of the seed is partly filled with a hard brittle mass of substance with no definite structure. As already mentioned, the endosperm of this type also shows evidence of digestion.

In general, there is a marked correlation between the development of the embryo and that of the endosperm. The complete defectives in which the endosperm remains practically stationary have very rudimentary, undifferentiated embryos which show no further development after the early milk stage. (Plate XXI.) Defectives higher in the series show some increase in size from week to week, but no clear differentiation of various parts of the embryo is apparent though a "growing point" is indicated by a greater concentration of nuclei in certain regions. Beginning with de_8, a scutellum, coleptile and several rudimentary leaves are distinguished, while in some of the partial defectives the development of the embryo is fairly normal.

The embryos of the defective seeds often show considerable dis-

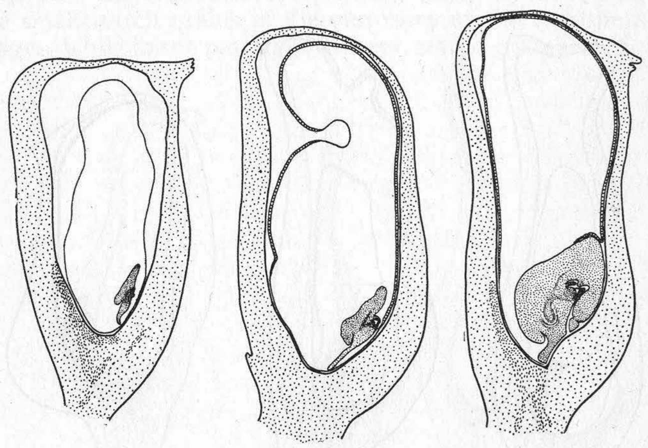

FIG. 58.—Three successive stages of de_8. No aleurone layer is found in the early stage but a partial or complete layer is formed later. Note the distortion of the embryo in the final stage.

tortion in shape. In later stages this may be attributed to the pressure exerted by the normal seeds on either side as shown in Plate XXIII, but in some cases a distortion is noted even when the defective seeds have not been under pressure. The embryo tends to be short and "blocky" as shown in Plate XXII, which may be compared to Plate XXIV which shows the successive stages in the development of the normal embryo.

GENERAL ASPECTS

Aside from the interesting demonstration that the pericarp, once its development is stimulated by pollination, proceeds quite independently of the tissues which it encloses, the most outstanding

feature of the morphology of the defective seeds is the marked correlation between the development of the endosperm and embryo.

An external examination of some of the defective seeds had led to the assumption that these, in many cases, contained no tissue whatever. It was surprising, therefore, to find distinct, though rudimentary, endosperm and embryo at some stage in every type examined. It was even more surprising to find that the deleterious influence of the lethal factors, which they carried, affected both of these structures to almost the same degree. It might be supposed that some factors would affect specifically the embryo, permitting the endosperm to continue in a more or less normal fashion. Others might be expected to inhibit particularly the endosperm. This has not been found to be the case. Even in the de_4 type, which lacks an embryo at maturity, the development of both structures proceeds normally in the early stages and the influence which later destroys the embryo also has a very marked effect upon the endosperm.

Although there is still some difference of opinion among morphologists as to the real nature of the endosperm in angiosperms, from the standpoint of the geneticist it has always been considered a sporophyte, differing from its near relative the embryo, in structure, in capacity for continued development, and in ability to reproduce. In the expression of the hereditary factors which they receive, the endosperm and embryo are fundamentally alike and eventually the morphologists, too, may come to regard the endosperm of angiosperms as a modified sporophyte.

TABLE 3. Average Weight of Seeds from Ears Harvested at Successive Stages of Maturity.

Days after Pollination	Av. wt. in mg. 1	2	3	Av.	Relative Development
14	5	5	5	5	1.5
21	25	27	37	30	9.1
28	82	86	71	80	24.2
35	111	97	126	111	33.6
41	159	166	189	171	51.8
51	234	222	226	227	68.8
75	374	319	306	330	100.0

PHYSIOLOGY OF DEFECTIVE SEEDS

Histological examinations of the normal and defective seeds were confined largely to a rather brief period beginning with the blister stage and ending when the seeds had reached the dough stage. In order to determine the differences between normal and defective seeds in later stages of development, a comparison of their rate of growth, final dry weight, percentage of germination and effect upon the sporophyte and gametophyte in the haploid condition was made.

RATE OF GROWTH, FINAL WEIGHT AND GERMINATION OF NORMAL SEEDS

The rate of growth of normal seeds of maize was determined as follows: A large number of plants of an F_1 hybrid of homozygous inbred strains were grown under uniform soil conditions. These plants, all being genetically alike, came into silk and were pollinated at about the same time. At two weeks after pollination, and at intervals thereafter until maturity, three ears were taken at random from these plants. The ears were reduced to an air dry condition after which the kernels were removed, counted, weighed "en masse" and the average weight at each stage determined by simple division.

It is quite possible that in ears harvested at various stages of maturity in this way there is a transfer of materials from the cob to the kernels during the drying out process. Such an exchange, if it occurs at all, would probably be proportionate for the various stages and is not regarded as a serious source of error.

TABLE 4. Percentage Germination of Corn Seeds Harvested at Successive Stages of Maturity.

Days After Pollination	Relative Development	Percent Germination
14	1.5	0
21	9.1	28
28	24.2	56
35	33.6	72
41	51.8	92
51	68.8	96
75	100.0	98

The average weights in milligrams and the relative weights, as compared to the final weight at maturity, of these seeds harvested at various stages of development, are given in Table 3. Figures 1 and 2 of Plate XXV show respectively a representative ear at each stage and 50 seeds from each ear.

The 50 seeds representing each stage of development were planted in sand in the greenhouse with the results shown by the photograph in Plate XXV, Figure 3. Some germination occurred in every lot except the first which was harvested at fourteen days after pollination. The percentage of germination of each lot and the relative weight of the seeds from which it was grown are given in Table 4.

The normal seeds of maize, like those of barley (Harlan and Pope, 1922), are apparently capable of some germination at all stages of development but the very earliest.

RATE OF GROWTH, FINAL WEIGHT, AND GERMINATION OF DEFECTIVE SEEDS

The rate of growth of defective seeds as compared to normal seeds from the same ears was determined for one type, de_{10}. Ears from an F_1 hybrid of this stock crossed with an unrelated inbred strain were harvested when the segregation on the ears first became apparent and at intervals thereafter until maturity. When all the ears had been reduced to dryness, the kernels were shelled off, the normal and defective seeds separated, counted and weighed, and the average weight of each class determined. The growth curves of the normal and defective seeds from ears segregating for de_{10} are shown in Figure 59. Although the rate of

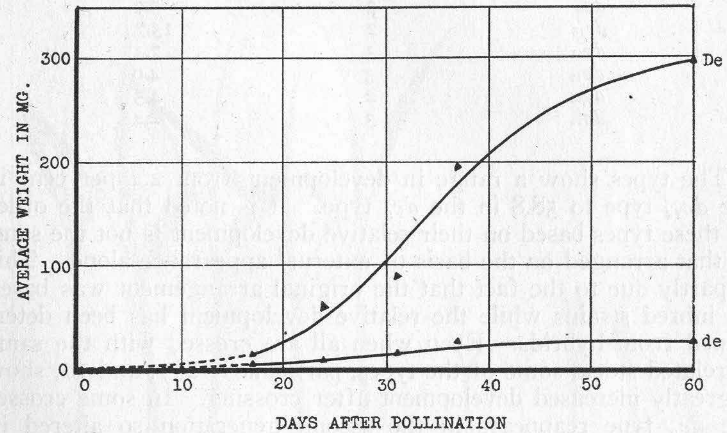

FIG. 59.—Growth curves of normal and defective seeds from the same segregating ears of the de_{10} stock.

increase in dry weight is very low for the defective seeds, the two curves appear to be of the same general type.

In determining the relative development at maturity of the fourteen types, dry weight was used as a criterion. Obviously, the relative development cannot be determined with any high degree of accuracy because it is influenced to some extent by the environment and considerably by the hereditary constitution of the stocks, certain of the types showing more development in crosses than in inbred strains. In order to make the determinations as nearly comparable as possible, the figures on relative development have, with one exception, been taken from crosses which were all identical with respect to one of the parents, and all grown the same season. In this way the defectives are compared under conditions in which hereditary and environmental differences are reduced to a minimum.

The relative development of defective seeds at maturity of each of the fourteen stocks is shown in Table 5.

TABLE 5. Relative Development in Defective Seeds of Fourteen Stocks as Compared to Normal Seeds on Same Ears.

Stock	No. Ears	Relative Development
de_1	6	50.4
de_2	3	58.8
de_3	3	29.9
de_4	3	37.3
de_5	2	18.0
de_6	3	34.0
de_7	3	18.8
de_8	3	15.0
de_9	3	5.9
de_{10}	2	13.7
de_{11}	3	7.3
de_{12}	3	4.0
de_{13}	2	4.5
de_{14}	3	2.4

The types show a range in development from 2.4 per cent in the de_{14} type to 58.8 in the de_2 type. It is noted that the order of these types based on their relative development is not the same as that arranged on the basis of external appearance alone. This is partly due to the fact that the original arrangement was based on inbred strains while the relative development has been determined from hybrids. Even when all are crossed with the same unrelated stock, some of the types, particularly 2, 7, and 10, show a greatly increased development after crossing. In some crosses the de_2 type reappears in the second generation so altered in appearance that it is scarcely recognized. The recessive seeds are almost equal to normal seeds in size and weight, and differ from the latter only in a paler color and a mottled appearance.

Whether this increase in development which follows crossing is due to the greater vigor of the plants on which they are borne, or to the action of modifying factors contributed by one or both parents, is not known. That some of the defectives are influenced by modifying factors, is almost certain. The de_5 and de_{11} types, for example, are genetically alike, yet differed in appearance, not only in the original stocks, but in hybrids in which both were crossed to the same unrelated stocks.

Judging from the dry weight alone, the fourteen types of defectives correspond to various stages in the development of the normal seed. This is shown diagramatically in Figure 73 (Part III) in which the relative development of each type is represented by a point on the normal growth curve of maize seeds.

At first glance, the defective seeds are comparable to normal seeds which have had their development arrested at an early stage,

as has occurred in the ears harvested at successive stages of development, shown in Plate XXV. When these various defective seeds are tested for germination, however, it is found that they are by no means equal to normal seeds of the same relative development. This is shown by the figures in Table 6, in which the germination of each type of defective is compared to the theoretical germination of immature normal seeds of the same relative development. The theoretical germination of the normal seeds was determined by interpolation of the figures in Table 4.

It is noted that the defective seeds in every case show a much lower germination than would be expected from normal seeds of

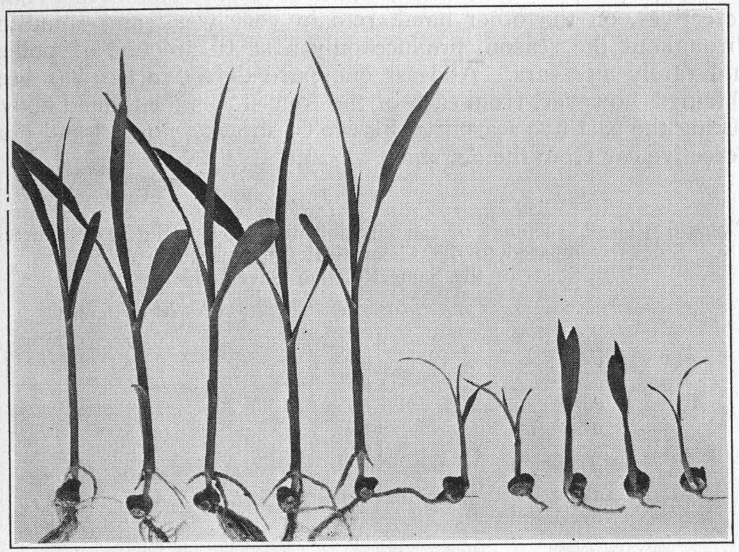

FIG. 60.—Seedlings from normal and defective seeds of de_2. Only rarely do the seedlings from the recessive seeds survive more than a few weeks.

similar development. In fact, the types below de_7 showed no germination whatever in this test with the exception of one seed from a total of 131 seeds of the de_{11} type. Defective seeds of de_8 have also shown slight germination in some cases, but in the ears used in this particular test no germination occurred.

Not only are the defective seeds less able to germinate than normal seeds of the same development, but those which do succeed in sprouting produce very weak seedlings which are lacking in vigor and soon die. Seedlings from normal and defective seeds of the de_2 stocks are shown in Figure 60. By planting large numbers of seeds in the greenhouse and transplanting the most vigorous of the seedlings to the field, it has been possible to obtain homozygous plants of stocks 1, 2, 3 and 6.

The behavior of the plants grown from homozygous defectives is in striking contrast to those which result when immature normal seed is grown. In appearance the two lots of seed are almost identical, both being badly shrivelled and aborted. Both types give a low germination and the seedlings are, in both cases, very weak and spindling. The plants which are genetically normal, however, soon recover from the handicap of the poor food supply which the aborted seed affords, and by flowering time are fully normal in stature, and yield practically as much grain as plants which grow from well filled, mature seed. The homozygous defectives, on the other hand, remain very weak and spindling throughout the season, produce only a small amount of pollen, and rarely any ears. At least one pure defective ear has been obtained, however, from each of the four stocks mentioned above, during the past five seasons. Figure 61 shows a normal and pure defective ear from the de_3 stock.

TABLE 6. The Percentage of Germination in Defective Seeds of Fourteen Stocks Compared to the Theoretical Germination of Normal Seeds of the Same Relative Development.

Stock	Defectives	Theoretical Normal
de_1	45.6	91.0
de_2	44.9	94.0
de_3	54.0	66.5
de_4	3.5	75.5
de_5	11.2	47.5
de_6	11.8	72.5
de_7	19.6	49.0
de_8	0	42.0
de_9	0	17.0
de_{10}	0	39.0
de_{11}	0.8	22.0
de_{12}	0	10.0
de_{13}	0	12.5
de_{14}	0	3.5

The fact that the germination of the defective seeds is considerably lower than that of immature normal seeds of the same relative development, that the seedlings of all types are extremely weak, and that even the most vigorous ones which are able to survive make a very feeble growth throughout the season, indicates that these lethal and semi-lethal factors do more than merely arrest the seeds at a certain stage; apparently these factors in a homozygous condition have a deleterious influence on the sporophyte at any stage in which they are given an opportunity for expression. In most of the types the deleterious influence is so

marked that the career of the new sporophyte is brought to an end in the seed stage and the lethal factors have no opportunity for further damage past this period.

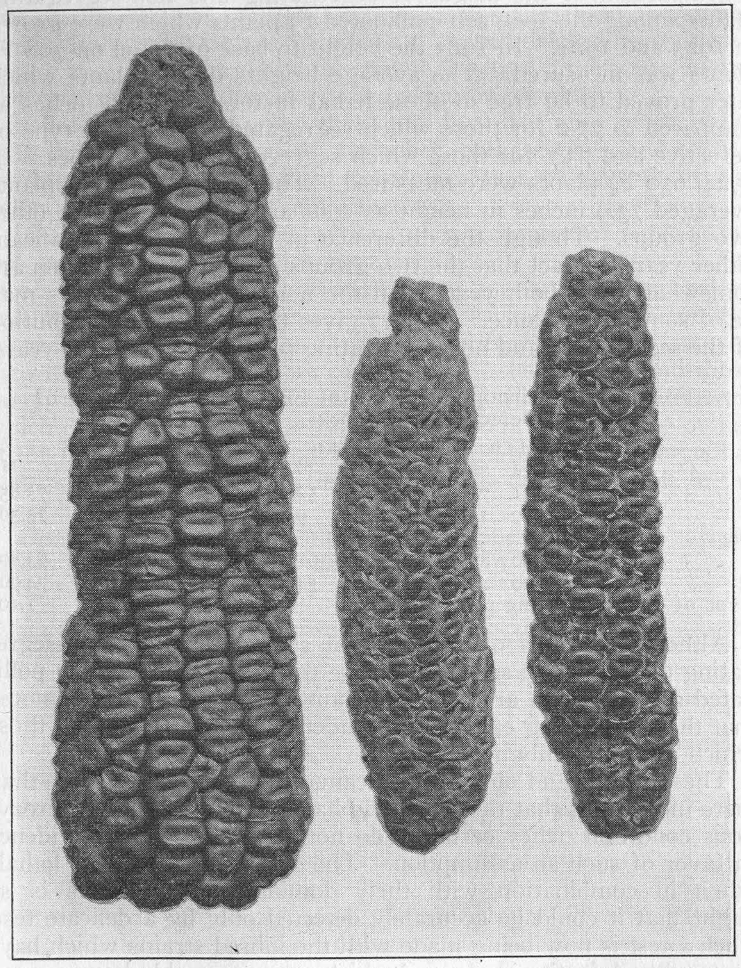

FIG. 61.—Left; ear segregating de_3. Center; self-pollinated ear from a plant homozygous for de_3. Right; open-pollinated ear from homozygous plant.

THE INFLUENCE OF LETHAL FACTORS IN HETEROZYGOUS CONDITION

Since the effect of the lethals is so marked when they are in homozygous condition, it might be questioned whether they have not a similar unfavorable influence, though in a smaller degree, in the heterozygous condition.

The only evidence bearing on this question is that secured from a comparison of the height of segregating and non-segregating plants among the 1089 self-pollinated F_1 plants which were grown in 1923 and 1924. In 1923 the height to base of tassel on 398 F_1 plants was measured. The average heights of the plants which later proved to be free of these lethal factors was 77.9 inches as compared to 77.2 for those which segregated for a single type of defective and 73.7 for those which segregated for two types. In 1924, 659 F_1 plants were measured. The non-segregating plants averaged 73.9 inches in height as compared to 71.9 for the other two groups. Though the difference in height is not significant either year, the fact that the two groups of segregating plants are somewhat lower both years than the non-segregating plants may be of some significance. Table 7 gives the frequency distribution of the segregating and non-segregating plants for these two years.

TABLE 7. Frequency Distribution in Height of F_1 Plants from Crosses of Defective Seed Stocks.

Type of Plant	Mid-Class Values in Inches: 42	47	52	57	62	67	72	77	82	87	92	97	102	Total	Mean
Segregating 3:1	3	7	9	22	51	72	86	117	98	52	12	2	..	531	73.85 ± .29
Segregating 9:7	..	..	1	6	9	15	23	20	17	9	..	..	..	100	73.30 ± .57
Total segregating plants	3	7	10	28	60	87	109	137	115	61	12	2	..	631	73.80 ± .36
Not segregating	..	5	8	21	29	45	78	89	69	54	15	2	1	416	74.90 ± .33
Difference in favor of non-segregating plants															1.10 ± .49

Although no data on the yield of segregating and non-segregating plants can be secured because the ears are artificially pollinated and full ears are seldom obtained, it has often been noted that the segregating ears have a tendency to be smaller than those which are uniformly normal.

These results and observations cannot be regarded as more than mere indications that the lethals do have an effect in the heterozygous condition; they certainly do not afford conclusive evidence in favor of such an assumption. The effect, if any, of the lethals when in combination with their dominant allelomorphs is so slight that it could be accurately detected only by a delicate test. Such a test is now being made with the inbred strains which have mutated to defective seeds, and which are presumably homozygous for all factors with the exception of a single pair involving the defective factor and its dominant allelomorph.

EFFECT UPON THE GAMETOPHYTE

The gametophyte generation is ordinarily assumed to be independent of the influences of the genetic factors distributed on the chromosomes which it carries. Recent evidence (Jones, 1924) (Mangelsdorf and Jones, 1926) indicates, however, that there are exceptions to the rule and that in some cases, the gametophytes from the same plant are not all alike in their ability to reach the micropyle and accomplish fertilization. This brings up the question of the effect of the lethal factors on the gametophyte generation. Since these factors have such a marked deleterious influence on the sporophyte at all stages, might they not have some degree of expression in the gametophyte generation as well?

It has already been noted that there is a deficiency of recessive seeds on segregating ears of a number of these types and such a condition might be explained by slower rate of growth of the pollen tubes carrying the lethal factors.

In order to answer this question, a large number of segregating ears of the de_3 stock which regularly shows a deficiency of the recessives were divided arbitrarily into top and bottom halves and the normal and defective seeds in each half were counted separately. If there were a constant difference in the rate of growth between pollen tubes carrying the lethal factors and those carrying the dominant allelomorphs, then the greater difference which the pollen tubes were forced to travel in reaching the ovules at the base of the ears would act against those carrying the lethal factors and cause a greater deficiency of the defective seeds in the lower halves of the ears.

The results of making counts in the upper and lower half of fifteen ears segregating for de_3 are shown in Table 8.

TABLE 8. Normal and Defective Seeds on Top and Bottom Halves of Ears Segregating de_3.

Ear No.	Top Half: Normal	Top Half: Defective	Bottom Half: Normal	Bottom Half: Defective	Percent Defective: Top	Percent Defective: Bottom
10	165	60	204	50	26.7	19.7
29	146	48	158	48	24.7	23.3
30	154	44	145	39	22.2	21.2
33	89	24	78	36	21.2	31.6
45	190	57	207	54	23.1	20.7
46	210	63	200	65	23.1	24.5
51	156	44	178	36	22.0	16.8
55	155	45	185	55	22.5	22.9
56	138	40	172	60	22.5	25.9
58	145	56	171	50	27.9	22.6
120	119	32	144	48	21.2	25.0
135	119	32	79	31	21.2	28.2
139	145	47	96	31	24.5	24.4
148	125	41	145	42	24.7	22.5
158	115	46	112	41	28.6	26.8
Total	2171	679	2274	686	23.8	23.2
Ex 3:1	2137.5	712.5	2220	740		
Deviations	33.5		46			
P. E.	15.6		15.9			
Dev./P. E.	2.2		2.9			

Although the percentage of recessives in the bottom halves of these ears is lower than that in the top halves, the difference is not significant. When the ears are examined individually it is noted that the percentage of recessives is lower in the top half almost as frequently as in the bottom half.

From these results it may be concluded that the lethal factors have very little, if any, effect upon the rate of pollen tube growth. Even very slight differences in the ability of the pollen tubes to reach the micropyle would cause marked distortions in the ratios and should result in different proportions of defective seeds in the upper and lower halves of the inflorescences.

LINKAGE RELATIONS

Although no special study of the linkage relations of these characters has yet been made, it was to be expected that some indications of linkage would be encountered as by-products of the other investigations. This proved to be the case.

The first linkage to appear was that between de_2 and a factor for albino seedlings. This linkage has been briefly mentioned in a previous paper. (Mangelsdorf, 1922.)

TABLE 9. Seedlings from Normal and Defective Seeds Showing Linkage Between de_2 and w.

Ear No.	Normal Green	Normal White	Defective Green	Defective White
2	126	15	30	20
4	158	19	23	19
5	79	19	0	19
7	130	20	1	39
8	119	1	28	32
Total	612	74	82	129

As already noted, the de_2 character is peculiar in that it is greatly modified in certain crosses. In a cross between the de_1 and de_2 stocks the recessive seeds of the latter reappeared, so altered in appearance, and so well developed, that it was considered feasible to plant a row of them in the field in order to secure a stock homozygous for this factor. A week later when the seedlings had emerged, this row was easily the most conspicuous one in the field. With one exception all of the seedlings were albinos, and this solid row of pure white seedlings in striking contrast to the normal green plants on either side furnished a most striking demonstration of linkage.

The remaining ears of this cross were tested in the greenhouse and the results are given in Table 9. Figure 62 shows the seedlings grown from the normal and defective seeds from one of these ears.

The amount of crossing over between de_2 and w is 18 per cent as determined from the normal seeds and 21.5 per cent as determined from the recessive seeds.

These values are believed to be somewhat high because of possible inaccuracies in the classification of normal and defective seeds on these ears. A large number of F_3 progenies were therefore grown. In these the development of the defective seed was reduced, and the segregation so well defined that, it is believed,

FIG. 62.—Seedlings from normal and defective seeds of de_2 showing linkage between defective seeds and a factor for white seedlings.

a fairly accurate separation was made. The results of planting the normal and defective seeds from 17 F_3 ears are given in Table 10.

The amount of crossing over as determined from the normal seeds is 11.7; from the defective seeds, 10.5.

As nearly as can be determined from the records the de_2 stock is the same one in which the w_2 factor for white seedlings was found. (Lindstrom, 1924.) The w_2 factor is known to belong to the second linkage group in maize and it is probable, therefore, that the de_2 factor is also a member of this group although further tests are necessary to substantiate such an assumption. Some additional evidence for it exists in the fact that Lindstrom (1923) has also found a case of close linkage between w_2 and a defective seed which answers the description of the de_2 type.

LINKAGE BETWEEN *su* AND *de* FACTORS

The relation between the factor for sugary endosperm, a representative of the third linkage group, and the fourteen factors for defective seeds, may be determined from the crosses between de_7 and the thirteen remaining types. The de_7 stock, originally starchy, had been changed over to sugary before any crosses were made.

TABLE 10. Seedlings from Normal and Defective Seeds of F_3 Progenies Showing Linkage Between de_2 and w.

Normal		Defective	
Green	White	Green	White
84	3	5	28
89	5	16	22
79	17	0	12
83	9	2	32
91	1	27	32
54	7	1	16
58	2	1	2
42	0	0	6
8	3	0	2
63	3	1	25
21	2	3	2
84	8	1	26
81	12	12	33
51	0	0	4
74	9	1	11
68	4	0	15
59	2	2	15
1089	87	72	283

Since the defective seeds, with the exception of two or three types, cannot be accurately classified with regard to their endosperm texture, their linkage relations with sugary must be determined from the normal seeds alone. Linkage of sugary endosperm with any of the lethal factors would be indicated by a distortion of the normal 3 starchy : 1 sugary ratio. An excess of sugary seeds is expected when the sugary and defective seed factors enter the cross from opposite parents and the recessive factor of one is linked with the dominant allelomorph of the other. With complete linkage between *Su* and *de*, 33⅓ per cent sugary seeds in the normal class are expected. Thus the range in crossing over from 50 per cent to 0, corresponds to a range in percentage of sugary seeds of 25 to 33⅓. This is shown diagrammatically in Figure 63.

F_2 progenies of crosses between sugary endosperm and all of the defective seed types have been grown. The results of separating and counting the starchy and sugary seeds in the normal class, on ears from all of these crosses, are shown in Table 11.

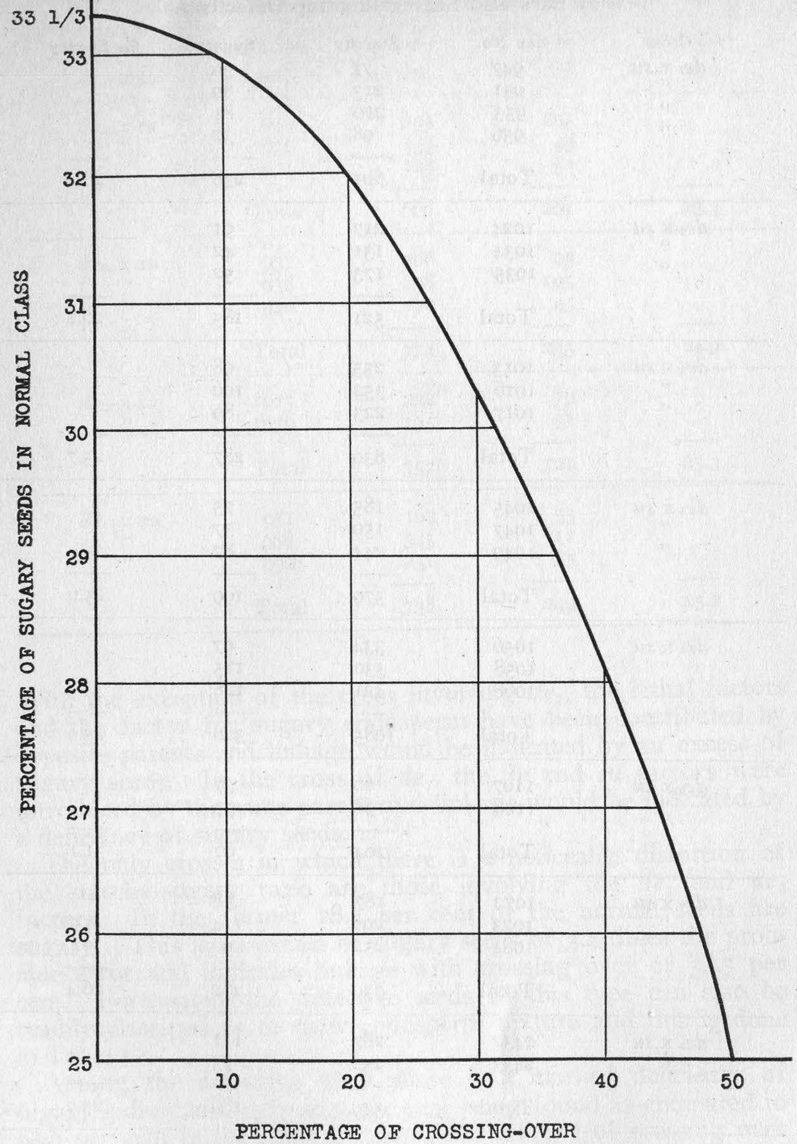

FIG. 63.—Diagram showing the theoretical distortion of the starchy : sugary ratio among the normal seeds when a defective seed factor is linked with the normal allelomorph of sugary. With complete linkage 33⅓ per cent sugary seeds are expected in the normal class.

TABLE 11. Segregation of Starchy and Sugary among the Normal Seeds of Ears also Segregating for Defectives.

Cross	Ear No.	Starchy	Sugary	% Sugary
*de*₁ x *su*	947	71	36	
"	951	213	89	
"	953	219	81	
"	956	98	32	
	Total	601	238	28.4
de_2 x *su*	1024	217	91	
"	1034	131	42	
"	1035	173	52	
	Total	521	185	26.2
de_3 x *su*	1013	255	98	
"	1016	352	100	
"	1017	223	89	
	Total	830	287	25.7
de_4 x *su*	1045	185	75	
"	1047	150	37	
"	1049	244	87	
	Total	579	199	25.6
de_5 x *su*	1056	334	97	
"	1058	330	115	
"	1068	421	128	
	Total	1085	340	23.9
de_6 x *su*	1107	66	37	
"	1108	138	55	
	Total	204	92	31.1
de_7 x *su*	1072	187	58	
"	1073	291	114	
"	1084	252	90	
	Total	730	262	26.4
de_8 x *su*	2432	287	111	
"	2433	252	75	
	Total	539	186	25.7
de_9 x *su*	1096	200	62	
"	1098	177	50	
"	1102	242	72	
	Total	619	184	22.9

TABLE II (*cont'd*). Segregation of Starchy and Sugary among the Normal Seeds of Ears also Segregating for Defectives.

Cross	Ear No.	Starchy	Sugary	% Sugary
de_{10} x *su*	996	278	88	24.0
de_{11} x *su*	969	295	104	
"	970	137	43	
"	971	228	54	
	Total	660	201	23.3
de_{12} x *su*	937	306	95	
"	938	298	105	
"	940	170	45	
	Total	774	245	24.0
de_{13} x *su*	1075	222	70	
	1079	135	51	
	Total	357	121	25.3
de_{14} x *su*	981	162	55	
"	988	345	111	
"	992	231	83	
	Total	738	249	25.2

With the exception of the cross involving de_7, the lethal factors and the factor for sugary endosperm have been contributed by opposite parents and linkage would be indicated by an excess of sugary seeds. In the cross of de_7, the *de* and *su* factors were introduced by the same parent and linkage would be indicated by a deficiency of sugary seeds.

The only crosses in which there is a noticeable distortion of the starchy-sugary ratio are those involving the de_1 and de_6 factors. In the former 28.4 per cent of the normal seeds are sugary. This is an excess of sugary seeds of 3.4 times the probable error and indicates linkage with crossing over of 38.5 per cent. Fortunately the defective seeds of this type can also be readily classified as to their endosperm texture and this is done in Table 12.

Among the defective seeds there is a marked deficiency of sugary individuals, only 20.6 per cent being found as compared to 28.4 per cent in the normal class. The amount of crossing over as determined from the defective seeds is 39 per cent. This agrees very closely with the percentage as determined from the normal seeds. The evidence is fairly good, therefore, that the de_1 and *su* factors are linked.

TABLE 12. Segregation of Starchy and Sugary among the Defective Seeds from Ears of a Cross de_1 x *su*.

Ear No.	Starchy	Sugary	% Sugary
947	42	10	19.2
951	75	27	26.5
953	85	18	17.5
956	45	9	16.7
Total	247	64	20.9
Ex. 3:1	233	78	25.0
Deviation	14	—14	4.4
Probable Error:	5.15		

In the cross of de_6 x *su*, 31.1 per cent of the normal seeds were sugary. This is an excess of 3.6 times the probable error and indicates linkage with crossing over of 26 per cent. Unfortunately the defectives on these ears could not be classified with regard to their endosperm texture and it is not so certain that linkage between de_6 and *su* exists, although it is strongly indicated. An excess of sugary seeds of 3.6 times the probable error would be expected as a chance deviation only once in about 65 trials.

The cross between the de_1 and de_6 factors shows independent inheritance of these two characters as is shown in Table 13. This would be expected even though both are linked with the *su* factor providing that the loci of the two lethals were on opposite sides of the *su* locus.

TABLE 13. Segregation in F_2 of a Cross between de_1 and de_6 Showing Independent Inheritance.

Ear No.	Normal	Defective
166	124	103
168	117	83
175	161	142
178	195	131
Total	597	459
Ex. 9:7	594	462
Deviation	3	—3

LINKAGE OF DEFECTIVES WITH EACH OTHER

In most varieties of maize there are ten pairs of chromosomes. (Kuwada 1915, Kiesselbach and Petersen 1925.) Therefore, in crossing thirteen different factors in all combinations some cases of linkage are almost certain to occur. The difficulty lies in their detection. With independent inheritance two defectives when crossed give a 9:7 ratio in F_2. With complete linkage these two defectives should give a 1:1 ratio. Thus the entire range of cross-

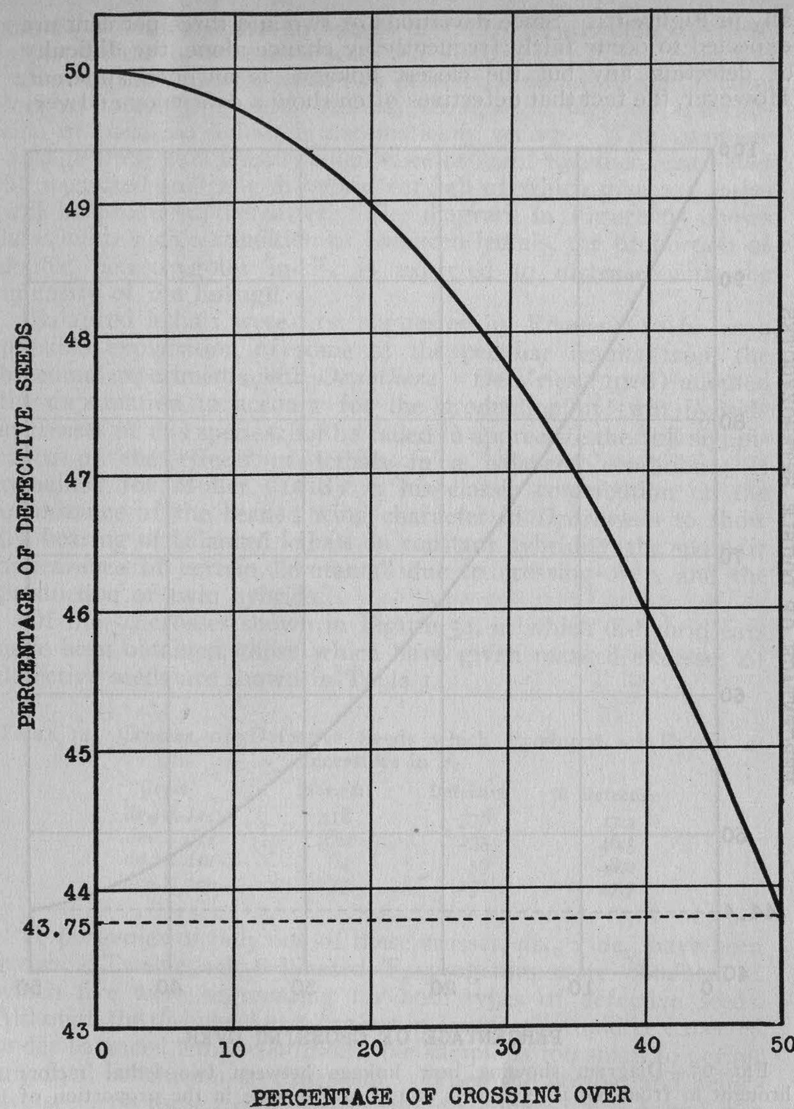

FIG. 64.—Diagram showing how linkage between two defective seed factors would distort the normal 9:7 di-hybrid ratio. If each defective is completely linked with the dominant allelomorph of the other, a 1:1 ratio is expected.

ing over from 50 per cent to 0 corresponds to a range of 43.75 to 50 in the percentage of defectives. This is shown diagrammatically in Figure 64. Since deviations of two and three per cent are expected to occur fairly frequently by chance alone, the difficulty of detecting any but the closest linkages is at once apparent. However, the fact that defectives often show a deficiency and very

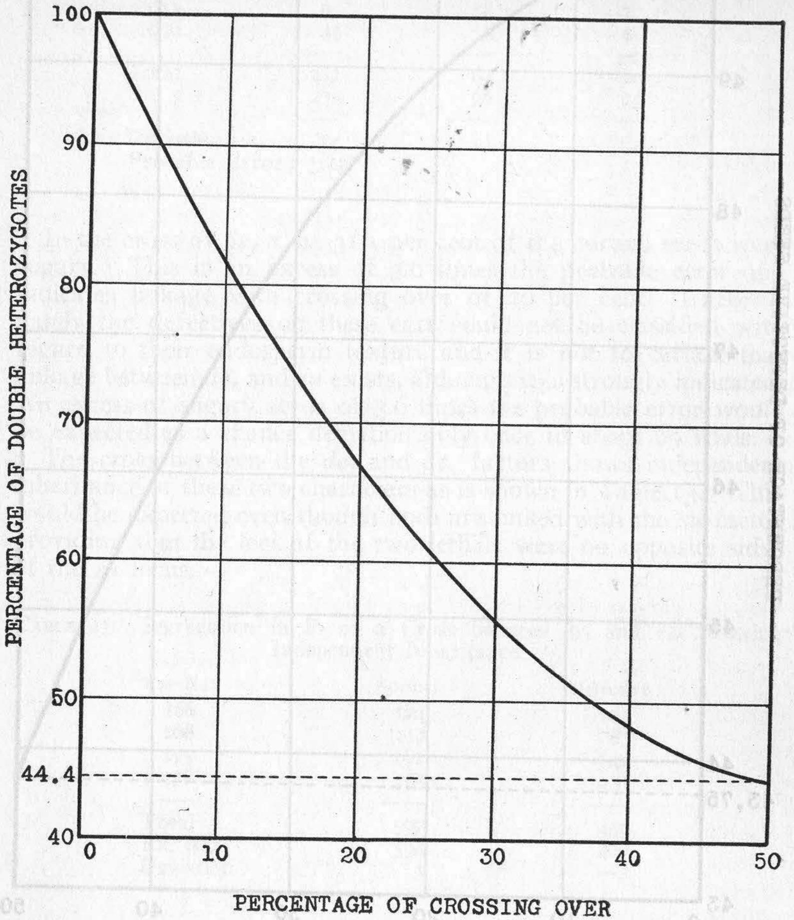

FIG. 65.—Diagram showing how linkage between two lethal factors brought in from opposite parents causes an increase in the proportion of heterozygotes.

rarely an excess, makes it necessary to regard any di-hybrid ears which produce more than 43.75 per cent defectives as possible cases of linkage. Further evidence must then be obtained by growing additional di-hybrid ears or by examining F_3 progenies. If the high percentage of defectives in F_2 is due to linkage, then

the F_3 should produce an excess of heterozygous plants as well as an excess of recessive seeds on a majority of the di-hybrid ears. In other words, when two defectives, whose factors occupy loci on homologous chromosomes, are brought together, a condition of balanced lethals is automatically set up. With complete linkage these two lethals, when once brought together, can never be separated and only di-hybrid ears all of which give 1:1 ratios will be produced thereafter. The diagram in Figure 65 shows how, with such a condition of balanced lethals, the proportion of double heterozygotes in F_3 is expected to increase with the intensity of the linkage.

Balanced lethals were first suggested by Renner (1916) as a possible explanation of some of the peculiar results from the breeding experiments with *Oenothera*. De Vries (1916) adopted the explanation to account for the production of twin hybrids in crosses of this species, but he failed to appreciate the full significance of the effects of lethals in a balanced condition. It remained for Muller (1918) in his classic contribution on the inheritance of the beaded wing character in *Drosophila* to show the bearing of balanced lethals on constant hybridity, the sporadic appearance of certain "mutants" due to crossing-over, and the production of twin hybrids.

Of the 59 crosses shown in Figure 54, in which di-hybrid ears have been obtained, those which have given marked excesses of defective seeds are shown in Table 14.

TABLE 14. Crosses of Defective Seeds which Produced an Excess of Recessives in F_2.

Cross	Normal	Defective	% Defective
de_{10} x de_3	418	376	47.4
de_6 x de_5	270	235	46.5
de_{10} x de_6	64	59	48.0
de_{14} x de_{11}	275	251	47.7

F_3 progenies of only one of these crosses, de_{10} x de_3, have been grown. Twelve self-pollinated F_3 progenies were obtained of which five were segregating for both types of defective seeds. Although the di-hybrid ears are not in excess, as would be expected under balanced lethal conditions, the sample is too small to permit any final conclusion on this point. When the normal and defective seeds on these five di-hybrid ears are counted, it is found that there is again an excess of the recessive seeds as is shown in Table 15.

When these five progenies are combined with the two F_2 progenies already shown, making a total of 1060 normal to 916 defectives, the deviation is 52 ± 13. The average percentage of defective seeds is found to be 46.3, which indicates linkage with crossing over of 38.5 per cent.

TABLE 15. Normal and Defective Seeds from F_3 Progenies of a Cross of de_{10} x de_8 Indicating Linkage between These Factors.

Ear No.	Normal	Defective	% Defective
858	112	99	46.9
859	130	100	43.5
862	132	112	45.9
867	125	105	45.7
868	143	124	46.4
Total	642	540	45.7
Expected	665	517	43.7
Deviation	—23		
P. E. = 11.5			

It should be mentioned, that with a condition of balanced lethals, occasional progenies are expected in F_3 in which there is a deficiency of recessives instead of an excess. This condition would be brought about through crossing over so that the two lethal factors, originally on homologous chromosomes, are now borne on the same chromosome. Thus unless the linkage between the two lethals were fairly close, so that the excesses and deficiencies within each progeny were sufficient to permit a separation, the two types of F_3 progenies would tend to balance each other and linkage would be almost impossible to detect.

LINKAGE OF DEFECTIVES WITH GROWTH FACTORS

The method of improving corn by selection in self-fertilized lines aims at the removal of all recessive abnormalities such as white seedlings and defective seeds. There seems to be a general belief that these factors have a deleterious effect, even in the heterozygous condition.

Lindstrom (1920) suggests that these recessive abnormalities, if they do have an unfavorable effect in the heterozygous condition, are permitted to persist in the germplasm only when they are linked with particularly good growth factors, and that in removing them by inbreeding, some of the best germplasm is lost. Jones and Mangelsdorf (1925) have shown, however, that inbred strains from which all recessive abnormalities have been eliminated, yield fully as well as sister strains which still carry one or more of these abnormal characters. Apparently nothing of value was lost through their elimination; neither was there any marked improvement when their supposedly unfavorable influence was removed. Still assuming that these factors have an influence in the heterozygous state, a probable explanation of these conflicting results is that the defective seeds and other lethal abnormalities are permitted to persist and accumulate, not because they are linked with especially good factors for development, as Lindstrom has suggested, but because their presence tends to keep short sections of the chromosomes which they occupy in a continued state of heterozygosity. The increased vigor which results from such enforced heterozygosity of the accompanying growth factors enables the recessive abnormalities to survive in the germplasm even though they have an unfavorable influence in themselves.

Furthermore, when two such lethal factors which occupy homologous chromosomes are brought together, a condition of balanced lethals is set up which may so increase the vigor of the stock by keeping whole chromosomes or large sections of chromosomes in a continued state of heterozygosity, that the lethals are actually given an advantage and are able to survive even though they are linked with especially poor growth factors instead of particularly good ones.

Shull (1923) has pointed out that varieties of *Oenothera* which carry lethal factors are, in general, more vigorous than those which lack these characters. The mechanism of crossing over in *Oenothera* appears to be different from that in most species as is shown by both cytological and genetic studies; Shull (1923), Cleland (1925). All of the characters so far studied in this species fall into a single linkage group and the amount of crossing over between the members of the group is relatively low. It is possible, therefore, that lethal factors in *Oenothera* keep all of the chromosomes, with their hereditary factors for growth and development, in a continued state of enforced heterozygosity. If such is the case, then the increased vigor brought about in *Oenothera* by the presence of lethal factors is probably more marked than would occur in other species where there are as many linkage groups as chromosomes.

A PLANT CHARACTER FOR DEFECTIVE SEEDS

In addition to the thirteen endosperm characters which cause one-fourth of the seeds on segregating ears to be defective, a plant character which causes defectiveness in all the seeds on one-fourth of the plants has been found.

This character appeared in the de_{13} stock which was received from Mr. H. A. Wallace of Des Moines, Iowa. Mr. Wallace had found among the plants of the variety "Illinois Two Stalk" several which produced only aborted seeds, and which appeared to be homozygous for defective seeds. Pollen from one of these plants applied to a hybrid of inbred strains known to be free of hereditary defectives produced only normal seeds. The F_1 plants grown from these normal seeds were selfed and produced some ears which were segregating for defective seeds of the type which has already been described as de_{13}. Not all of the ears were segregating, however, as should have been the case, had one of the parents been homozygous for the defective factor. Nor did the recessive seeds on the segregating F_1 ears resemble the aborted seeds of the pollen parent. The extracted recessives on the F_1 ears were completely aborted, appeared to have no endosperm tissue and showed no germination whatever. It was difficult to understand how this type could have been obtained in a homozygous condition, or why, if the pollen parent was homozygous for defective seeds, only part of the F_1 ears were segregating for the character.

This confusing situation was cleared up, however, when a large number of F_2 ears, which had been grown for another purpose, were harvested. A total of 201 F_2 ears were examined and of these 51, or almost exactly one-fourth, bore only aborted seeds and were identical in appearance to the ears of the grandparental pollen parent. The other 150 ears were normal in appearance although some were segregating for defective seeds and others were not.

Apparently the plant of "Illinois Two Stalk" which served as the pollen parent for this cross, in addition to being heterozygous for a recessive endosperm character de_{13}, was homozygous for a recessive plant character, to which the symbol de_{pl} may be given. On this hypothesis the genetic composition of the parental stocks and the F_1 seeds is as follows:

Pollen parent	$De_{13}\ de_{13}\ de_{pl}\ de_{pl}$
Seed parent	$De_{13}\ De_{13}\ De_{pl}\ De_{pl}$
F_1 Seeds	$De_{13}\ De_{13}\ De_{pl}\ de_{pl}$
	$De_{13}\ de_{13}\ De_{pl}\ de_{pl}$

Half of the F_1 seeds when selfed should produce ears segregating for the endosperm character de_{13}. The other half should give only normal seeds. Apparently these conditions have been met; of the five F_1 ears which had been selfed 3 were segregating for defective seeds and two were not.

That the new variation de_{p} is actually a plant character is further demonstrated by the fact that the recessive plants produce only defective seeds regardless of the pollen which they receive. If it were an endosperm character cross pollination with normal plants should give only normal seeds.

The seeds on the defective ears show considerable variation in development, some being almost completely defective, others only partially so. None, however, are as fully developed as normal seeds, though many are capable of germination and when grown produce fairly vigorous plants which in turn bear only defective ears. Defective ears from such homozygous plants are shown in Figure 66.

There seems to be no relation between the defective seed type which appeared in the F_2 endosperm generation and the defective ears which came to light in the F_2 plant generation. The fact that both came out of the same cross is regarded merely as a coincidence. The two have now been separated and stocks segregating for one and lacking the other have been obtained.

This variation is of interest in connection with the defective seeds because it produces practically the same effect in the individual seeds as do some of the endosperm characters.

The character of the endosperm is usually determined by the genetic constitution of the zygote* which results from the fusion of the endosperm nuclei with a sperm nucleus. The defective ear, however, represents a condition in which the expression of the hereditary factors of the new sporophyte is prevented. Apparently there is present or lacking, in the recessive plants, something which causes all of their seeds to be aborted regardless of the genetic constitution of the seeds themselves. Such a situation might be compared to a population of plants in which all the plants were dwarfed because of a lack of moisture or fertility,

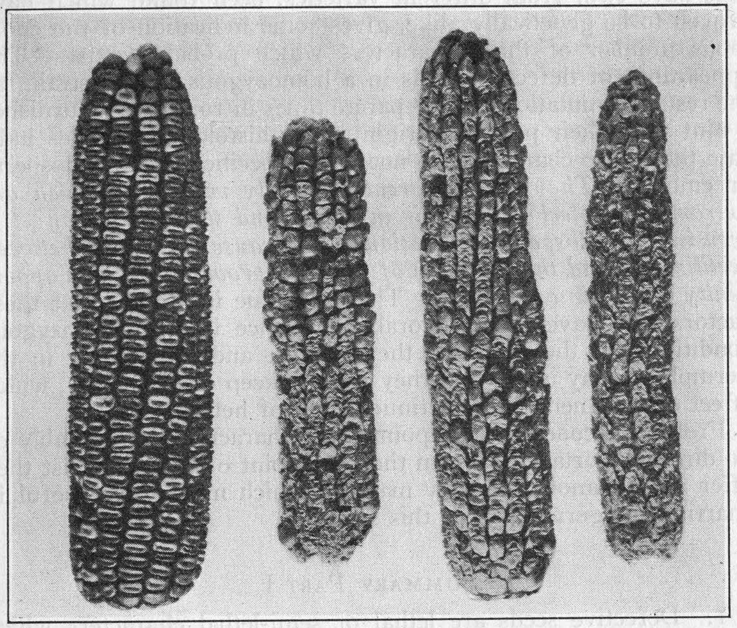

FIG. 66.—Normal and defective ears of the de_{pl} stock. This factor causes all of the seeds on one-fourth of the plants to be defective regardless of the genetic constitution of the endosperm.

* To be strictly accurate, perhaps the term "zygote" ought not to be applied to the endosperm, but its use in this connection is probably less confusing than would be the adoption of a new term.

while in a better environment some of the plants would be tall and others dwarfed, because of the hereditary factors which they carried.

DISCUSSION

The fact that defective seeds have been noted in almost every variety of maize which has been examined and that only in one case have two, from different varieties, been found which have proven to be genetically alike, gives some indication of the enormous number of these characters which probably exist. The appearance of defective seeds in a homozygous inbred strain, as the result of mutation, four separate times in four years, furnishes a hint as to their probable origin. The histological studies indicate that these characters do not affect specifically the endosperm or embryo. *They are, apparently, merely variations which are extremely deleterious in their influence and their major effect is seen in the endosperm generation only because the period between fertilization and the maturity of the seed provides the first opportunity for their expression.* There is some indication that these factors also have an unfavorable influence in the heterozygous condition and the fact that they survive and accumulate in the germplasm may imply that they tend to keep other factors, which affect development, in a continued state of heterozygosity.

From the economic standpoint these characters are probably of no direct importance. From the standpoint of the geneticist they offer a vast amount of new material which may prove useful in charting the germplasm of this species.

SUMMARY PART I

1. Defective seeds are lethal or semi-lethal characters which affect the normal development of the seed.

2. These characters have been noted in many varieties of maize and it is estimated that one plant in every thirty, on the average, is heterozygous for defective seeds.

3. Defective seeds have been the most frequent variations to arise by mutation in homozygous inbred strains of maize.

4. Fourteen stocks segregating for defective seeds have been crossed in 82 combinations. Only two of these which are genetically alike have been found.

5. Histological studies show that normal fertilization apparently occurs in the formation of these seeds, and that both endosperm and embryo are produced. These structures develop very slowly, however, and remain rudimentary. Both are affected to almost the same degree by the influence of the lethal factors.

6. The relative development of the fourteen stocks of defective seeds as compared to normal seeds on the same ears ranges from 2.4 per cent to 59 per cent, based upon the dry weight of the seeds.

7. The following indications of linkage have been encountered: The de_2 factor with a factor for white seedlings, probably the w_2 factor, which is a representative of the second linkage group. Crossing over is about 11 per cent.

The de_1 and de_6 factors with the factor for sugary endosperm which is a representative of the third linkage group. Crossing over in the first case is 39 per cent, in the second 26 per cent.

Linkage between two different defectives is indicated in four crosses.

8. In addition to the 13 endosperm characters which cause one-fourth of the seeds to be defective, a plant character which causes all of the seeds on one-fourth of the plants to be defective, has been found.

PART II

Non-Hereditary Defective Seeds

Almost every ear of maize bears some aborted seeds. On most ears only a few of these are found scattered at random throughout the inflorescence; on others, entire regions of the ear produce only defective kernels. These undeveloped seeds have commonly been attributed to "imperfect pollination" though it has never been clear just what conditions were included by this term. It is now evident that many of these abortive seeds are lethal or semi-lethal characters, inherited as simple Mendelian recessives, but it must also be recognized that there are, in addition to the hereditary characters, various other types of defective seeds which do not appear to have an hereditary basis or at any rate are not inherited as recessive endosperm characters.

These non-hereditary types are formed regardless of whether the ear is self-pollinated or cross-pollinated. They are found in all varieties and occur as frequently in homozygous inbred strains as in ordinary heterozygous varieties. In appearance they are practically identical to some of the hereditary types, and in separating dominant and recessive individuals from a segregating ear, they are included with the latter. Because they sometimes represent a significant source of error in classification, it has been considered important to determine the frequency of their occurrence, the conditions causing their production and, if possible, some means of distinguishing them from the Mendelian characters which they resemble so closely.

A microscopic examination of sectioned material from various sources showed that there are at least four morphologically distinct types of non-hereditary defective seeds and that these are probably produced as the results of the following conditions:

1. Stimulus resulting from pollination without fertilization. (Parthenocarpy.)
2. Arrested development due to competition, dominance or other physiological conditions.
3. Irregularities in the mechanism of fertilization.

PARTHENOCARPIC DEFECTIVES

The first of these four types was found on an ear which had been bagged as a pollination check. After a period of several weeks, the silks grew to such a length that some of them protruded from below the bag and became exposed to pollen. As a result, a few of the ovules on this ear developed slightly. These were not normal in appearance and contained, instead of the usual milky fluid, only a clear watery liquid and a jellylike tissue.

Microscopic examination of sections of these ovules showed that their development was due entirely to a marked growth of nucellus. The embryo sac was readily recognized, though it had begun to disintegrate at the apical end and the antipodals had moved into the nucellar tissue. Within the sac was found some disintegrated granular material and, in several specimens, the egg and polar nuclei were still visible. No indications of fertilization were found in any of the sections and no remains of the pollen tube could be distinguished, although these might have been present and not have been clearly brought out by the stain used. In no case was there the slightest trace of endosperm or embryo. The nucellus in maize is very distinct from the endosperm and there is little danger of confusing these two tissues. In none of the specimens examined did the nucellus show any indication of starch grain formation. A photomicrograph of one of these ovules is shown in Fig. 4, Plate XXVI.

The natural conclusion is that no fertilization occurred in these partially developed ovules. Either the pollen tubes failed to reach the micropyle, or if they reached it, failed to accomplish fertilization. Apparently, however, the tubes in growing down the styles had in some way transmitted a stimulus to the ovule which resulted in a marked growth of the nucellus and pericarp, even though fertilization did not occur.

Though the nucellus of maize is of minor importance in the mature caryopsis, becoming compressed into a thin integument by the pressure of the growing endosperm, yet these partially developed, though unfertilized, ovules are comparable in certain respects to some of the seedless fruits which are produced in the absence of pollination, and to which the term "parthenocarpic" has been applied.

The term "parthenocarpy" was first used by Noll (1902) to describe the situation in which certain plants, under exclusion of pollen, are able to form fruits outwardly normal, or nearly so, but in which the seeds are absent or aborted. Noll reported this condition in the cucumber and Ewert (1909, 1910) has noted it in other fruits.

Winkler (1908) makes a distinction between "stimulative" parthenocarpy in which the seedless fruits are produced only after pollination with their own or foreign pollen or in consequence of an insect prick or other irritation, and "vegetative" parthenocarpy in which the seedless fruits occur without the action of pollen or other stimuli.

Wellington (1913) found that in Nicotiana species, capsules were caused to swell by merely tickling them with a sharp-pointed instrument. Abortive seeds, probably without embryos, were produced by singeing the buds with a hot wire, by exposure of the plants to chloroform gas, and by cutting away a portion of the pistil and pollinating the stub, or by grafting the stigmatic end of another pistil to the excised one and pollinating the new pistil.

These abortive ovules of Nicotiana, as well as those of maize, if they can be legitimately termed parthenocarpic, fall into the category of "stimulative" parthenocarpy since they represent a development brought about by stimuli other than fertilization.

An inflorescence of maize from which pollen has been excluded throughout the season is shown in Fig. 67. Maize never produces seeds of any description in the complete absence of pollen though it may be possible to produce with artificial stimuli, such as used by Wellington in Nicotiana, the same development of the ovules which results when pollen tubes enter the style without accomplishing fertilization.

Parthenocarpy is not to be confused with parthenogenesis. In the former no embryo is produced, in the latter normal seed formation may occur. Parthenogenesis occurs regularly in some plants but, so far as is known, has never been found in maize or closely related species. Parthenocarpy, on the other hand, may be widely distributed. In species such as maize, however, where the stimulated parts are of little importance, parthenocarpy is of significance only as it has a bearing on the physiology of pollination, or represents a source of error in genetic experiments.

SOME CONDITIONS WHICH INFLUENCE THE FREQUENCY OF PARTHENOCARPIC DEFECTIVES IN MAIZE

Several conditions noted in the experience of making artificial pollinations in maize suggested the possibility that the frequency with which parthenocarpic defectives are produced probably depends to a large extent on the age of the silks. As already mentioned, these seeds were first noted on ears which had received no pollen until several weeks after the silks had emerged. An inbred strain of flint corn in which the husks are extremely long, so that the silks must attain a length of 50 cm. or more before emerging, regularly produces a large proportion of parthenocarpic defectives. This same strain bears normal seeds when the husks are cut back.

These conditions suggest that the silks may become of such a length that the pollen tubes are no longer capable of reaching the micropyle or that the embryo sac, after lying idle for so long a period, becomes disorganized and is no longer capable of entering into fertilization even though the styles still retain their receptivity and furnish a medium for the growth of the pollen tubes.

Parthenocarpic defectives are also frequently produced on ears which have been artificially pollinated several days sooner than the normal time. In making hand pollinations it is sometimes necessary to use ears from which the silks have not yet emerged. The husks are cut back to the tip of the spike, exposing silks which under natural conditions would not have been pollinated until

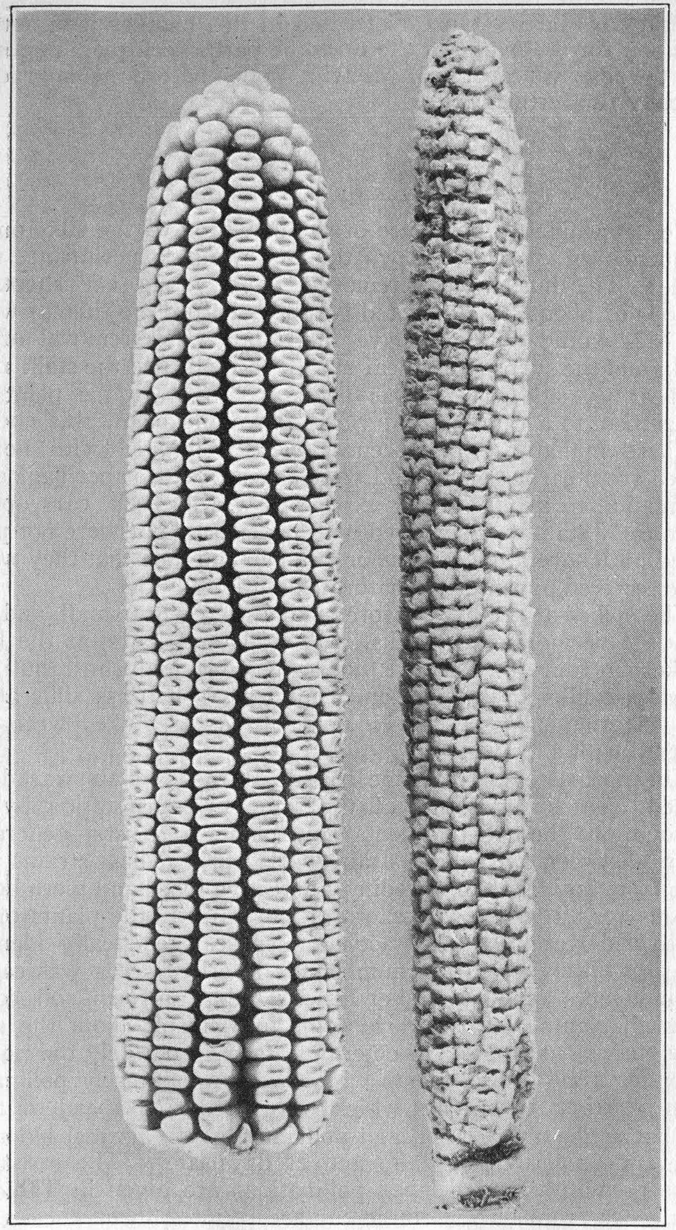

FIG. 67.—An inflorescence from which pollen has been excluded throughout the season, compared to an open-pollinated ear from the same strain. No development of any kind occurs in the complete absence of pollination.

several days later. On ears treated in this manner it is not uncommon for the ovules at the tip to be parthenocarpic, suggesting that the silks are capable of receiving pollen before the embryo sac is ready for fertilization.

INFLUENCE OF AGE OF SILKS

To determine the influence of the condition of the silks on the frequency of parthenocarpy, the following experiments were made: The husks were removed from young ear shoots at periods of about six, four, and two days before the time at which the ears would normally have silked out. The removal of the husks and the surrounding leaf sheath so weakened the stalk at the ear-bearing node that it was necessary to brace the plants by tying them to a thin strip of wood above and below this node.

These immature inflorescences were pollinated with normal pollen from earlier plants and were covered with paper bags after pollination to avoid further exposure. As a check, ears opened at an early stage were covered with paper bags but were not pollinated until several days later, or at about the time that they would have received pollen under natural conditions.

The spikes at six days before silking were very small, and had only a few rudimentary silks, without lateral hairs, at the base. Spikes at four days before flowering time had short but well developed silks at the base and rudimentary hairless silks at the tip. At two days before blooming time the spikes were well covered with silks.

The normal blooming time for all of these plants was determined from sister plants of the same first generation hybrid. Throughout these experiments only plants of a first generation hybrid between two inbred strains were used. These strains were free from any types of hereditary defective seeds and were homozygous for all visible characters. Consequently the plants of the F_1 hybrid were, for all practical purposes, genetically identical and any difference in the number of defective seeds was caused by influences other than heredity. Under uniform soil conditions all plants of this hybrid come into silk at about the same time, making it possible to determine fairly accurately the normal blooming time of the plants which were prematurely pollinated.

In addition to the ears which were pollinated ahead of time, another series was bagged and pollinated at the normal blooming time and at periods of 7, 17 and 25 days later. The results of these premature and delayed pollinations are given in Table 16. The seeds from only a single ear are counted in each case. In the pollinations made at six days before blooming time no seeds were set and in that made at 25 days after silking all the ears

Table 16. Influence of the Age of Silks upon the Percentage of Parthenocarpic Defectives.

Days before or after Silking	Total No. of Seeds	No. of Defectives	Percent Defective
6 days before	0	0	0
4 " "	237	85	35.9
2 " "	121	8	6.6
Normal time	783	8	1.0
7 days after	678	11	1.6
17 " "	382	83	21.7
25 " "	60	10	16.7

except one were barren. The one exception produced 60 poorly developed seeds at the tip of the spike of which 50 contained endosperm and embryo and ten were parthenocarpic.

These results indicate that the silks are apparently receptive to pollen for a period greater than that during which fertilization can occur, and that pollinations which are made very early or very late do not accomplish fertilization in many cases but succeed merely in inducing a development of the nucellus and pericarp.

INFLUENCE OF THE AGE OF POLLEN

An experiment was also made to determine whether the condition of the pollen has any influence on the proportion of parthenocarpic defectives which are produced.

This experiment was planned to test the pollen at regular intervals of six hours after collection. In order to avoid the necessity of making some of the pollinations during the night, two collections were made. The first, designated as A in the table, was made at noon, the second, B, from the same plants in the evening, about seven hours later.

The pollen was kept in a cool basement room where the temperature and humidity were relatively constant. Pollinations with the two lots were made every twelve hours on silks which were trimmed off, as nearly as possible, to a uniform length, and a supply of pollen ample to insure full ears under natural conditions was applied. Three ears were pollinated for each six hour period up to 44 hours, which, from previous experience, was considered the maximum period of viability for maize pollen.

When the ears were harvested a marked difference was noted in those resulting from the two lots of pollen. Ears produced from pollination with Lot A were completely filled with the exception of those resulting from the 44 hour pollen. Ears from the B lot were all poorly filled, the earlier pollinations showing a few missing kernels, the later ones, many. Apparently the pollen collected in the evening was injured in some way, perhaps by the higher humidity of the atmosphere at that time.

One ear from each pollination was shelled and the normal and defective kernels counted. The figures are given in Table 17.

TABLE 17. Influence of the Age of Pollen upon the Percentage of Parthenocarpic Defectives.

Hours after Collection	Total No. of Seeds	No. of Defectives	Percent Defective
Lot A			
7	586	23	3.9
19	641	19	3.0
31	718	14	2.0
44	585	46	7.9
Lot B			
0	788	47	6.0
13	554	51	9.2
24	543	57	10.5
37	161	45	28.0

It is noted that in Lot A, where there was apparently an abundance of good pollen at all periods, there is little change in the percentage, of defective seeds, accompanying the increase in age of the pollen. In the ears of Lot B, however, where the number of viable pollen grains was never enough to give completely filled ears, the percentage of parthenocarpic defectives increased progressively with the age of the pollen, beginning with 6.0 per cent at time of collection and ending with 28.0 at 37 hours.

There seems to be no question that the age of pollen has some influence on the frequency with which the parthenocarpic defectives occur. It is probable that in the older pollen many of the grains are capable of germinating but are not vigorous enough to reach the micropyle, and succeed merely in transmitting a stimulus which induces the development of the nucellus and pericarp. Where there is an abundance of pollen these weakened pollen tubes produce no effect since fertilization can be accomplished by more vigorous tubes growing in the same styles. Where the supply of viable pollen is limited, however, so that in many of the styles there is no such competition, the weakened pollen grains germinate but succeed only in producing parthenocarpic defectives.

There are, no doubt, other conditions which influence the appearance of parthenocarpic defectives. Any unfavorable weather conditions, for example, which might prevent the pollen tubes from reaching the micropyle, would probably result in the formation of parthenocarpic defectives. In artificially self-pollinated ears where an abundance of pollen is applied to ears that are fully silked out, the proportion of parthenocarpic seeds which are scattered throughout the ear remains relatively constant. In ears in which it is evident that a large number of these seeds are present

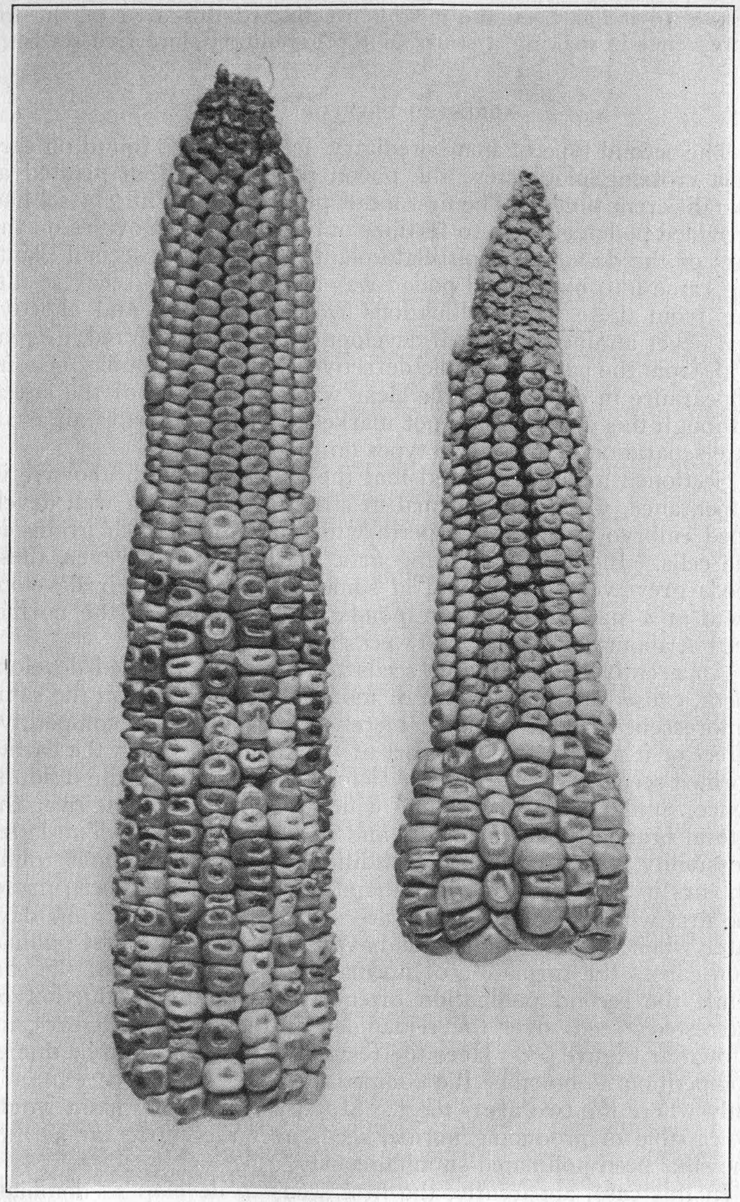

FIG. 68.—Ears which have been pollinated two separate times. The first pollination resulted in normal seeds; the second, made some days later, produced only "arrested" seeds.

at the tip it has been the custom to discard this area of the inflorescence in making a study of the hereditary defective seeds.

ARRESTED DEVELOPMENT

The second type of non-hereditary defective was found on ears in a crossing plot where the pollen parent had been planted at two different times. The first lot of plants to come into tassel had provided pollen enough to fertilize only a few of the ovules on the ears of the de-tasselled pistillate plants. When the second planting came into bloom and pollen was again shed, the seeds resulting from these later pollinations were very small and abortive and never attained a normal development. They differed, in general, from the parthenocarpic defectives, in having a milky opaque appearance in contrast to the clear watery condition of the latter, although this distinction is not marked enough to permit an accurate separation of these two types on the same ear.

Sectioned material showed that these seeds, though abortive in appearance, were quite normal in structure, having a well developed embryo and an endosperm with numerous starch grains in the cells. Instead of growing at a normal rate, however, these seeds grew very slowly and in some cases ceased their development at a stage which corresponds to that found in the normal seed at about ten days or two weeks after fertilization.

Apparently these abortive seeds represent an arrested development, caused by the presence of more advanced seeds on the same inflorescence. This may be merely the result of a competitive effect or it may be due to a sort of "dominance" which the earlier formed seeds have over the physiological processes of the inflorescence, similar to the advantage which a growing tip has over the lateral branches both in plants and in lower animals. The latter possibility is suggested by a condition which is sometimes found on ears in which two separate hand pollinations have been made, the first when only a few silks are out, and the second some days later when the remaining silks have appeared. The first pollination causes the formation of normal seeds at the base of the ear, while the second pollination often results in the production of "arrested" seeds over the remainder of the ear. Such ears are shown in Figure 68. Here the results do not appear to be due to competition alone since the competitive effect would be expected only where the two areas meet. Moreover, the same plant would be capable of producing normal seeds over the entire ear had all the silks been pollinated simultaneously.

In this case, apparently, the first seeds to develop so dominate the physiological processes of the plant, that the later seeds are deprived of normal nourishment. In fact it is not uncommon in such ears for the area containing the arrested seeds to be completely cut off so that the upper part of the spike disintegrates and is finally pushed off completely.

Seeds of the arrested type are not an important source of error in the defective seed studies, since they occur most commonly when all the silks are not pollinated simultaneously. In some strains, however, they occur regularly even when all the silks are pollinated at once. In such strains due allowance must be made for the disturbance which they cause in the ratios.

IRREGULARITIES IN THE FERTILIZATION MECHANISM

The non-hereditary defectives which are believed to be due to irregularities in the fertilization process are morphologically of two types. The first of these, designated as "germless," contains an endosperm but lacks the embryo, while the second type, termed "miniature," has both structures though these are greatly reduced in size.

In the germless seeds the development of the endosperm varies from a condition in which only a small mass of mealy tissue occurs to one in which well defined floury and corneous regions are distinguishable. In the miniature type the endosperm and embryo are both apparently normal, though the former is greatly compressed by the pressure of the normal seeds on either side and the latter is scarcely half the size of a normal embryo.

These types are found in small numbers on almost any ear of maize. A count of the seeds on fourteen open-pollinated ears of a hybrid between inbred strains known to be free from hereditary defectives, gave total of 10,235 seeds of which 50 or approximately one out of every 205 seeds was germless. The miniature seeds on nine of these ears were also counted and fifteen were found in a total of 6,245 or one in every 416 seeds. The germless seeds apparently occur about twice as frequently as the miniature type.

The suggestion that these two types of non-hereditary defectives, particularly the germless type, are due to irregularities in fertilization, comes from a microscopic examination of sectioned material. In specimens fixed at the early dough stage, it was found that the germless seeds contained normal endosperm tissue and an aleurone layer but that no trace of embryo tissue was present. Opposite the micropyle was a cavity in the endosperm and this appeared to be a remnant of the embryo sac. Within the cavity was found, in two specimens, a single large nucleus, to all appearances the unfertilized or undivided egg, or perhaps the polar nucleus. A photomicrograph of one of these specimens is shown in Figure 3, Plate XXVI.

Apparently this represents a case of single fertilization, in which one of the female nuclei had never been fertilized or, if fertilized, had not divided. The other nucleus, after fusion, or as the result of some other stimulus, had divided and produced an endosperm, which, though greatly reduced in size, was normal in structural details, the cells being packed with starch grains.

There is, of course, the possibility that fertilization did not occur at all; that the aborted endosperm was produced vegetatively by the division of the polar nuclei. The endosperm of maize is usually the product of a sexual fusion in which one of the sperm from the pollen tube fuses with the two polar nuclei of the embryo sac. In gymnosperms, however, and in some angiosperms, the endosperm is formed independently of any fusion and in some species, where fusion naturally occurs, endosperm formation may be induced by artificial stimuli.

From the experience of artificial pollinations in maize it can be positively stated that no development of the endosperm occurs in the complete absence of pollination. However, the parthenocarpic defectives, already described, show that the mere growth of the pollen tube in the style, transmits a stimulus to the ovule which causes the nucellus to expand and the pericarp to grow. It would, therefore, not seem to be an impossibility for the same stimulus of pollination to occasionally induce endosperm formation even though actual fertilization did not occur. In other words, a condition regularly found in the gymnosperms and some of the angiosperms, might be encountered occasionally as an irregularity in this particular angiosperm.

That the endosperm of the germless seeds is not produced vegetatively by the division of one or both of the unfertilized polar nuclei, is shown by a series of pollinations in which dominant aleurone and endosperm color characters are introduced by the pollen parent. On ears of a variety with white endosperm pollinated by one in which the endosperm is yellow, all of the germless seeds with sufficient tissue to show any color, were yellow. On ears of a strain with colorless aleurone, pollinated by a type with purple aleurone, the most developed of the germless seeds were purple. The appearance, due to xenia, of these dominant characters from the pollen parent, leaves no doubt that the male nucleus has taken part in the formation of the endosperm tissue of these aberrant seeds and that they are not the result of a vegetative division of one or both of the polar nuclei.

On the other hand, if the germless seeds are due to single fertilization, as first suggested, it seems rather strange that seeds containing an embryo, but lacking the endosperm, are not found as frequently as the reciprocal combination. If only one fertilization occurs, the fusion of egg nucleus and sperm might be expected to take place as frequently as that of polar nuclei and sperm, since under normal conditions the two usually occur almost simultaneously. (Weatherwax 1919, Miller 1919.)

There is the possibility that seeds of this type do occur but that the embryo is so dependent upon the endosperm for nourishment that it fails to develop in the absence of the latter, and seeds resulting from a fusion of sperm and egg nucleus alone are classified as parthenocarpic defectives.

Another possibility is, that if single fertilization occurs at all, it always results in formation of an endosperm regardless of which of the nuclei of the embryo sac was fertilized. Such a situation would be in interesting contrast to other species where irregularities of this sort usually result in the production of embryos. In *Naias major,* for example, Guignard found that in some cases the second male nucleus fused with the synergid

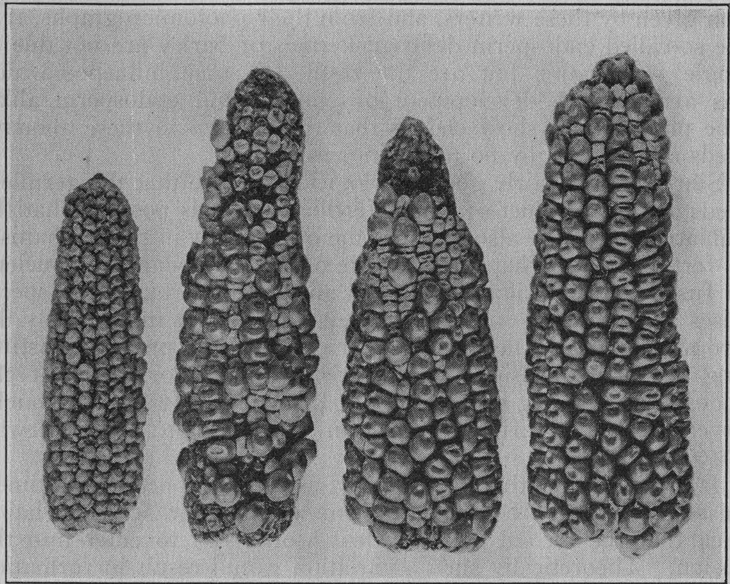

Fig. 69.—Four open-pollinated ears of a homozygous inbred strain showing the varying proportions of non-hereditary defective seeds which may occur under natural conditions.

instead of the primary endosperm nucleus. When this occurred two embryos and no endosperm were produced.

The possibility that single fertilization always results in endosperm formation in this species, is offered only as a suggestion. It seems more probable that seeds with embryos but lacking an endosperm are so poorly developed that they are classed as parthenocarpic and it is expected that such specimens will be encountered when more of the parthenocarpic defectives in early stages of development are examined microscopically.

In this connection it may be mentioned that Harlan and Pope (1925) have recently described a number of defective seeds in barley, in part of which no embryo could be found, in the remainder no endosperm, both types being attributed by them to single fertilization. In the so-called "endosperm deficient" kernels, however, disintegrating masses of tissue whose cells show early stages of starch grain formation are found. These writers believe this tissue to be of nucellar origin.

In the parthenocarpic defectives of maize, in which the nucellus is stimulated to such a marked degree, no evidence of starch grain formation has been found in any stage. Though the possibility of the nucellus assuming the role of an endosperm under some conditions is not denied, it seems more probable, from the description given by these writers, and from their photomicrographs, that the so-called endosperm deficient kernels of barley are not due to single fertilization but are the result of some influence which has arrested the development of embryo and endosperm alike. The photographs show clearly that the embryo in these abortive seeds of barley is by no means normal.

Since there is fairly good cytological evidence that the germless seeds are the product of single fertilization, it is possible that the miniature seeds are also due to some irregularity in the mechanism of fertilization, perhaps to a failure of the antipodal polar nucleus to fuse with the micropylar polar nucleus. Normally the sperm fuses first with the one polar nucleus and almost immediately the two are joined by the second polar nucleus, this process constituting the "triple fusion" characteristic of the formation of the endosperm in many angiosperms. In maize the two polar nuclei never fuse until after fertilization (Miller 1919, Weatherwax 1919).

It is conceivable that occasionally, as often as once in 416 times, this exceedingly precise mechanism might show some variation such that the second polar nucleus would fail to enter into the fusion. Theoretically such a variation would result in formation of embryo and endosperm, though the latter, being the product of the fusion of two haploid entities instead of three would have the diploid instead of the usual triploid number of chromosomes and might be expected to be somewhat reduced in size, as a consequence.

Such a condition is not to be confused with that suggested by Webber (1900) as a possible explanation of mosaic seeds in which part of the endosperm shows maternal characters, the remainder paternal. Webber thought that these seeds might be due to a fusion of the sperm with one polar nucleus while the second polar nucleus divided vegetatively, the two tissues growing side by side. East and Hayes (1911) suggested that these seeds were due to a vegetative segregation, and Emerson (1921) has recently

presented considerable evidence indicating that the mosaic seeds are the result of non-disjunction of single pairs of chromosomes.

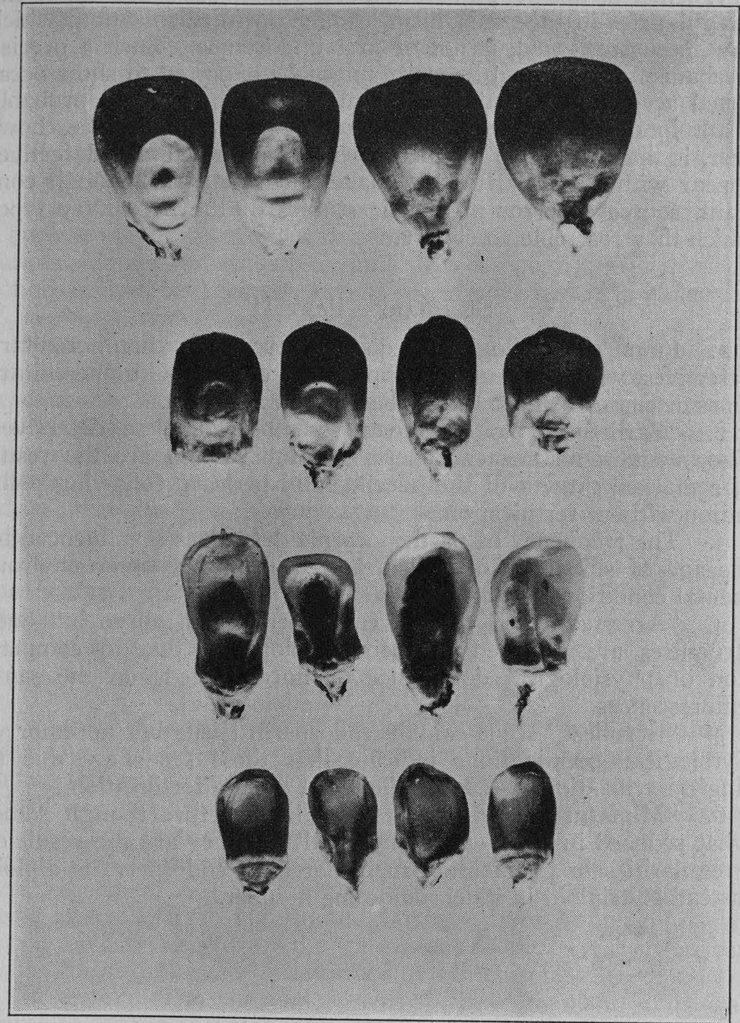

Fig. 70.—From top to bottom: normal, miniature, germless, and parthenocarpic defectives from same ear. The miniature seeds contain both endosperm and embryo, the germless seeds only an endosperm, while the parthenocarpic defectives lack both structures.

The suggested expanation of the miniature seeds, on the other hand, is that one of the polar nuclei is fertilized but that the other, failing to fuse, does not divide and plays no part in formation of the endosperm.

Whether or not the miniature and germless seeds are due to the irregularities in the mechanism leading up to fertilization, which have been suggested, is not of first importance. Such a precise mechanism as is found in maize might be expected to show occasional accidental variations, and such variations would probably result in defective seeds. The fact of main importance, however, is that these two distinct types of non-hereditary defectives appear with a regularity that makes them a small, though constant, source of error in genetic studies of the hereditary types which they resemble so closely.

Summary—Part II

1. Four morphologically distinct types of non-hereditary defectives, which resemble in appearance certain of the hereditary types discussed in Part I, have been found.

2. "Parthenocarpic defectives resemble complete defectives. They contain neither endosperm or embryo and are the result of a marked growth of the nucellus and pericarp following pollination without fertilization.

3. The frequency of parthenocarpic defectives is influenced by the age of silks, age of pollen, and probably by other environmental conditions.

4. "Arrested" seed contain endosperm and embryo but both structures are retarded in their development due to competition or physiological dominance of normal seeds on the same inflorescences.

5. "Germless" seeds contain endosperm tissue but no embryo. Cytological examinations indicate that these seeds are due to single fertilization instead of the usual double fertilization.

6. "Miniature" seeds are normal in structure though somewhat reduced in size. It is suggested that they are the result of irregularities in fertilization such that their endosperm is diploid instead of triploid in its chromosome number.

PART III

Genetic Factors Which Influence the Texture of the Endosperm

In addition to the thirteen, and probably many more, genetic factors which primarily affect the *amount* of endosperm produced, there are a number of others which govern the chemical or physical nature of the storage material and result in differences in the *texture* of the endosperm.

Several of these factors are already familiar to geneticists. Three of them, sugary, waxy, and shrunken, are inherited as simple Mendelian recessives and are complementary in their action, crosses between any two of these types resulting in starchy F_1 seeds.

The texture of the endosperm of flint and flour varieties of corn has also been found to show alternative inheritance in some crosses. These characters differ from the other three in that a double dose of one is always dominant to a single dose of the other, with the result that the F_1 seeds of a cross are always maternal in appearance no matter which way the cross is made, while the F_2 progenies show a 1:1 segregation no matter which type of F_1 seeds is planted. (Hayes and East, 1925.)

To these already familiar characters affecting the texture of the endosperm, must be added another one, *brittle,* which has appeared in the course of these investigations.

BRITTLE ENDOSPERM*

In 1922, in a lot of about 100 self-pollinated ears of Sanford White, a typical eight-rowed, New England flint variety, were found two ears which segregated for an endosperm character which had not been noted previously. In appearance the recessive seeds on these two ears were somewhat similar to the familiar sugary seeds, being translucent instead of opaque and wrinkled instead of smooth. They differed from sugary seeds, however, in being generally less wrinkled and having a more shrunken appearance. In fact, except for the translucent condition, they were not unlike the shrunken seeds described by Hutchison.

On examination, the endosperm of these aberrant seeds was found to consist of a mass of amorphous tissue, distinctly sweetish to the taste and very brittle in texture. Because of this latter feature the new character has been given the name *brittle* endosperm and the factor symbol *bt.*

* Prof. J. B. Wentz, Iowa State College, writes that he has recently sent to the Journal of Heredity a manuscript in which he describes this same character as *concave.*

Some of the brittle seeds from one of these ears were planted in 1923. Though the germination was poor and the plants lacked somewhat in vigor, a few self-pollinated pure brittle ears were obtained. The original segregating ear and one of the brittle ears derived from it are shown in Figure 71.

When outcrossed to an unrelated stock the brittle seeds reappeared in the F_2 endosperm generation as simple Mendelian recessives. A count of the normal and brittle seeds from five self-pollinated ears of such a cross is given in Table 18.

TABLE 18. Starchy and Brittle Seeds on Self-pollinated Ears.

Ear No.	Starchy	Brittle
1747	212	61
1748	349	91
1749	273	93
1750	190	57
1751	335	104
Total	1359	406
Ex. 3:1	1324	441
Deviation 35		
P. E., 12.27		
Dev./P. E., 2.9		

Because this new character resembled, in some respects, both sugary and shrunken endosperm, it was crossed with both of these. The F_1 seeds in both series of crosses were starchy, indicating that brittle endosperm is a condition genetically different from either sugary or shrunken.

SUGARY X BRITTLE

Although the brittle seeds on the original segregating ear were similar to sugary seeds in appearance, the two types were distinguishable and could be separated with a fair degree of accuracy when both occurred on the same ears. In addition to the general differences already mentioned, it was noted that on ears of which all the seeds were genetically white, the brittle seeds were characterized by a faint yellowish cast, a sort of discoloration of the endosperm, while the sugary seeds, like the starchy, were a clear white.

Table 19 gives the results of separating the starchy, sugary, and brittle kernels from three ears and Figure 72 illustrates the P_1, F_1, and F_2 ears of this cross.

Although the results fit a 9:3:4 ratio the deviation from expectation is rather high, there being an excess of starchy and a deficiency of sugary seeds greater than four times the probable error. The deviation of the brittle seeds is within the limits of random sampling. The marked deviation in the starchy : sugary

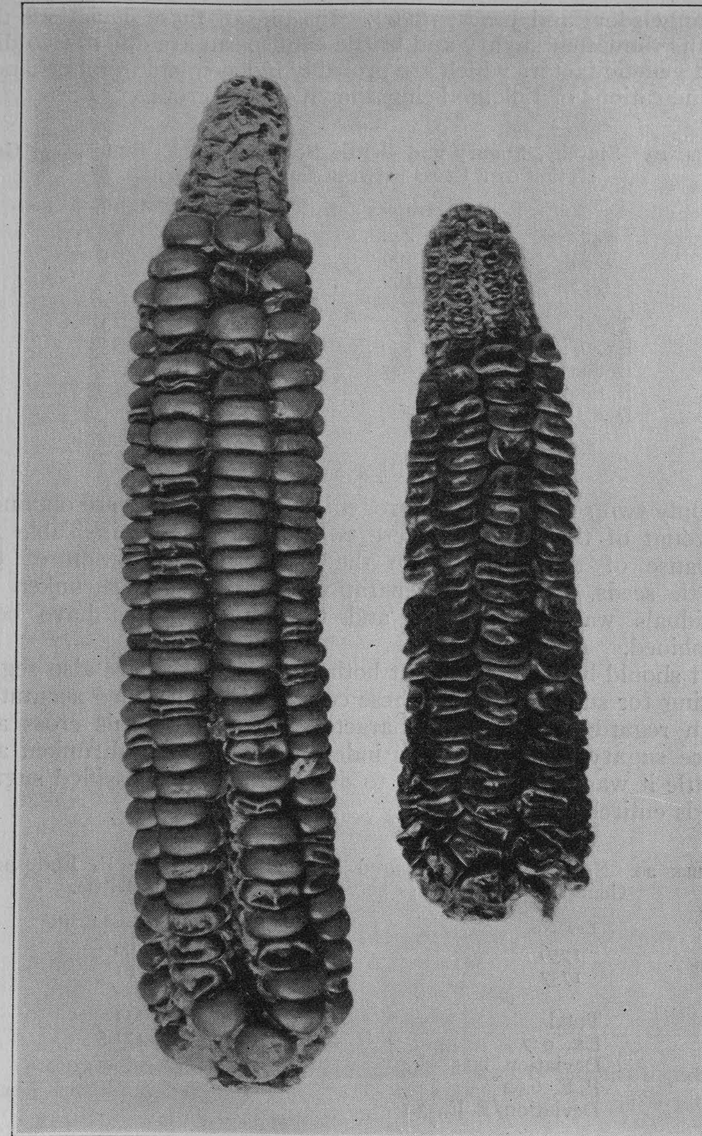

FIG. 71.—Original ear of Sanford White segregating for brittle endosperm and a pure brittle ear derived from it.

ratio may be due to genetic factors affecting the rate of pollen tube growth which are discussed in Part V, published elsewhere

(Mangelsdorf and Jones, 1926). In spite of these deviations the results show that sugary and brittle endosperm are due to two distinct genetic factors which are probably independent in inheritance, no indications of linkage being shown in this cross.

TABLE 19. Starchy, Sugary and Brittle Seeds in the F_2 Endosperm Generation of a Cross between Sugary and Brittle.

Ear No.	Starchy	Sugary	Brittle
422	242	61	78
1754	169	47	63
1755	166	43	72
Total	577	151	213
Ex. 9:3:4	530	176	235
Deviation	47	—25	—22
P. E. 9:7 ratio 10.26			
Dev./P. E. 4.6			

SHRUNKEN X BRITTLE

Only two segregating F_2 progenies of this cross were obtained. A count of the seeds on these two ears is shown in Table 20. Because of the variation in the translucent condition of the brittle seeds, an accurate separation of brittle and shrunken individuals was not possible and these two classes have been combined.

It should be mentioned that both of these ears were also segregating for sugary seeds. These could not be classified accurately with regard to the other characters involved in this cross and since sugary is known to be independent of both shrunken and brittle it was considered safe to disregard the unclassified sugary seeds entirely.

TABLE 20. Starchy, Shrunken, and Brittle Seeds in the F_2 Endosperm Generation of a Cross between Shrunken and Brittle.

Ear No.	Starchy	Shrunken and Brittle
1756	122	90
1757	119	61
Total	241	151
Ex. 9:7	220.5	171.5
Deviation, 20.5		
P. E. 6.62		
Deviation/P. E., 3.1		

Although there is a deviation of 3.1 times the probable error, the results approach a 9.7 ratio. This indicates that brittle and shrunken endosperm are due to two distinct genetic factors which are complementary in their action and are inherited independently. Linkage between the *bt* and *sh* factors would be indicated by an

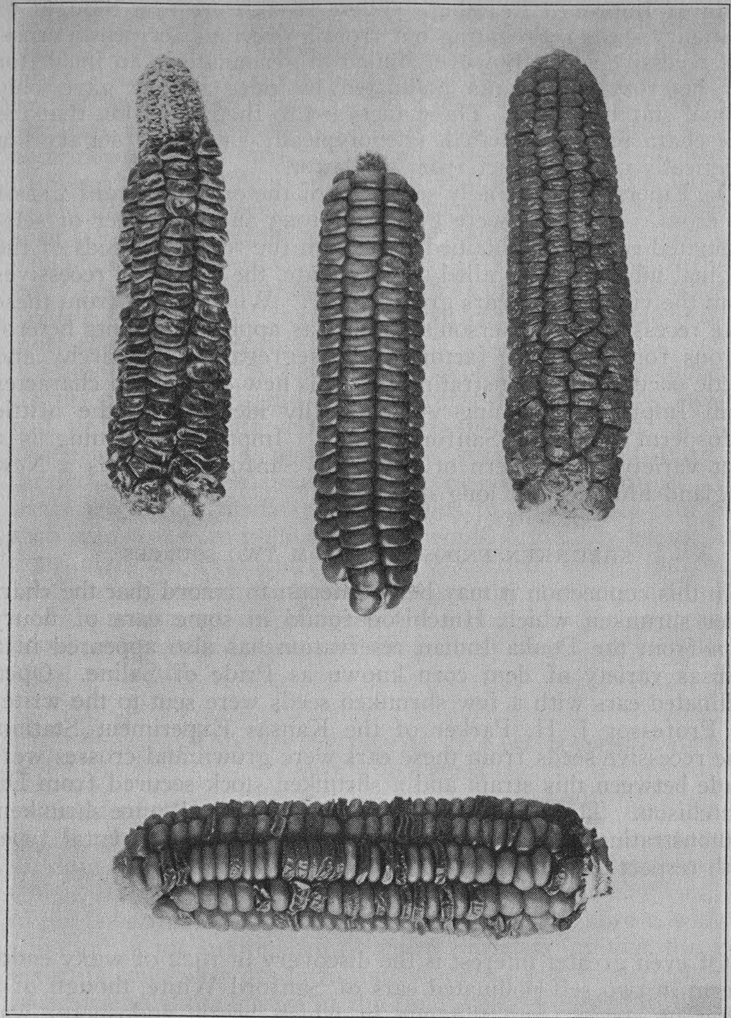

FIG. 72.—Parental, F_1 and F_2 generations of a cross between sugary and brittle endosperm.

excess of the recessive types; actually there is a significant deficiency.

BRITTLE ENDOSPERM FROM TWO VARIETIES

In 1923, Dr. R. A. Emerson, in a letter to Dr. D. F. Jones, wrote that wrinkled, translucent seeds had been found in an inbred strain of Improved Leaming. These seeds were first thought to be sugary seeds segregating out from a previous accidental cross. The recessive seeds, however, failed to germinate in an incubator and heterozygous plants pollinated by pure sugary gave only normal starchy seeds. These facts led to the conclusion that the new character was a lethal, phenotypically similar to sugary but genetically quite distinct from the latter.

Dr. Emerson very kindly sent seed of the original strain and of the cross. Both lots were grown in 1923 and a number of self-pollinated ears were obtained. Though the recessive seeds of the original inbred strain failed to germinate, the extracted recessives from the vigorous F_1 ears grew readily. When pollen from these pure recessives of Emerson's strain was applied to plants heterozygous for the brittle factor, a 1:1 segregation of starchy and brittle occurred, demonstrating that this new endosperm character from Improved Leaming is genetically identical to the brittle endosperm found in Sanford White. Improved Leaming is a dent variety of Western origin while Sanford White is a New England Flint type of long standing.

SHRUNKEN ENDOSPERM FROM TWO SOURCES

In this connection it may be of interest to record that the character shrunken which Hutchison found in some ears of floury corn from the Ponka Indian reservation has also appeared in a Kansas variety of dent corn known as Pride of Saline. Open pollinated ears with a few shrunken seeds were sent to the writer by Professor J. H. Parker of the Kansas Experiment Station. The recessive seeds from these ears were grown and crosses were made between this strain and a shrunken stock secured from Dr. Hutchison. The F_1 seeds of such crosses were all pure shrunken, demonstrating the genetic similarity of the two parental types with respect to this character.

WAXY ENDOSPERM IN CHINA AND AMERICA

Of even greater interest is the discovery in 1922 of waxy endosperm in two self-pollinated ears of Sanford White, though of a different strain from the one in which brittle endosperm was found.

This peculiar endosperm texture had previously been found only in three isolated localities in China, Burma, and the Philippines. Collins (1920) failed to find a single waxy variety among more than a thousand American varieties which he examined.

The waxy type isolated from Sanford White was crossed with a waxy strain which had come originally from Shanghai, China. This cross gave only pure waxy F_1 seeds, proving that the two strains were genetically alike in their endosperm texture.

So far as is known, the only waxy corn ever grown in Connecticut is the Chinese strain which has been used in genetic investigation at the experiment station farm for a number of years. No corn of any kind has ever been sent from the station to the locality from which the ears of Sanford White were obtained, and it is scarcely possible that the appearance of waxy endosperm in this variety is due to previous crossing with the Chinese waxy. Nor is there any indication that the strain in which waxy has appeared has undergone any recent crossing with such a widely different sort as the Chinese waxy. The strain which carries the waxy endosperm is typical of the variety in every respect, including number of rows of grain on the ear which Collins (in a letter) suggests as the character which would be most affected by crossing.

The origin in an American variety of this peculiar endosperm texture, previously found only in several isolated Asiatic localities, will probably remain a matter for speculation. It may have arisen as a mutation in very recent years or it may have been carried by the stock as a hidden recessive for centuries. Waxy seeds are not particularly conspicuous in appearance and a few such seeds on open pollinated ears would ordinarily escape attention, and the character might be carried along indefinitely. Neither is a recent mutation from starchy to waxy an impossibility, since mutations affecting the endosperm have appeared in homozygous inbred strains of maize in at least four instances, as noted previously.

CONSTANT VARIATION IN THE STORAGE MATERIAL OF THE ENDOSPERM

The finding of brittle endosperm in Leaming and Sanford White, of shrunken endosperm in Pride of Saline and a variety of flour corn from the Ponka Indians, of waxy endosperm in China, Burma, the Philippines, and finally in New England, leads to the conclusion that these recessive characters have a wide distribution in the germplasm of maize varieties, or that the germplasm is constantly producing anew these variations which affect, so profoundly, the nature of the food material stored in the endosperm. Under domestication some of these variations, as for example, sugary, offer economic advantages and are retained. Others may have a survival value under certain climatic conditions and are automatically sorted out. This may have been the origin of waxy varieties in China, Burma, and the Philippines.

It is now generally agreed that maize was confined to the American continent previous to the beginning of the sixteenth century. Why waxy varieties should have been developed in these Asiatic localities and apparently in no other part of the world is difficult to understand, unless this peculiar type of endosperm has natural advantages under the environmental conditions obtaining in these regions, or unless waxy varieties were isolated because of their economic superiority. Since the waxy corn is generally regarded as inferior to the starchy types for food purposes, where both are known, it seems more likely that the isolation of waxy varieties has been brought about by natural selection. This assumption is substantiated by the discovery of waxy endosperm in varieties of *Coix* and *Andropogon sorghum* from these same regions. (Kempton 1921.)

THE RELATIVE DEVELOPMENT OF ENDOSPERM CHARACTERS

The fact that the brittle seeds show such a low percentage of germination, in some cases none at all, suggests that these various factors which affect the texture of the endosperm are not fundamentally different from the lethal and semi-lethal seeds described in Part I; that all represent "defective" conditions of the endosperm, and that any distinction which is made is one of degree rather than of kind.

It will be recalled that when both normal and defective seed from segregating ears were weighed, the defectives showed a development ranging from 2.4 per cent in the completely lethal types to 59 per cent in the semi-lethal types.

The same method of determining the relative development of these five endosperm characters has been followed. The dominant and recessive seeds from segregating ears were separated, counted, and weighed. The average weight of each type was determined by simple division and the relative development obtained by a comparison of the two quotients.

The average weights of the seeds and the relative development of each type of endosperm texture is shown in Table 21.

TABLE 21. Average and Relative Weights of Dominant and Recessive Seeds fom Segregating Ears.

Character Segregating	No. of Ears	Av. Wt. Dominant Seeds in mg.	Av. Wt. Recessive Seeds in mg.	Rel. Wt. of Recessives
Waxy	3	306	295	96.5
Floury	3	208	199	95.6
Shrunken	3	321	295	91.9
Sugary	5	255	226	88.5
Brittle	2	230	143	62.3

It will be noted that in every case the recessive seeds were lower in weight than the dominant seeds from the same ears. Hutchison (1921) weighed a large number of individual starchy and shrunken seeds from segregating ears and though the shrunken seeds were lower in weight the difference was not significant when the probable error was considered. He concluded, therefore, that the shrunken seeds were equal to the starchy seeds in their development. Although the method used here does not permit the calculation of probable errors it does give a very accurate average weight of the dominant and recessive seeds. Of the many segregating ears which have been used in these and other determinations not one has ever been found in which the recessive seeds were equal in weight to the dominant ones.

Apparently the seed of maize attains its maximum development only when the endosperm is genetically starchy. Genetic factors which cause the formation of other carbohydrates in the endosperm, such as dextrose in the case of sweet corn, possibly some other sugar in the brittle seeds, and perhaps erythrodextrin in the waxy seeds (Weatherwax 1922), do so at the expense of total dry matter laid down. Although the amount of dry matter is not necessarily the sole criterion of endosperm achievement, it nevertheless appears to be the most important one.

The waxy seeds most nearly approach the normal condition in relative development, the floury seeds come next, followed by shrunken, sugary and brittle in the order given. The germination of the seeds and the vigor of the seedlings is closely correlated with the relative development of each type, the waxy and floury seeds being almost equal to starchy in these respects while the shrunken and sugary seeds are somewhat inferior and the brittle seeds are very poor.

DISCUSSION

These five characters which influence the texture of the endosperm and the thirteen factors which govern the amount of tissue can be arranged in a series representing different stages of endosperm formation. All of the factors result in a decreased development of the endosperm as measured by the dry weight of the seed. When the relative development of these six types is represented by points on the normal growth curve of the seed of maize, together with the thirteen defectives, as shown in Figure 73, it is noted that these 18 endosperm characters form a continuous series ranging from the de_{14} type to waxy endosperm.

In other words, the seeds of maize, to attain a relative development of 100 per cent, must pass safely through all the points represented on the growth curve. This means that *in order to attain the normal or "starchy" condition a seed must be dominant for at least 18 genetic factors*, any one of which in the homozygous recessive condition would reduce its development.

The space on the curve between 50 and 90 is not heavily populated and it is possible that characters which fall into this region are still to be found.

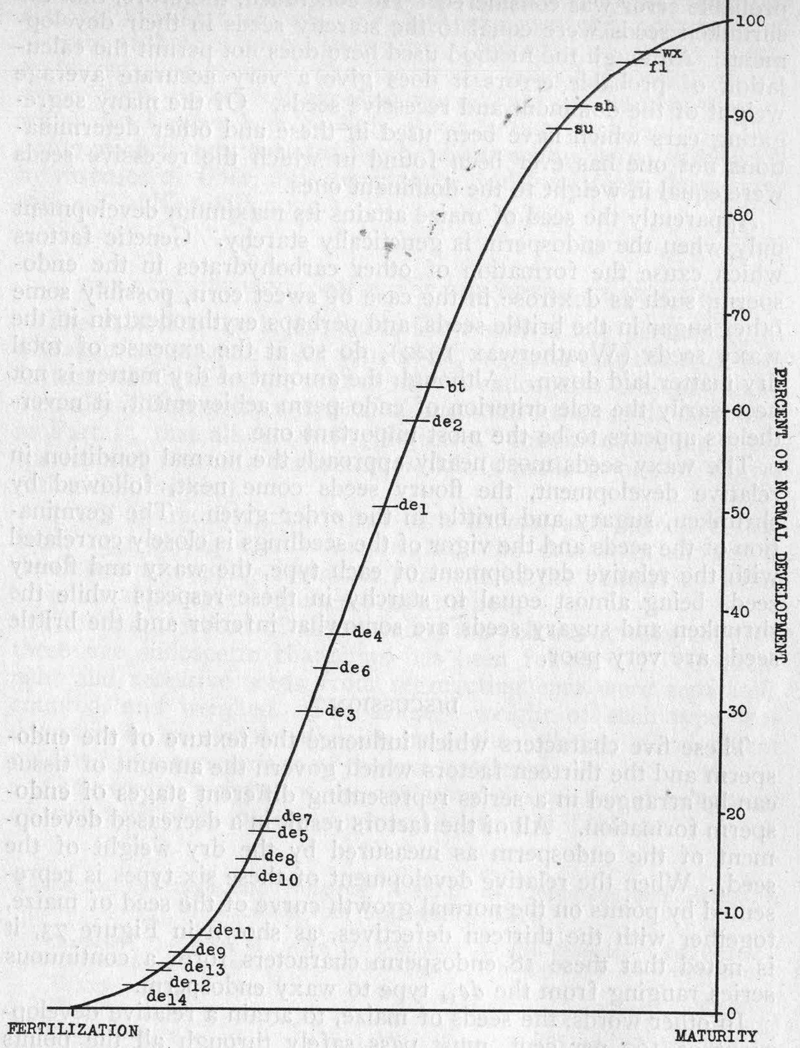

FIG. 73.—Diagram in which the relative development of endosperm characters is represented by points on the growth curve of normal seeds of maize.

The characters which show a development of 50 per cent or more are the most useful to the geneticist because there is enough endosperm development for differences in texture to be apparent

and in most cases these characters can be secured in a homozygous condition. This latter feature constitutes an advantage when linkage relations are studied because it permits the use of backcrosses.

SUMMARY—PART III

1. *Brittle* endosperm, a new character intermediate between sugary and shrunken in appearance, is inherited as a simple recessive.
2. Crosses between brittle and sugary or brittle and shrunken give starchy seeds in F_1 and 9:3:4 or 9:7 ratios in F_2. No indication of linkage is shown in either series of crosses.
3. Brittle, shrunken, and waxy endosperm have been found in widely separated localities and in unrelated varieties indicating their widespread distribution in the germplasm or constant reappearance by mutation.
4. The endosperm of maize apparently attains its maximum development when genetically starchy. The relative development of waxy, floury, shrunken, sugary and brittle seeds is always less than that of starchy seeds from the same ears.
5. The characters which affect the texture of the endosperm are not fundamentally different from the defective seeds previously described, which influence primarily the amount.
6. The maize seed in order to attain the normal or "starchy" condition must be dominant for at least 18 genetic factors.

PART IV

Premature Germination of Maize Seeds and Genetic Factors Which Govern Dormancy

In a paper on defective seeds, the writer (1923) mentioned briefly a condition in maize in which the seeds fail to go through a resting period, germinating while still attached to the ear of the growing plant and before the seed is mature. A similar condition was reported simultaneously by Lindstrom (1923) who found among the ears of a strain of Golden Bantam sweet corn, which was being studied for defective endosperm, one ear which also segregated for germinating seeds. Somewhat later Eyster (1924) described a similar character which he calls "primitive sporophyte,"* and more recently, in another paper (Eyster, 1924), he reports a second factor for premature germination.

Since 1921 a number of stocks which segregate for germinating seeds have come under observation of the writer. Self-pollinations and crosses in these stocks indicate that there are at least five complementary factors and two sets of duplicate factors involved in premature germination of maize seeds. A description of these characters and an account of their genetic behavior is given in the following pages.

COMPLEMENTARY FACTORS

ge_1

The first type of premature germination was found in 1921 in a strain of Gold Nugget flint corn which had been twice self-pollinated. The germinating seeds were not noted in the first generation and either had not appeared, or the germination was so slight as to escape notice. The ratio of dormant to germinating seeds was approximately 3:1 and the character has continued to behave as a simple Mendelian recessive both in the original strain and in crosses. A count of the dormant and germinating seeds from eight ears of this stock is shown in Table 22.

Premature germination induced by the ge_1 factor begins at an

* The term *primitive sporophyte* as used by Eyster in describing premature germination in maize, has not been adopted by the writer because it is thought to be somewhat misleading. Eyster compares the condition in maize to that found in *Selaginella ruprestris* in which the sporophyte develops while the egg is still attached to the female gameteophyte. The resemblance between this condition and that found in maize is more superficial than real. As a mere term to designate the character, primitive sporophyte would serve as well as any, except for the fact that readers, not familiar with the premature germination in maize, might draw the conclusion that prematurely germinating seeds actually represent a reversion to the primitive condition of the race and that a change in a single gene can carry back the maize plant, phylogenetically, so to speak, to the group in which the club mosses are found.

early stage. The actual sprouting of the seed has usually occurred when the seeds are in the late milk stage but the segregation is

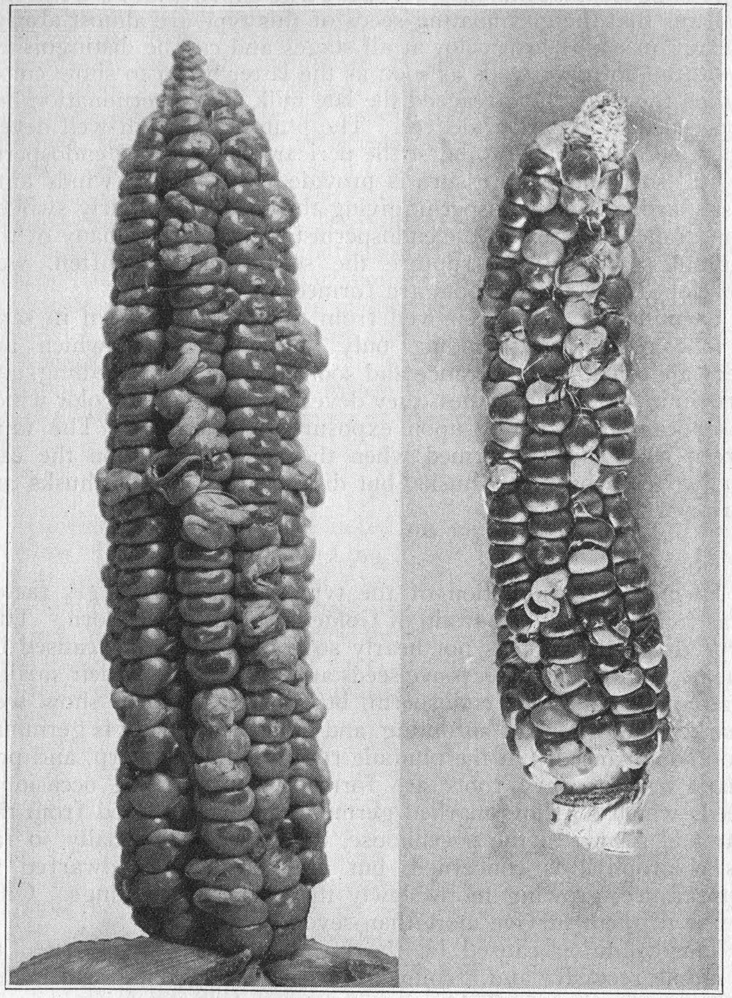

FIG. 74.—Two ears segregating for germinating seeds of the ge_1 type. Germination begins at an early stage. The ear at the right shows the apparent linkage between endosperm color and premature germination.

apparent at an earlier period because the recessive seeds are, with few exceptions, white, while the dormant seeds on the same ear are yellow. Eyster reports a similar association between premature germination and the absence of color in the endosperm and explains this on the basis of close linkage. Evidence presented later suggests that this may not be the true explanation, but the fact remains that the germinating seeds of this type are almost always lacking in endosperm color at all stages and can be distinguished from the dormant seeds as soon as the latter begin to show color. When the seeds have reached the late milk stage, germination has proceeded to a marked degree. The plumule, though well developed, is often unable to burst the pericarp because the endosperm is still soft and no pressure is provided. Instead it winds aimlessly around the endosperm, giving the seed a peculiarly swollen appearance. Later, as the endosperm tissues harden, many of the plumules are able to rupture the seed coat and, often, well developed roots and shoots are formed.

Germinating seeds, removed from the ear and grown in sand in the greenhouse, produce only albino seedlings which are very abnormal in appearance and soon die. If such seedlings are grown in complete darkness they develop a faint green color which disappears immediately upon exposure to full light. The faint green color is also formed when the seeds remain on the ear, well covered by heavy husks, but disappears when the husks are stripped down.

ge_2

Premature germination of the type caused by the ge_2 factor was found in an inbed strain of Golden Bantam sweet corn. This type of germination is not nearly so complete as that caused by the ge_1 factor. The recessive seeds are recognized by their smaller size and pale yellow endosperm, but not all of them show well marked indications of sprouting, and only occasionally is germination so advanced that the plumule ruptures the pericarp, and primary or secondary roots are formed. When these occasional seeds which do show marked germination are removed from the ear and grown in the greenhouse, they develop normally so far as chlorophyll is concerned, but are considerably dwarfed in appearance, growing more slowly than normal seedlings. Only a few of them survive more than several weeks.

The condition caused by the ge_2 factor is also inherited as a simple recessive and a count of seven ears segregating for this character is given in Table 22.

TABLE 22. Segregation of Dormant and Germinating Seeds in Stocks ge_1, ge_2, ge_3 and ge_4.

Type	No. of Ears	Total	ge	Ex. 3:1	Dev.	P. E.
ge_1	8	2220	528	555	—27	13.8
ge_2	7	1928	509	482	27	12.8
ge_3	4	446	99	112	—13	6.2
ge_4	1	169	44	42	2	3.8

ge_3

In 1924, Dr. Lindstrom very kindly furnished the writer with seed of his strain which had been segregating for germinating seeds. In some respects this type of premature germination, designated as ge_3 in this series, is almost identical to ge_1. The germinating seeds are white, with few exceptions, while the dormant seeds have a deep yellow color so characteristic of the Golden Bantam variety. The plumules produced by the germinating seeds are, like those of ge_1, albinos. They differ from the latter, however, in failing to form the faint tinge of green which characterizes the ge_1 seedlings under certain conditions.

The processes of germination in the ge_3 seeds evidently begin earlier and proceed further than in ge_1 seeds. When the dormant seeds are mature, the endosperm of the germinating seeds is almost completely exhausted and the pericarp is little more than an empty shell containing the withered remains of the partly grown seedling. This character is inherited as a simple recessive as indicated by the counts of the seeds from four ears shown in Table 22.

ge_4

Germinating seeds were noted on an ear of an eight-rowed, yellow flint variety of the Longfellow type, received from Mr. T. B. Macaulay of Montreal, Canada. No count of the seeds was made on the original ear which was thought to be open-pollinated. When the dormant seeds from this ear were grown and the plants self-pollinated, segregating ears were again obtained. The proportion of dormant to germinating seeds on one of these ears is given in Table 22.

Germination in this stock does not begin until the seeds are fairly hard. The premature germination is not associated with absence of color in the endosperm as in the three stocks already described, nor are the seedlings albinos as in the case of ge_1 and ge_3. Germinating seeds of this type, when removed from the ear and planted in the greenhouse, produce seedlings which are almost normal in appearance. By growing a large number of such seedlings it might be possible to mature a few homozygous plants in the greenhouse during the winter months. This stock, however, is the only one in which there seems to be any possibility of ever attaining a homozygous condition.

ge_5

This factor evidently arose as a mutation in either the ge_1 or ge_3 stocks. A cross between these two stocks, in addition to giving the expected 9:7 and 3:1 ratios, also produced a few progenies in which the ratio was clearly 27:37, as the figures in Table 24 indicate. Evidently three factors for germinating seeds instead of two were involved in this cross. It is not known which of the parental stocks contributed the third factor but it seems fairly certain that it arose in one or the other by recent mutation, since both strains had previously given only mono-hybrid ratios and a later generation has done the same.

This new factor is almost identical to ge_3 in its effect. The recessive seeds are completely lacking in endosperm color and the sprouts are entirely without chlorophyll. The two types cannot be distinguished from each other but both are separable from ge_1 for a brief period during which the faint green color is visible in the sprouts of the latter.

DESCRIPTION SUMMARIZED

The chief characteristics of these five types of germinating seeds may be briefly summarized as follows:

Type	Approximate Time Germination Begins	Color of Endosperm	Color of Plumule
ge_1	late milk	white	white (green tinge)
ge_2	dough	pale yellow	green
ge_3	early milk	white	white
ge_4	hard dough	yellow	green
ge_5	early milk	white	white

It should be emphasized that all these stocks are genetically yellow in their factors for endosperm color and genetically green with regard to seedling color. The absence of endosperm and chlorophyll color is apparently due to the physiological effects of premature germination.

All these characters are fully as lethal in their effect as the defective seeds described in Part I. Under field conditions the growing seedling dies as soon as the plant matures and the moisture supply is cut off.

PHENOTYPICAL AND GENETIC DIFFERENCES

The breeding program with these five types of premature germination involves crossing them in all combinations. Only seven of the ten possible crosses have so far been made, but the distinct phenotypical differences between several of the types almost precludes the possibility that they are genetically alike, and a tentative conclusion has been reached that all five are probably genetically distinct.

It is noted that the types fall into two distinct classes with regard to plumule color, ge_1, ge_3, and ge_5 producing white sprouts, ge_2 and ge_4 producing only green plumules. That the first three

are genetically distinct is shown by the 27:37 ratios given in Table 24. The ge_2 and ge_4 types are considered to be distinct from the remaining three because of the marked phenotypical differences between the two groups, and crosses which have so far been made confirm this assumption. The cross between ge_2 and ge_4 has not yet been made and though these two differ in the amount of endosperm color, the time at which germination begins, and the vigor of the seedlings, these differences are all of degree and might result from the action of modifying factors. There

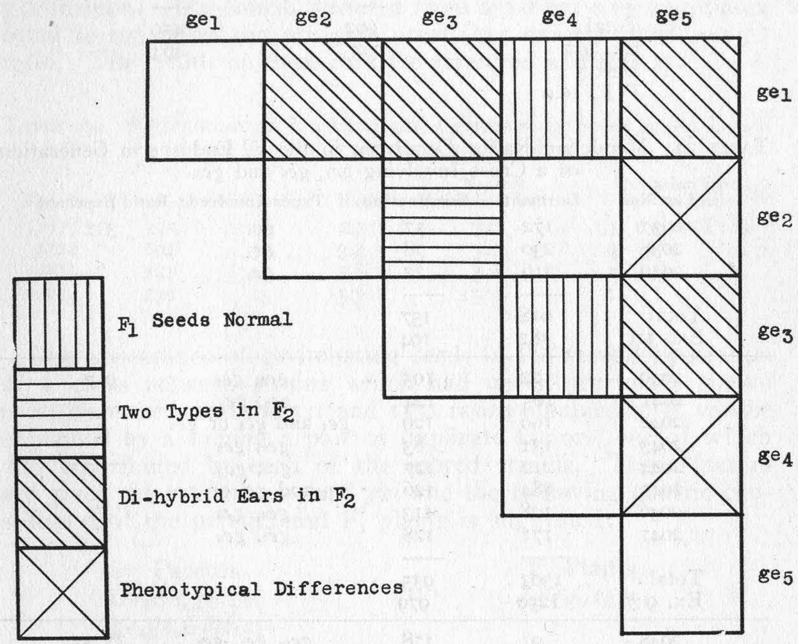

FIG. 75.—Diagram showing the crosses which have been made among the five stocks in which complimentary factors governing premature germination are involved.

remains the possibility, therefore, that ge_2 and ge_4 are genetically identical.

The situation with regard to these five types is shown in Figure 75. Squares with vertical cross hatching represent crosses in which the F_1 seeds are dormant and the F_2 has not yet been grown. Those with horizontal cross hatching indicate the combinations in which both types were recovered in F_2 although no di-hybrid ears were obtained. Diagonal cross hatching represents crosses in which di-hybrid ratios were found in F_2, while two intersecting diagonal lines indicate marked phenotypical differences between the types. The crosses in which di-hybrid ears were obtained are given in detail in Tables 23 and 24.

TABLE 23. Ears Segregating for Both Factors in the F_2 Endosperm Generation of a Cross of ge_1 and ge_2.

Ear No.	Dormant	Germinating
711	149	99
712	139	112
713	146	118
714	168	130
Total	602	459
Ex. 9:7	597	464
Dev. 5		
P. E. 10.9		

TABLE 24. Mendelian Ratios Occurring in the F_2 Endosperm Generation of a Cross Involving ge_1, ge_3 and ge_5.

Ear No.	Dormant	Germinating	Types Involved	Ratio Expected
2037	172	57	ge_1	3:1
2038	230	78	ge_1	"
2040	216	22	ge_1	"
Total	618	157		
Ex. 3:1	582	194		
2039	122	105	ge_3, ge_5	9:7
2041	165	124	ge_3, ge_5	"
2042	190	129	ge_1 and ge_3 or ge_5	"
2043	131	83	ge_3, ge_5	"
2044	212	127	ge_3, ge_5	"
2045	184	126	ge_1 and ge_3 or ge_5	"
2046	128	113	ge_3, ge_5	"
2047	171	128	ge_3, ge_5	"
Total	1303	935		
Ex. 9:7	1259	979		
2048	91	178	ge_1, ge_3, ge_5	27:37
2049	137	184	ge_1, ge_3, ge_5	"
2050	94	125	ge_1, ge_3, ge_5	"
Total	322	487		
Ex. 27:37	341	468		

The evidence so far as it goes indicates that these five types are all different and that the plant must be homozygous for the dominant allelomorphs of all five factors in order for all of its seeds to remain dormant until maturity.

DUPLICATE FACTORS

Premature germination due to the action of duplicate factors was first found on the F_1 ears of a cross between two strains of

Canada Flint which had been inbred for four generations. Germinating seeds had never been noted in either of these inbred strains nor did they appear among the F_1 crossed seeds. When the F_1 plants were grown, however, a number of the ears bore germinating seeds, scattered at random over the inflorescence. These ears were open-pollinated, and no attempt was made to determine the ratio in which the segregation occurred. Dormant seeds from one of these ears were grown and five self-pollinated ears were obtained. Three of these were clearly segregating in a 3:1 fashion. The fourth deviated from a 3:1 ratio by an amount equal to ten times the probable error, but exactly fitted a 15:1 ratio. The counts on these ears are arranged in Table 25.

TABLE 25. Segregation of Dormant and Germinating Seeds when Duplicate Factors ge_6 and ge_7 are Involved.

Ear No.	Dormant	Germinating	Ratio	Nearest Mendelian Ratio	Deviation from Nearest Ratio
2171	123	46	2.7:1	3:1	1.1 times P. E.
2172	104	31	3.4:1	3:1	.9 " "
2173	121	43	2.8:1	3:1	.5 " "
2174	230	15	15.3:1	15:1	.1 " "

The appearance of germinating seeds in the second generation of a cross between strains which had never previously shown these characters and the 3:1 and 15:1 ratios obtained in F_3 can be explained by assuming a pair of duplicate factors, one of which was contributed by each of the inbred strains. These factors are given the symbols ge_6 and ge_7 and the following genetic constitution of the parents and F_1 plants is suggested:

Parents	F_1 Plants
$Ge_6Ge_6ge_7ge_7$	$Ge_6ge_6Ge_7ge_7$
$ge_6ge_6Ge_7Ge_7$	

The F_1 plants when selfed should give 15:1 ratios. Whether or not they did could not be determined because the ears were all wind-pollinated. The dormant seeds from these plants should, when grown, give three types of progenies; (1), non segregating, (2), segregating 3:1, (3), segregating 15:1. Had the F_1 plants been selfed these three types of progenies would be expected in the ratio of 7:4:4 respectively. The non-segregating ears would be expected when one or both of the recessive factors is lacking; 3:1 ratios should occur when the plant is homozygous for one and heterozygous for the other, while the 15:1 ratios are expected on plants which are heterozygous for both factors.

It is noted that all three types of progenies have been obtained although the number of selfed ears examined is too small to determine in what proportions the various types are appearing.

Apparently the two factors involved in this stock are independent. Linkage would be indicated by a distortion of the 15:1 ratio, an excess of recessives being expected in the coupling phase, a deficiency in the repulsion phase.

Premature germination in this stock is somewhat similar to that caused by ge_2. The plumules are green but the endosperm color, instead of being pale yellow throughout, is affected only in the regions adjacent to the embryo. The endosperm color of the dorsal sides of the seed is, in most cases, full yellow.

RATIOS OF 8:1 AND 41:1

Another stock in which the action of duplicate, or perhaps triplicate, factors is suggested is the result of pollinating a chimera plant which appeared in the third generation of inbreeding in a strain of Sanford White, with pollen from an unknown yellow stock. The chimera had produced a pure white ear shoot and it was desired to obtain both selfed and crossed seeds from this plant. Accordingly pollen from an F_1 hybrid of two inbred strains of yellow flint corn was applied, but unfortunately no record was made of the row from which the pollen was taken and it is not known whether this particular hybrid had ever produced germinating seeds. It is known, however, that the inbred strain of Sanford White in which the chimera appeared had never shown germinating seeds.

TABLE 26. Segregation of Dormant and Germinating Seeds when Duplicate Factors ge_8 and ge_9 are Involved.

Ear No.	Dormant	Germinating	Ratio	Nearest Mendelian Ratio	Deviation from Nearest Ratio
2178	165	4	41.3:1	15:1	3.1 times P. E.
2179	163	22	7.4:1	15:1	4.6 " "
2180	187	21	8.9:1	15:1	3.3 " "

Four self-pollinated ears were obtained from the yellow seeds produced by cross-pollination with the unknown pollen parent. Three of these segregated for germinating seeds and the counts on these ears are set forth in Table 26. Two of the ears gave ratios approximately alike, the proportion of dormant to germinating seeds being about 8:1. This ratio deviates from 3:1 by more than nine times the probable error and from 15:1 by 5.6 times the error. The third ear, No. 2178, gave a ratio of 41:1 which differs from a 15:1 by 3.1 times the probable error and from 63:1 by an amount equal to 3.2 times the error.

These results may be explained on the basis of linkage between the two members of a pair of duplicate factors. A ratio of 8:1 would be expected if the two genes were linked with crossing over of approximately 34 per cent. The same two factors in the repulsion phase should give a ratio of 17:1. Ear No. 2178 may represent the repulsion phase since it deviates from the expected 17:1 ratio by less than three times the probable error.

It is also possible that three factors instead of two are involved. Plants heterozygous for two of these and homozygous for the third would be expected to give 8:1 ratios if the two heterozygous factors were linked with crossing over of 34 per cent. Plants heterozygous for all three, two of which are linked, should give 35:1 instead of 63:1 ratios. Ear No. 2178 fits such a ratio very closely. The data, however, are not sufficiently comprehensive to substantiate such an interpretation. If three factors are involved with 34 per cent crossing over between two of them, the following ratios are expected when dormant seeds from ear No. 2178 are grown; 3:1, 8:1, 15:1, 17:1, 35:1, and 71:1. Another season's results should show definitely whether duplicate or triplicate factors are involved.

Premature germination in this stock is similar to that caused by ge_4. Germination begins at a very late stage and the endosperm color is not greatly affected.

SUMMARY OF BREEDING BEHAVIOR

Tentatively, then, the genetic situation with regard to the stocks which have been studied may be outlined as follows:

- ge_1, ge_2, ge_3, ge_4, ge_5 — Five single factors, any one of which in a homozygous recessive condition causes premature germination.
- ge_6, ge_7 — A pair of independent duplicate factors which cause premature germination when both are present in the recessive condition.
- ge_8, ge_9 — A pair of linked duplicate factors causing premature germination when both are present. Crossing over is about 34 per cent. A third factor in this set, ge_{10}, is also indicated.

LINKAGE RELATIONS

A detailed study of the linkage relations of these factors with other well known characters has not yet been undertaken. Data are available, however, to show the relation of the ge_1, ge_2, ge_3, and ge_5 genes with the factor for sugary endosperm. In all these cases the germinating seeds cannot be accurately classified with regard to endosperm texture and linkage must be detected by the distortion in the starchy : sugary ratio among the dormant seeds. In the repulsion phase the percentage of sugary seeds in the dormant class should vary between 25 and 33⅓, depending on the intensity of the linkage. This is shown diagrammatically in Figure 63, Part I. In the coupling phase, linkage would be expected to cause a deficiency of sugary seeds in the dormant class, the percentage ranging from 25 to 0.

ge_1 x Su

The linkage relations of ge_1 with *Su* are determined from the cross between the ge_1 and ge_2 stocks. The former is a yellow flint variety, the latter a yellow sugary. Eight ears which were segregating for ge_1 were obtained from this cross and the proportion of sugary seeds in the dormant class on these ears is shown in Table 27.

TABLE 27. Starchy:Sugary Segregation in Dormant Seeds from Ears Segregating ge_1.

Ear No.	Starchy	Sugary	Percent Sugary
710	145	60	29.3
715	159	61	27.7
721	179	73	29.0
722	146	69	32.1
723	162	44	21.4
725	110	43	28.1
726	164	71	30.2
727	153	53	25.7
Total	1218	474	28.0
Ex. 3:1	1269	423	25.0
Dev. 51			
P.E. 12.0			

It is noted that there is an excess of sugary seeds, amounting to 4.25 times the probable error. Such a deviation would be expected by chance alone only once in about 250 trials. The excess, though it occurs in all but one of the eight ears, would not be regarded as significant if seeds from a smaller number of ears were counted. When all the ears are combined, however, the accumulation of small deviations is one direction results in a total deviation which can scarcely be attributed to chance. The excess of sugary seeds in this class can be explained by assuming linkage between the genes ge_1 and *Su* with approximately 40 per cent crossing over. It is realized, of course, that linkage values determined by the distortion in a single class necessarily have a large probable error and the value given must not be regarded as more than an approximation.

That the excess of sugary seeds in the dormant class is due to some relation with the ge_1 factor and not to errors in classification or to genetic factors affecting the rate of pollen tube growth, is further indicated by a count of the sugary seeds on eight ears from the same cross which are not segregating for ge_1. On these ears the percentage of sugary seeds is very close to expectation and deviations are minus almost as frequently as plus, as is indicated in Table 28.

TABLE 28. Starchy:Sugary Segregation in Ears Not Segregating ge_1 from Same Cross as Ears in Table 27.

Ear No.	Starchy	Sugary	Percent Sugary
728	192	48	20.0
729	221	80	26.6
730	211	65	23.6
731	204	69	25.3
733	163	57	25.9
734	185	82	30.7
735	227	68	23.0
736	175	79	31.1
Total	1578	548	25.8
Ex. 3:1	1594	532	25.0
Dev. 16			
P. E. 13.5			

ge_2 x su

The relation of ge_2 and *su* is shown by ears from this same cross which are segregating for ge_2 and sugary but not for ge_1. The counts from seven such ears appear in Table 29. Linkage in this case would be indicated by a deficiency of sugary seeds since the two factors entered the cross in the coupling phase. Actually there is a slight but not significant excess of sugary seeds in the dormant class and it appears safe to conclude that ge_2 and *su* are independent.

TABLE 29. Starchy:Sugary Segregation in Dormant Seeds of Ears Segregating ge_2 from Same Cross as Ears in Tables 27 and 28.

Ear No.	Starchy	Sugary	Percent Sugary
705	121	44	26.7
706	172	59	25.5
707	146	67	31.5
708	158	52	24.8
716	134	41	23.4
717	155	54	25.8
718	152	64	29.6
Total	1038	381	26.8
Ex. 3:1	1064	355	25.0
Dev. 26			
P. E. 11.0			

ge_3 and ge_5 x su

Five of the ears represented in Table 24 are segregating for *su*, ge_3 and ge_5. The two types of germinating seeds cannot be distinguished but if either one is linked with sugary a distortion of the starchy : sugary ratio in the dormant seeds would be expected. A count of the two types of seed in the dormant class on these five ears appears in Table 30. The agreement with expectation on the basis of independent inheritance is very good and it seems certain that both factors are independent of sugary.

TABLE 30. Starchy:Sugary Segregation in Dormant Seeds of Ears Segregating ge_3 and ge_5.

Ear No.	Starchy	Sugary	Percent Sugary
2039	99	23	18.9
2041	121	44	26.7
2043	96	35	26.7
2044	154	58	27.4
2046	99	29	22.7
2047	124	47	27.5
Total	693	236	25.4
Ex. 3:1	697	232	25.0
Dev. 4			
P. E. 8.9			

APPARENT LINKAGE WITH ENDOSPERM COLOR FACTORS

As has already been mentioned, there is a strong association between germinating seeds and absence of color in the endosperm. In the case of ge_1, ge_3 and ge_5 the recessive seeds are, with few exceptions, completely white, while in the ge_2 strain the germinating seeds are a pale yellow.

TABLE 31. Apparent Linkage between ge_1 and White Endosperm.

Ear No.	Yellow *Ge*	Yellow *ge*	White *Ge*	White *ge*
710	204	1	1	66
715	219	0	1	56
721	252	1	0	67
722	213	1	2	74
723	205	0	1	62
726	234	0	1	61
754	205	0	1	74
Total	1532	3	7	460

Occasionally, however, germinating seeds with yellow endosperm are found as well as white seeds which have not sprouted. The frequency of these exceptions in stocks 1 and 3 is shown in Tables 31 and 32. At first glance the situation represents a clear cut case of close linkage with less than 1 per cent of crossing over. Eyster (1924) has assumed this to be the situation in his stock and has calculated the amount of crossing over as 1.26 per cent. The writer (1923) had previously suggested physiological correlation as an explanation of these results and the evidence

indicates that this is probably the correct interpretation in the stocks reported here.

There are at least three series of facts which are not compatible with a linkage hypothesis:

1. All of the stocks in which the association between premature germination and color of endosperm appears have originated from varieties which were homozygous for yellow endosperm. White seeds might be expected to arise occasionally by mutation, but the appearance of four genetically distinct factors for white seeds, each one closely linked with a factor for germinating seeds, cannot reasonably be assumed.

2. When pollen from plants which are segregating for germinating seeds is applied to silks of a white variety, only yellow seeds are produced. If the segregating plants were heterozygous for endosperm color, as they appear to be, such crosses should produce 1:1 ratios, providing that the white endosperm of the germinating seeds has the same genetic basis as the white endosperm of common white varieties.

3. The apparent cross overs, white seeds which fail to sprout, should breed true if it is assumed that they are homozygous for a recessive endosperm color factor. Only a small number of these seeds have been available but all those which were grown produced only plants segregating for white seeds which germinated, with few exceptions.

TABLE 32. Apparent Linkage between ge_3 and White Endosperm.

Ear No.	Yellow *Ge*	Yellow *ge*	White *Ge*	White *ge*
758	70	1	0	22
760	60	0	0	17
761	101	0	0	27
Total	231	1	0	66

If the association between germinating seeds and endosperm color is not due to linkage, to what may it be attributed? A histological study of the germinating seeds of the ge_1 stock has given evidence which seems to have some bearing on this question.

PREMATURE DIGESTION AND PIGMENT FORMATION

Some of the white seeds were removed from the ear at an early stage, killed and fixed, imbedded in paraffin, sectioned, and stained. It was found that even at this early stage the processes of germination had already begun. The cells in the epithelial layer of the scutellum had elongated and the invaginations of this layer, so characteristic of mature seeds of maize, were already apparent. Sargant and Robertson (1905) have made a thorough study of the scutellum of maize and are of the opinion that these invaginations are glandular in nature and that their function is the secretion of diastase. There is some appearance of digestion in the cells of the endosperm of germinating seeds even at the early milk stage, and in material gathered from the same ears a week later, the digestion is quite marked.

It is possible that the normal production of color in the cells of the endosperm cannot proceed while digestion is occurring in these cells. The yellow color in the endosperm is found in the matrix which surround the starch grains, and if this matrix is being digested as rapidly, or more rapidly, than new material is being supplied by the plant, it is hardly to be expected that pigment formation would proceed in the normal fashion.

The apparent cross overs, the yellow seeds which germinate and the white seeds which remain dormant, may be merely variations of this condition.

Some of the germinating seeds probably remain yellow because the digestion does not begin soon enough or is not rapid enough to inhibit the formation of endosperm color. This would appear to be the case in the stock where the duplicate factors ge_6 and ge_7 are involved. In this stock the pale yellow is usually confined to an area adjacent to the embryo and the dorsal side of the seed retains the full yellow color.

The other class of apparent cross overs, the white dormant seeds, are more difficult to explain. The fact that all of these seeds which have ever been grown have given ears segregating for germinating seeds might suggest that this character occasionally manifests itself in the heterozygous condition.

THE RELATION OE PREMATURE GERMINATION TO CHLOROPHYLL DEVELOPMENT

Evidently there is also a physiological relation of some sort between premature germination and chlorophyll development. Types which begin germination at a very early stage, such as ge_3 and ge_5 always produce pure white sprouts. The ge_1 type, in which germination begins somewhat later, ordinarily produces white plumules but occasionally these show a tinge of green. The remaining types in which germination begins only after the kernels are well developed, produce only normal green sprouts. Apparently the premature germination, if it begins early enough, completely inhibits the formation of chorophyll just as it prevents the laying down of yellow pigment in the endosperm.

This association, too, is characterized by occasional exceptions. Germinating seed of ge_1, ge_3 and ge_5 are sometimes found which produce sprouts of normal green color, but dormant seeds which give albino seedlings when germinated have never been observed.

PHYSIOLOGY OF PREMATURE GERMINATION

Oppenheimer (1922) has found that in seeds of tomato, gourd, cucumber and *Nicotiana rustica,* germination can be suppressed by surrounding the seeds with crushed tissue of the receptacles of the mother plants or by growing them on filter paper saturated with an extract from these tissues.

The degree of suppression is approximately proportional to the amount of tissue present or the concentration of the extract. This suppression can be overcome by heating the tissue or extract to 100° C. Apparently the mother plants of these species normally supply the growing seed with inhibiting substances which prevent germination while the seeds are still attached to the plant. Mazé (1910) is of the opinion, and presents some evidence in favor of his view, that dormancy in seeds, buds, bulbs, and tubers is due, in some cases, to the action of volatile esters which prevent growth until they are eliminated.

Oppenheimer did not include seeds of maize in his experiments but a test made by the writer, in an effort to determine at what stage of development germination in the normal seed still attached to the plant could be induced, may have some bearing on the problem. An ear in the early milk stage was stripped down and wrapped with cotton. Around this were wrapped several layers of cloth. The ends of the cloth were submerged in a vessel of water and served as a wick, keeping the cotton surrounding the ear constantly saturated. The grains swelled considerably, indicating that water was being absorbed, but no germination occurred. A number of seeds which had been removed from this ear and placed in an ordinary germinator at approximately the same temperature and with the same moisture supply, began to sprout after about ten days. This is much longer than the time required by immature, dry seeds to germinate under the same conditions and indicates that inhibiting substances were first eliminated before germination could begin.

THE EFFECTS OF PREMATURE GERMINATION ON THE GROWTH OF THE SEED

An attempt was made to determine whether the germinating seeds receive the normal amount of nourishment from the plant while germination is going on or whether these seeds cease their development after germination begins. Ears which were segregating for germinating seeds (ge_1) were harvested at three weeks after pollination, and at intervals of one week thereafter, until maturity. These ears were dried on a rack until thoroughly dry, at which time the kernels were shelled off, the dormant and germinating seeds separated, counted and weighed, and the average weight of each class determined by simple division. The results are shown in two curves in Fig. 76. It will be seen that already in the early milk stage there was a noticeable difference in the relative development of the two types as represented by their dry weights. This difference increased in the second week under observation and thereafter the germinating seeds no longer increased in weight and actually fell off somewhat during the last

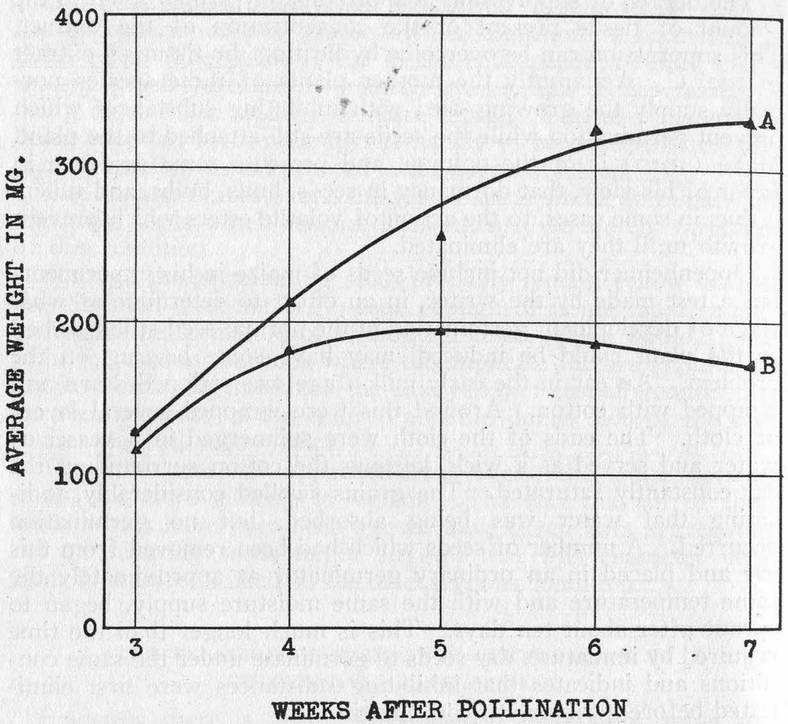

FIG. 76.—Growth curves of dormant and germinating (ge_1) seeds from the same segregating ears. The sprouting seeds do not receive enough nourishment from the plant to replace the material lost in germination.

three weeks. The normal seeds on the same ears showed an increase in dry matter during every week of the test. It is evident from these two growth curves that the amount of nourishment supplied to the aberrant seeds by the plant is not sufficient to replace that consumed in germination. In fact, it is quite likely that the germinating seeds become partially or wholly "physiologically isolated" from the plant during the later periods. At maturity the germinated seeds weighed only 51 per cent as much as the dormant seeds from the same ears.

DISCUSSION

For a period of several weeks, while the seed is in the milk or dough stage, natural conditions for germination are almost at an optimum. The temperature is fairly high and the moisture supply is abundant. The embryos are sufficiently developed to produce plants capable of surviving and the endosperm contains enough food material to nourish the seedling until it begins to manufacture food for itself. That this is true is shown by the behavior of immature seeds harvested at these early stages when many of them are capable not only of germinating but of producing almost a normal yield of grain. (See Part I.)

Why is it, then, that the partially developed seed ordinarily never germinates while still attached to the plant? Apparently the mother plant, though it provides conditions suitable for germination, at the same time supplies inhibiting substances which prevent germination from beginning.

The physiological processes involved in maintaining a period of dormancy, which permits the embryo to attain a maximum development and the endosperm to accumulate a mass of food material, are probably very complicated. It is not at all surprising, therefore, to find a number of distinct genetic factors operating during this period. Every stage in the ontogeny of the sporophyte is evidently controlled by many genetic factors and the maintenance of a normal period of dormancy which prevents premature germination with its disastrous effects, and permits the sporophyte to pass safely through unfavorable seasons, is no exception. Nine Mendelian factors which govern this stage have already been identified. Many others will undoubtedly be found as maize is investigated more extensively.

SUMMARY—PART IV

1. Nine Mendelian factors involved in the maintenance of a normal period of dormancy in maize seeds have been identified.

2. Five of these are complementary factors. When any one of these is lacking the seed germinates prematurely. Plants heterozygous for one, two or three factors give 3:1, 9:7, and 27:37 ratios respectively.

3. A pair of independent duplicate factors results in ratios of 15 dormant: 1 germinating when plants are heterozygous for both.

4. A pair of linked duplicate factors gives 8:1 ratios when plants are heterozygous for both. Crossing over is about 34 per cent.

5. The ge_1 factor appears to be linked with the gene for sugary endosperm. Crossing over is about 40 per cent. ge_2, ge_3 and ge_5 are found to be independent of sugary.

6. An apparent case of close linkage between endosperm color and several types of germinating seeds is probably due to the physiological effects of premature germination upon the accumulation of pigment in the cells of the endosperm.
7. A similar association between germinating seeds and white seedlings may also be due to physiological complications. Seeds which germinate at early stage produce only white plumules; those which germinate later have normal green sprouts.
8. Premature germination is apparently caused by the lack or loss of inhibiting substances normally supplied by the plant to the growing seeds.
9. It is suggested that many genetic factors are involved in the maintenance of a normal period of dormancy in maize seeds.

Conclusion

The mature, dormant seed of maize with its well developed embryo and the cells of its endosperm packed with starch grains, represents a real organic achievement.

Each ovule has its separate style; each style, in order for a seed to develop, must receive a pollen grain capable of germinating and producing a tube sufficiently vigorous to reach the micropyle. Failure of the growing tube to attain its goal results in the production of "parthenocarpic" defectives without endosperm or embryo.

After the pollen tube has entered the micropyle, a very precise mechanism of fertilization begins to function. Failure of this intricate mechanism in any detail may cause the formation of "germless" seeds, lacking an embryo, "miniature" seeds in which the endosperm is greatly reduced in size or perhaps aborted seeds of several other types.

The fertilization mechanism having functioned properly, the growing seed begins to receive the influence of various genetic factors. Thirteen distinct factors have been found which arrest the development of the seed and cause it to be defective and incapable of normal growth and germination. Five additional factors may affect the nature of the stored food material to such a degree that the seed is handicapped and cannot attain a maximum development.

In addition to the 18 genetic factors so far found which *retard* development to a greater or lesser degree, nine other factors have appeared which *stimulate* certain functions prematurely, with equally disastrous consequences. The seed, in order to reach maturity and pass safely through unfavorable seasons must remain dormant while still attached to the plant, even though it is capable of germination at this stage and the conditions favoring germination are almost optimum. Five complementary factors and two pairs of duplicate factors are involved in the maintenance of dormancy during development. The loss of any one or pair of these causes the seed to germinate prematurely with fatal results.

A fully mature, normally developed, dormant, white, starchy seed, then, represents the cumulative action of 27 Mendelian factors of which we know the mode of inheritance. How many additional factors are involved would be difficult to estimate, but since all these permanent departures from the normal condition of the germplasm have been found in a limited amount of material, it is certain that many more hereditary factors of a similar nature will appear. This gives some clue as to the infinitely large number of genes always working to produce a normal seed. The majority of these can not be known because they do not vary.

All hereditary units here studied concern only the seed which comprises a brief period betweeen fertilization and the resting stage of the embryo. What, therefore, must be involved in the ontogeny of the entire plant? The young seedling, the growing plant, the chlorophyll processes, reproductive machinery and even the gametophyte generation are all controlled by genetic factors the tabulation of which has only been started.

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EXPLANATION OF PLATES.

PLATE XXI. Longitudinal sections of normal seed and three successive stages of development of defective seeds of de_{14} stock. x 11.

1. Normal seed at early milk stage.
2. Defective seed, early milk.*
3. Defective seed, late milk.
4. Defective seed, dough.

PLATE XXII. Three successive stages in development of defective seeds of the de_5 stock. x 11.

1. Defective seed, early milk.
2. Defective seed, late milk.
3. Defective seed, dough.

PLATE XXIII. Three successive stages in development of defective seeds of the de_8 stock. x 11.

1. Defective seed, early milk.
2. Defective seed, late milk.
3. Defective seed, early dough.

PLATE XXIV. Successive stages in the development of the normal embryo. x 15.

1. Blister stage.
2. Early milk.
3. Milk.
4. Late milk.
5. Dough.

PLATE XXV. 1. Ears of a uniform first generation hybrid harvested at successive stages of maturity. From left to right the ears represent stages of 14, 21, 28, 35, 41, 51 and 75 days after pollination.

2. Fifty seeds from each of the ears. In appearance and dry weight these normal seeds harvested at successive stages of development resemble various types of hereditary defectives.

3. The results of planting the fifty seeds shown in 2. In ability to germinate the immature normal seeds are superior to hereditary defectives of the same relative development.

PLATE XXVI. Four morphologically distinct types of seeds which may occur on any ear of maize. x 11.

1. Normal seed with well developed endosperm and embryo.
2. Hereditary defective with aborted endosperm and embryo.
3. Germless seed containing endosperm but no embryo. This type is probably due to single fertilization.
4. Parthenocarpic defective with neither endosperm nor embryo. This type is caused by pollination which fails to accomplish fertilization.

* The relative stage of development, in every case, is that of normal seeds from the same ear, and not of the defectives themselves.

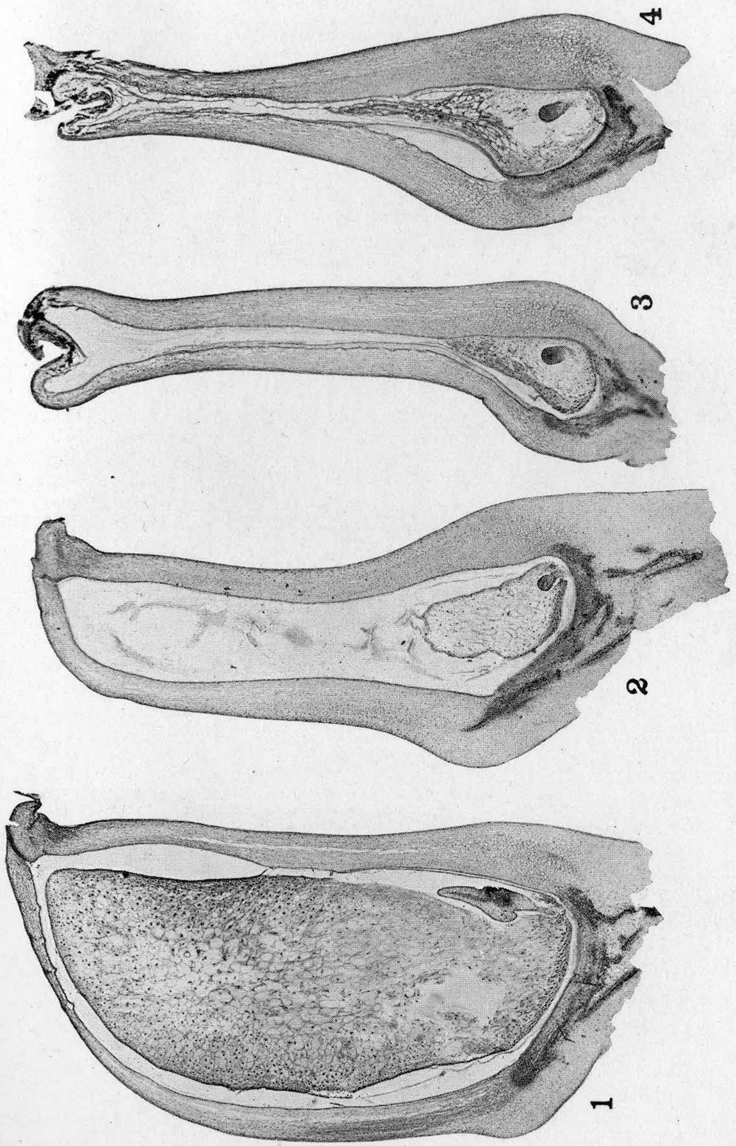
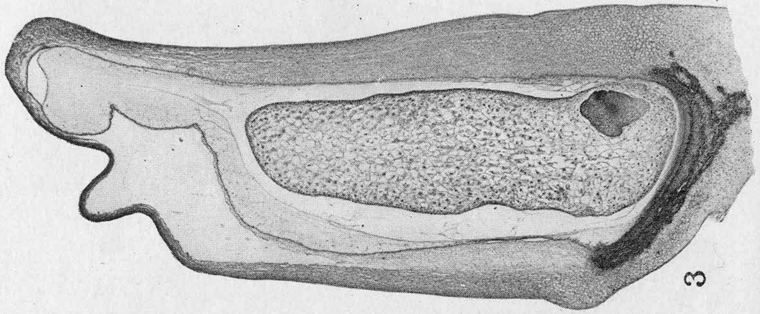


PLATE XXII.



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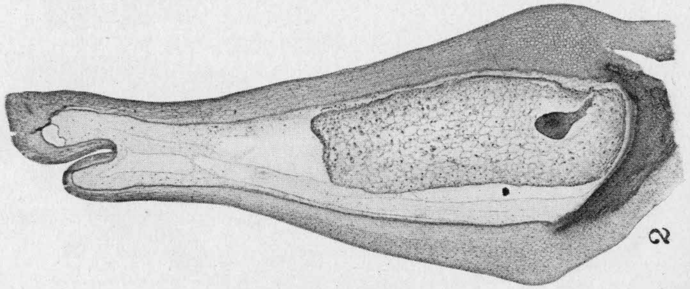

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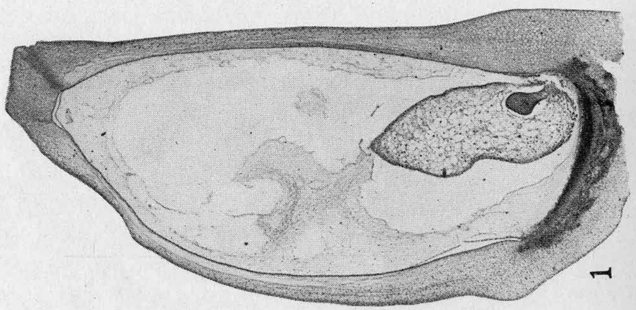

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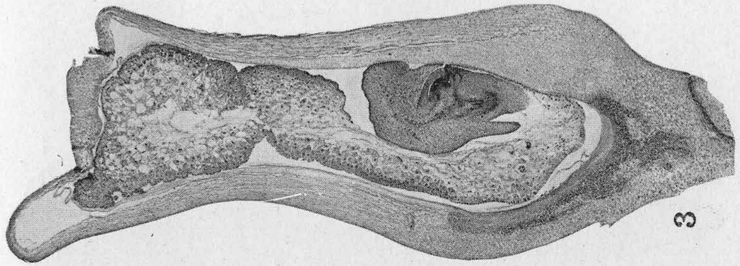
PLATE XXIII.



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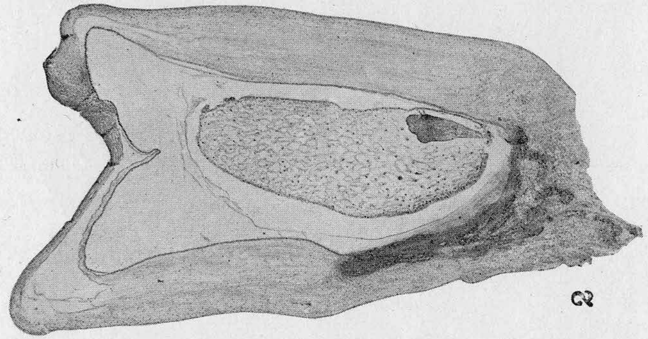

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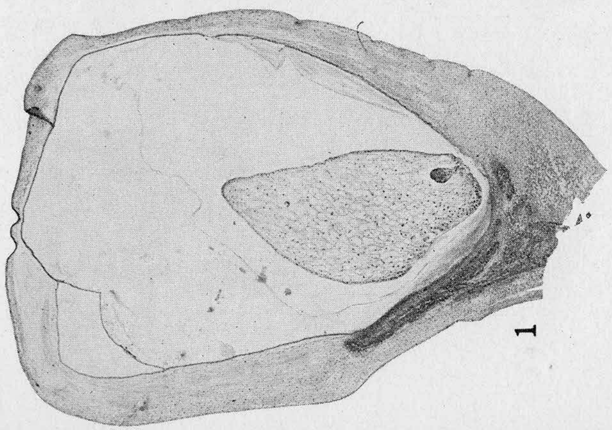

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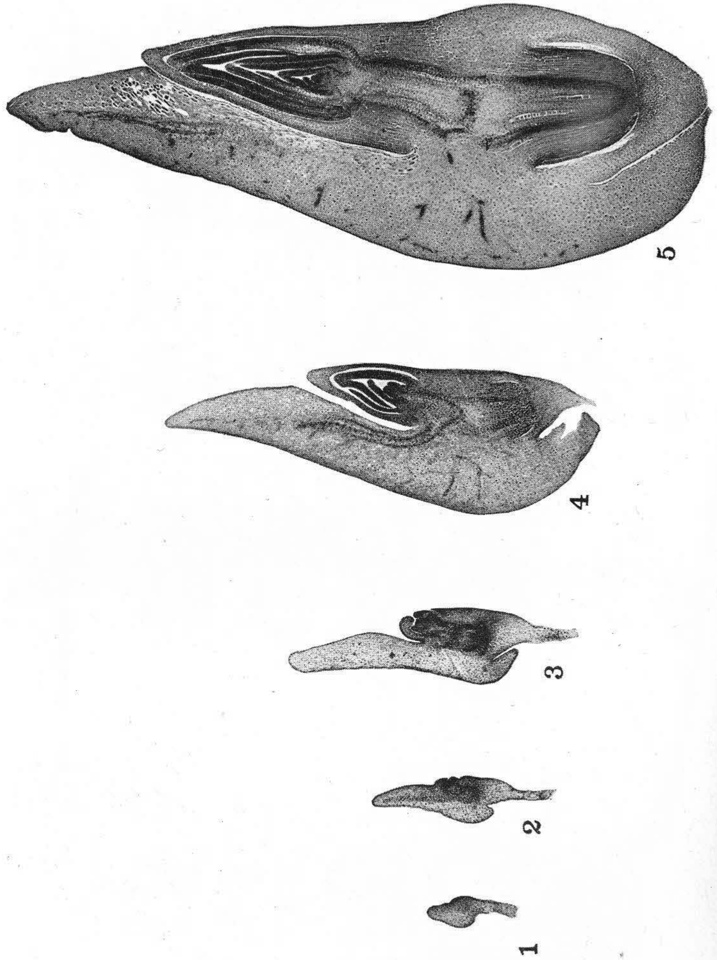
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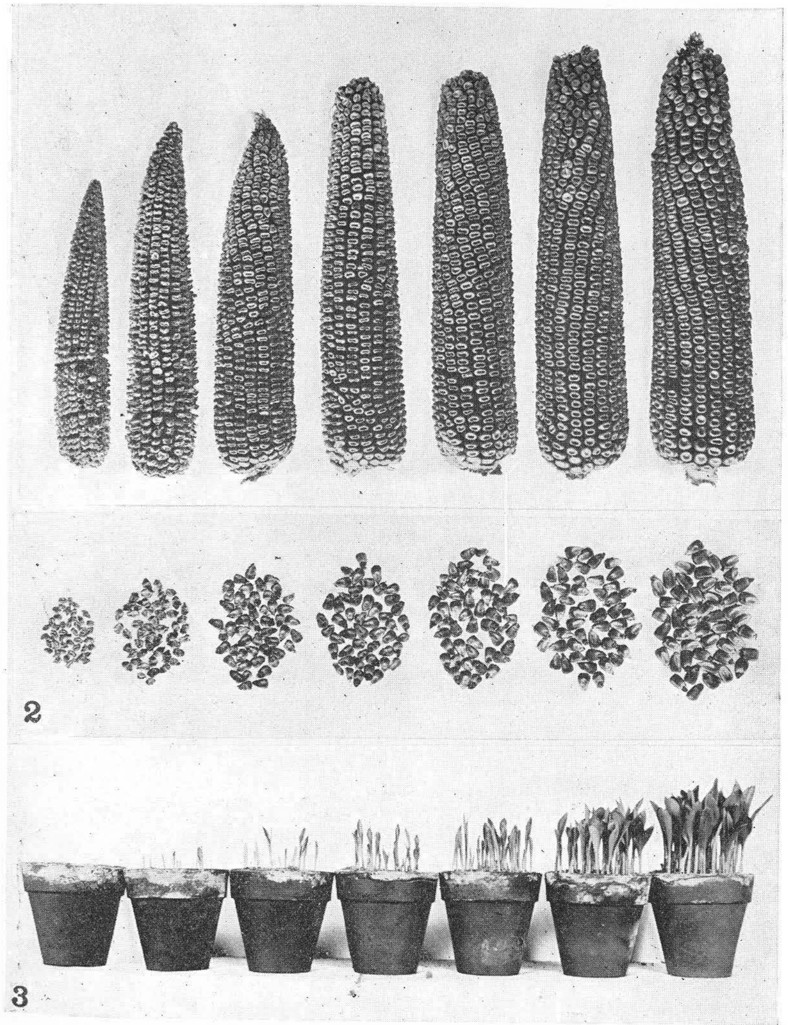
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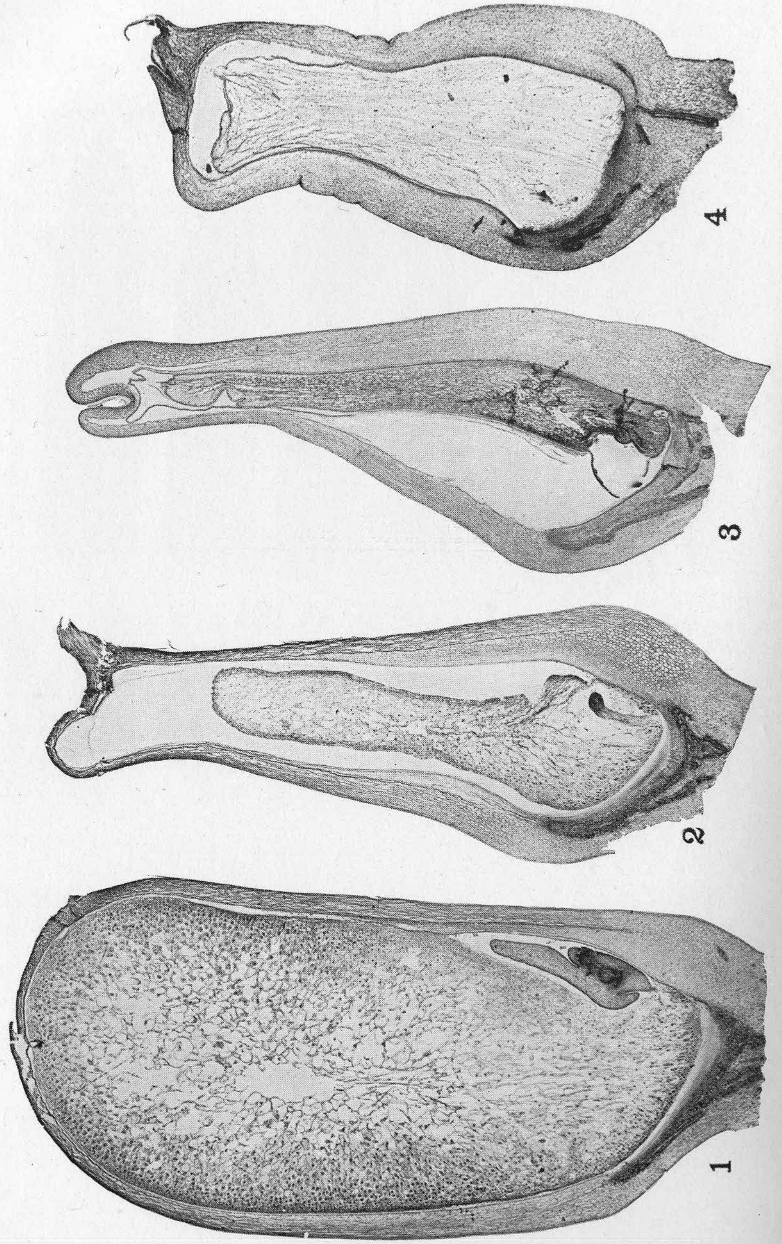


BULLETIN 280 JULY, 1926

Connecticut Agricultural Experiment Station

New Haven, Connecticut

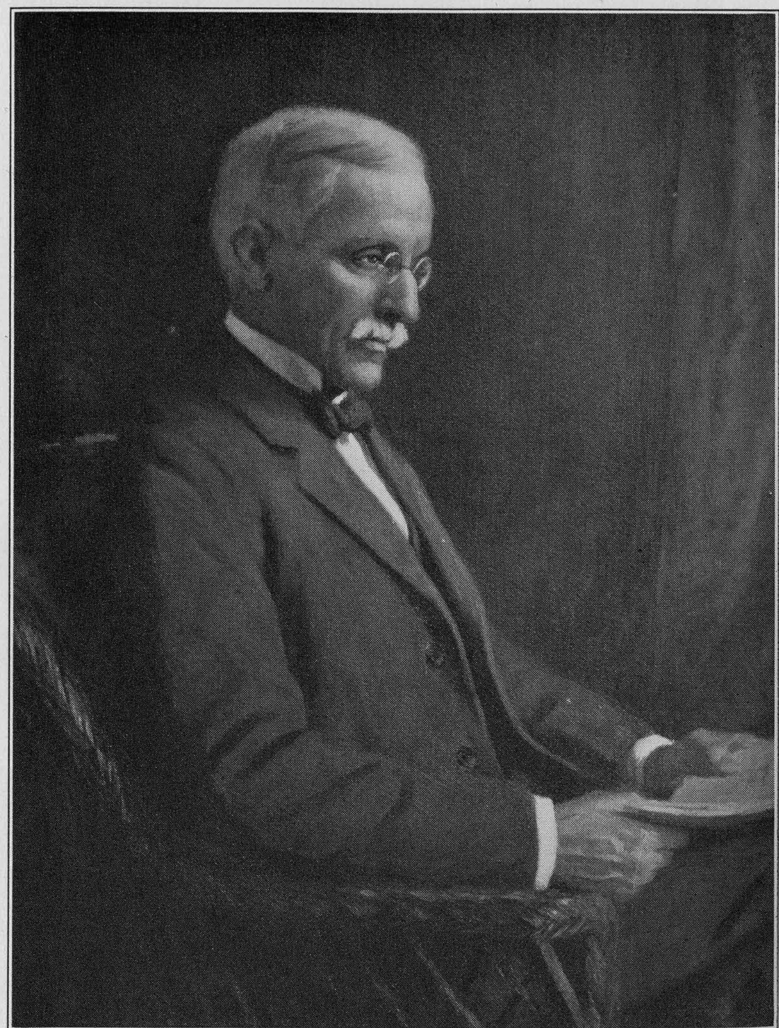
1875 - 1925

SEMI-CENTENNIAL

OF THE

Connecticut Agricultural Experiment Station

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to other applicants as far as the editions permit.



SAMUEL WILLIAM JOHNSON

Professor Samuel W. Johnson may be well called the father of the agricultural experiment station idea in this country. Beginning in 1855, his writings for the agricultural press on the progress and results of scientific agriculture in Europe, his reports on commercial fertilizers as chemist of the State Agricultural Society and later of the State Board of Agriculture, his frequent addresses at farmers' meetings in all parts of the state and his papers on science as an aid to agricultural practice, prepared the way and urged on the movement to found an Agricultural Experiment Station in Connecticut. This was the first Station to be established in America and so proved its value as to encourage other states immediately to follow the example.

The portrait here reproduced was presented to the Station by Professor Johnson's daughter, Mrs. Thomas B. Osborne.

SEMI-CENTENNIAL

of the

Connecticut

Agricultural Experiment Station

1875-1925

Seventy-five years ago Samuel W. Johnson began his labors in the interest of American agriculture. Through his contributions to the agricultural press, his early analyses of fertilizers to expose frauds, his addresses before agricultural societies, he soon became a leader, especially in Connecticut, where he labored to improve the status of the farmer and bring to him the teachings of science. During these early years he never lost an opportunity to urge the need of research and the propriety of maintaining an agricultural experiment station at public expense. In 1875, after twenty years of constant effort, Professor Johnson saw the fruit of his labors in the establishment of this station. It seemed appropriate, therefore, that the semi-centennial of this station, which marks the passage of fifty years in experiment station history in this country, should be fittingly recognized.

The announcement on the next page was sent to all experiment stations, to many scientific institutions and societies in this country and abroad and to the citizens of Connecticut. Following this will be found a brief history of the station, its establishment and government, its growth and some of its outstanding accomplishments. There are also included the two principal addresses delivered on this occasion, and reproductions of the portraits and memorials presented to the station at that time.

THE BOARD OF CONTROL

OF THE

CONNECTICUT AGRICULTURAL EXPERIMENT STATION

INVITE YOU TO BE PRESENT

AT THE EXERCISES TO BE HELD ON THE

TWELFTH DAY OF OCTOBER

NINETEEN HUNDRED AND TWENTY-FIVE

AT

NEW HAVEN, CONNECTICUT

IN CELEBRATION OF THE

FIFTIETH ANNIVERSARY

OF THE FOUNDING OF THE STATION

JOHN H. TRUMBULL
GOVERNOR OF CONNECTICUT
AND
PRESIDENT OF THE BOARD

HISTORICAL SKETCH
OF
THE STATION

The Connecticut Agricultural Experiment Station dates its birth early in 1875. At that time the General Assembly, voting that the Trustees of Wesleyan University at Middletown had tendered "the free use of laboratory and other facilities for establishing and carrying on an Experiment Station for the general benefit and improvement of agriculture and kindred interests of the State of Connecticut," appropriated $2,800 a year for two years for its support. Prof. W. O. Atwater of Wesleyan University was chosen director.

With very limited means at its disposal the Station's efforts were chiefly directed to the examination of commercial fertilizers and the study of their adaptation to special local requirements. But the director saw clearly the real purpose of an agricultural station, declaring that "it will be worthy of the name in proportion as it carries on accurate and thorough investigation and experiment in agricultural science."

The usefulness of the Station was made so apparent that at the end of the two year period the State resolved to establish it as a separate and independent State institution. This was done by an act of incorporation approved March 21, 1877. The Station's purpose was declared to be, "To promote agriculture by scientific investigation and experiment." Five thousand dollars were appropriated for its annual support and it was placed at New Haven.

Unlike other stations, afterwards organized, it is not connected with any other institution and has the corporate rights to receive and hold real and personal property and to sue and be sued in courts. It is managed by a Board of Control of eight members, one each appointed by the State Board of Agriculture, the State Agricultural Society, Wesleyan University and the Sheffield Scientific School and two by the Governor. The Governor of the State and the Station director are *ex-officio* members. Of the original members four were leading farmers, one an agricultural editor and one a professor in the State Agricultural College. Prof. S. W. Johnson was chosen director.

The Station for a time occupied an office and laboratory in the Sheffield Scientific School given by the School for its use without charge, but in 1882 the General Assembly provided a permanent home in New Haven, which the Station has occupied ever since, with about six acres of land, a dwelling house and barn. A laboratory was also built for its use.

WILBUR O. ATWATER, PH.D., LL.D.

First Director, Connecticut Agricultural Experiment Station, 1875-1877.

Graduated from Wesleyan University (A.B.), 1865; graduate student, Yale University (Ph.D.), 1869, Leipzig and Berlin, 1869-1871; Professor of Chemistry, Tennessee, 1871-1873; Maine State College, 1873; Wesleyan University, 1873-1907; First Director, Storrs Agricultural Experiment Station, 1888-1902; Founder and Director, Office of Experiment Stations, United States Department of Agriculture, 1888-1891; Established the series of United States Farmers' Bulletins, 1889; Special Agent, Nutrition Investigations, 1891, Chief in 1893, and until some three years before his death carried on the long series of dietary studies and investigations with the respiration calorimeter; Honorary LL.D., University of Vermont, 1904; Recipient of the Elliot Cresson gold medal of the Franklin Institute, and gold medal from the Paris Exposition in 1900, and other medals. Fellow, American Association for the Advancement of Science; member American Chemical Society, American Physiological Society, Washington Academy of Sciences, and of many foreign societies. Born, Johnsburg, N. Y., May 3, 1844. Died, Middletown, Conn., September 22, 1907.

(Illustration by courtesy of the Wesleyan University Alumni Association.)

Since then the Station has acquired from the income of the Lockwood fund, to be noticed later, an experiment field and orchard of 35 acres at Mt. Carmel; 13 acres of land with barns, sorting and fermenting rooms and a small greenhouse for tobacco experiments at Windsor;* tracts of 150 acres in Windsor and Granby and 4 acres in Enfield for experiments in forestry.

On the Station land in New Haven have been built, as the need developed, greenhouses, a large fireproof laboratory (the Johnson Laboratory) accommodating most of the departments, a smaller laboratory for the soils work and the plant breeding department and various small buildings for storage, etc. The original chemical laboratory has been made over for a library.

The steady growth and diversification of the Station's work, as they were made possible by appreciation of its service and by federal and state appropriations, may be indicated as follows:

From the beginning, studies of fertilizers, seeds, feeding stuffs, of analytical methods were carried on. In 1882 began investigations in the interest of dairying; the examination of foods in 1885, a food law being passed in 1895; of drugs in 1907; a department of economic botany was organized in 1888; investigations of the protein bodies followed in 1890. A department of horticulture, soon becoming entomology, was established in 1896; of forestry in 1901; of plant breeding in 1905 and of soils in 1923.

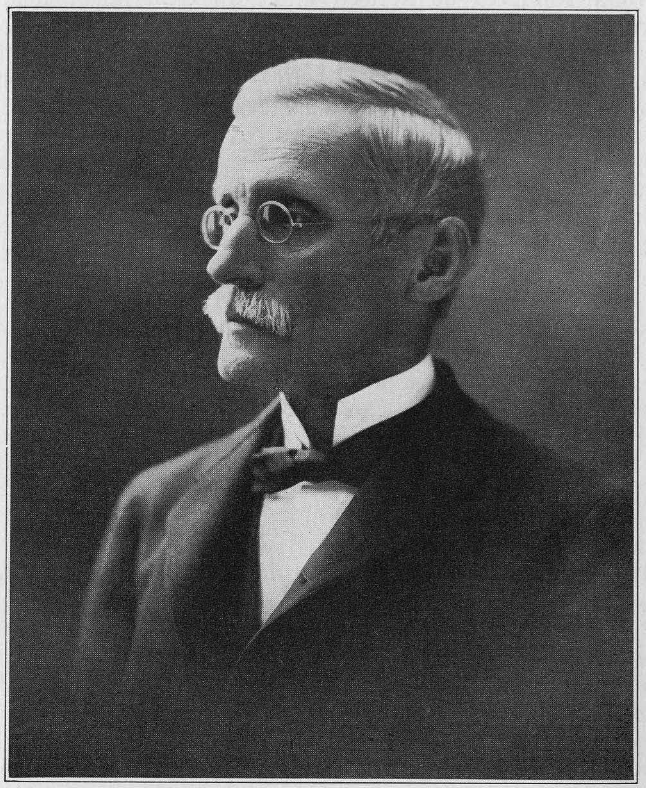
The Station has also been charged with much control work by special statutes. For instance, the fertilizer control; the control of foods and drugs, in coöperation with the Dairy and Food Commissioner; nursery and orchard inspection; control of insect and fungous pests, in immediate charge of the State Entomologist and Botanist, both members of the staff; the work of mosquito elimination; blister rust eradication; and apiary inspection.

For years the State forester was also a member of the staff. The Station forester, entomologist and botanist are an examining board to examine and certify those who are qualified to practice remedial treatment of trees outside their home towns.

What has the Station accomplished in these fifty years? It is impossible here to answer in detail. The few items mentioned below can only serve as examples of its work. It should be remembered that at its beginning there was no telephone exchange in the state, no radio, no trolley service, no automobile, no hardened state roads. No one knew definitely about the nitrogen-fixing habits of the legumes or the control of insects and fungous diseases; there was not a spraying outfit in the state, nor a silo.

There was no efficient grange organization. The only farmers' gathering of importance, outside of local farmers' clubs, was the annual meeting of the State Board of Agriculture.

* These last with the help of an association of tobacco dealers and growers.



SAMUEL W. JOHNSON, M.A.

Director, Connecticut Agricultural Experiment Station, 1877-1899.

Student, Yale University, 1849-1850; Instructor in Chemistry, Physics and Human Physiology, State Normal School, Albany, N. Y., 1851-1852; Student, Leipzig, 1853-1854, Munich, 1854-1855; Honorary M.A., Yale University, 1857; Professor of Agricultural Chemistry, Yale University, 1856-1896; Emeritus, 1896; Associate Editor, *American Journal of Sciences,* 1869-1880; member National Academy of Sciences, American Academy of Arts and Sciences, Society for the Promotion of Agricultural Science, and American Chemical Society, of which he was president in 1878. Author of "How Crops Grow," 1868, translated into six other languages; "How Crops Feed," 1870, translated into four other languages. Born, Kingsboro, N. Y., July 3, 1830. Died, New Haven, Conn., July 21, 1909.

In its early days the Station staff was its own "Extension Service" and went wherever its members could get a hearing, explaining its work; sometimes using its bulletins as a text, often greatly encouraged and sometimes saying with the prophet, "Who hath believed our report?" Personal relations with farmers and the give and take of the discussions which such gatherings made possible established a helpful relation and mutual understanding which made an enduring basis for the Station's usefulness.

Some illustrations of its work, as set forth in a History of Connecticut, are the following:

"It taught and proved by field trials the value of spraying for the protection of field crops and orchards from fungi and insects.

It has studied the life history of each new insect and fungus pest as it has appeared and the best methods of fighting it: the San José scale, the gypsy moth, the pine blister rust, the elm leaf beetle, etc. It has directed the work of mosquito elimination and accomplished much with the insufficient means at its disposal.

It substituted for the very unfair method of payment of cream by the space, the Babcock method of determining and paying for butter fat only, by adapting it for cream gathering creameries and proving its value.

It made, at the request of dairymen, a comparison of economy between the gravity and the separator systems of raising cream for butter-making creameries.

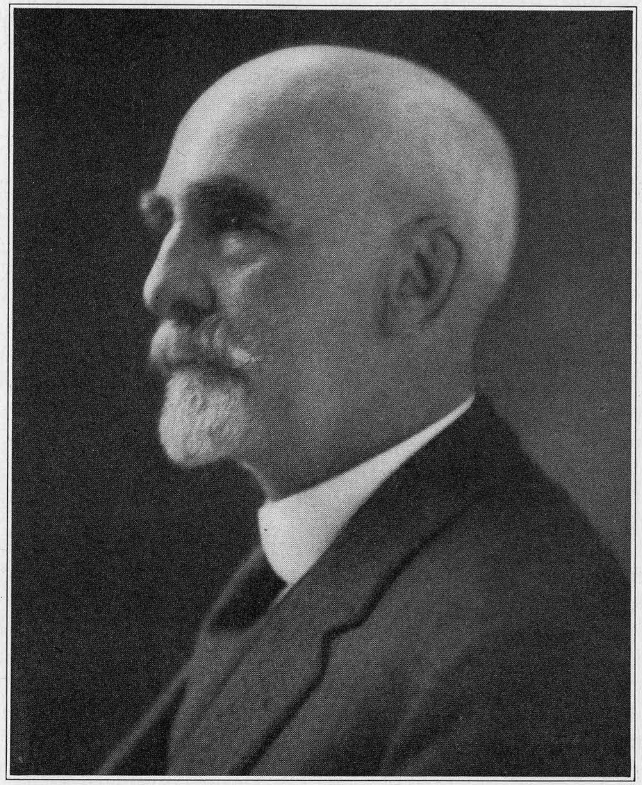
By its inspection and reports it has exposed the frauds in foods and fertilizers and driven most of them out of the State before the Federal Government undertook any of that work. As a part of that work it has examined all the special foods made and recommended for diabetic patients and the reports on them are the standard reference for specialists in the treatment of this disease.

The long continued and fruitful researches of Dr. Osborne have identified and showed the ultimate and structural composition and properties of the principal vegetable proteins.

An inquiry into their relative nutritive value led to extensive studies in nutrition, has perfected a new and most fruitful method of experiment in this field, has led to the discovery of vitamines and studies of their function and to medical studies on the cause of rickets, infertility, etc.

The study of plant breeding here has shown the futility of certain recommended methods of breeding and selection and by methods first adopted here has produced new and improved strains of corn and tobacco and has demonstrated methods of developing superior strains of field crops which have secured general recognition.

It introduced into the State the successful growing of shade tobacco and the method of fermentation in bulk and by its very elaborate field tests with fertilizers has greatly advanced the tobacco-growing industry in the State.



EDWARD H. JENKINS, PH.D.

Director, Connecticut Agricultural Experiment Station, 1900-1923; Emeritus, 1923.

Director, Storrs Agricultural Experiment Station, 1912-1923; graduated Yale University (A.B.), 1872; graduate student at Leipzig, 1875-1876, and then at Yale, receiving the Ph.D. in 1879. Chemist, Connecticut Agricultural Experiment Station, 1877-1900, Vice Director, 1884-1900, Treasurer, 1901-1923; Chairman, Connecticut State Sewerage Commission, 1897-1903; Charter member and President, Association of Official Agricultural Chemists and member of its first Committee on Food Standards; President, 1913, Association of American Agricultural Colleges and Experiment Stations; Fellow, American Association for the Advancement of Science; member, Society for the Promotion of Agricultural Science; Author of Agriculture in Osborn's History of Connecticut, 1925. Born, Falmouth, Mass., May 31, 1850, now lives at 108 East Rock Road, New Haven, Conn.

The station established an experimental forest for the study of forest problems, aided in the planting of private and corporation forests, besides giving advice by addresses and field demonstrations in the management of the farmer's wood lot.

These illustrations, by no means a summary, give some idea of the range of the station's work and show how it has gradually become a public service agency. While designed solely for the benefit of agriculture and while its main effort is directed to that end, circumstances have drawn it in several directions into the service of the whole community."

The State has increased appropriations to the Station from time to time, as its necessities required and the contributions made by the Federal government, one-half of which go to this Station, are known to all.

Important individual gifts to the Station should be noticed. Mr. William R. Lockwood of Norwalk, Conn., who died June 10, 1896, left half of his estate in trust to the Station and the other half conditionally. This also eventually came into the trust, the whole amounting to a little more than $200,000. The principal was to be held intact and the income to be used "in the promotion of agriculture by scientific investigation and experiment and by diffusing a knowledge of the practical results thereof among the people of the State of Connecticut" as the governing body of the Station deem most useful. In case of misuse of the trust, or if the Station ceases to exist, the trust terminates and the principal is given to the Sheffield Scientific School. This wholly unexpected gift has been a great boon and has made possible a development of the Station's usefulness which would have been impossible without it.

Prof. S. W. Johnson gave to the Station library, which now contains more than 14,000 volumes, 500 books from his own library, including very valuable series of agricultural and scientific journals, not otherwise obtainable. More recently his son-in-law, Dr. T. B. Osborne of the Station staff, has enriched the library by a much larger collection of rare and valuable works.

This very brief sketch necessarily omits any detailed account of the many pioneer undertakings, of the men who made them possible and of the present scope of the work. A complete history of the Station may be presented later.

THE PROGRAM

ANNIVERSARY EXERCISES

MONDAY AFTERNOON, TWO O'CLOCK

GREETING

William L. Slate, Jr., Director.

THE AGRICULTURAL EXPERIMENT STATION AND THE STATE

His Excellency, John H. Trumbull, Governor of Connecticut. President, Station Board of Control.

RELATIONS OF THE FEDERAL GOVERNMENT AND THE STATES IN AGRICULTURAL RESEARCH

Dr. E. W. Allen, Chief, Office of Experiment Stations, United States Department of Agriculture.

INFLUENCE OF EXPERIMENT STATIONS ON AMERICAN AGRICULTURE

Dr. R. W. Thatcher, Director, New York Agricultural Experiment Stations.

PRESENTATION OF PORTRAIT OF DR. JENKINS

Dr. Henry S. Graves, Provost of Yale University.

RESPONSE *Director Slate.*

ADDRESSES

The Relation of the Federal Government and the State Experiment Station

BY DR. E. W. ALLEN.

The Department of Agriculture extends cordial greetings and congratulations to this station on its fiftieth anniversary, an occasion of national interest because of the very significant forward step it commemorates. The station occupies a unique position as the original ancestor of a large and influential family, the progenitor of a new race in this country.

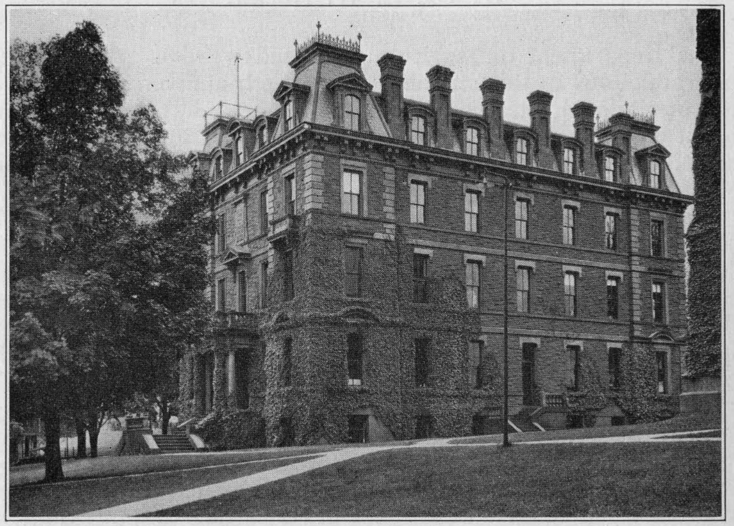
Age itself entitles to respect; age with noteworthy accomplishment brings honor and veneration. To be the forerunner of an idea which has proved so sound and practical as to be propagated in every State and Territory of the Union, and in the distant islands of the seas, is just cause for pride and self-congratulation. But modesty has always characterized this station, and it will be for its friends to bring the mete of praise it so well deserves.

In Washington we look with pride on the record of the Connecticut Station, and revere the names of its originators and leaders: Johnson, who as teacher, writer, and advocate, occupied a foremost position and wielded an influence exceeded by none; Atwater, who had the enthusiasm and persistence to impress others and to carry him over periods of opposition and discouragement; Jenkins, whose whole career has been devoted to this institution, and who for some forty years carried forward its high traditions and created here, as he modestly puts it, "an atmosphere and a somewhat comfortable place for research workers." All honor to them!

This station has served its State not only, but its country. It long since ceased to be merely a State institution; it belongs also to the Nation. As no man liveth to himself, so no such institution as this exists merely for its own community. Its benefits and relationships are limited only by the range and the application of its work; and in the sense that its work and influence have been of country-wide importance, it has come to belong to American agriculture. It is a worthy contribution of the State to the national welfare through the advancement of sound knowledge.

The Connecticut Station was one of the first to take a broad view of research which reached into the fundamentals of science as a means for understanding the common things in agriculture.

It set a standard for work which reveals not merely the bare facts but their real meaning and significance. It has dealt with simple things in a large way. What it has undertaken has been done in no superficial manner, but by digging deep to find out what lay back of the things seen, realizing that these are not themselves causes but manifestations. Its work has lived up to the declaration in an early writing of Dr. Johnson, that "it is not the novelty or the glory of discovery, but the genuineness of discovery that is of first importance." It was a bold stroke for a public institu-



ORANGE JUDD HALL, WESLEYAN UNIVERSITY, MIDDLETOWN.

This building housed the Station during the first two years, 1875-1877. The Station quarters were on the ground floor in the southwest corner and are shown at the right of the picture.

tion established with practical ends in view—a new demonstration of what is practical. It has helped to show the impracticality of half truths, and the permanent value of inquiry that is thoroughgoing.

There used to be a homely saw that what man doesn't know doesn't hurt him, or he does not worry about. Doubtless this was never to be taken too seriously, but to an extent it expressed an attitude at one time. The establishment of this experiment station was a direct answer to any such philosophy, even as applied to the backward art of farming. It was a response to a growing conviction that what man does not know he ought to make an effort to find out, and that in some things this is a just concern of the

State. Mankind has learned by hard experience that lack of knowledge or misbelief has been the greatest source of loss and worries and mistakes, but the founding of this station was the first public expression by any State of this conclusion as related to the industry on which all depend. It was a recognition of the power of research to free from error and guide to progress. It is worth while recalling these facts as showing what this anniversary really means.

Two great agencies have been set up in this country for the advancement of farming—the Department of Agriculture at Washington and the experiment stations in the States. They are separate in organization but have a common purpose, and they bear a relationship in many ways unique in the domain of research.

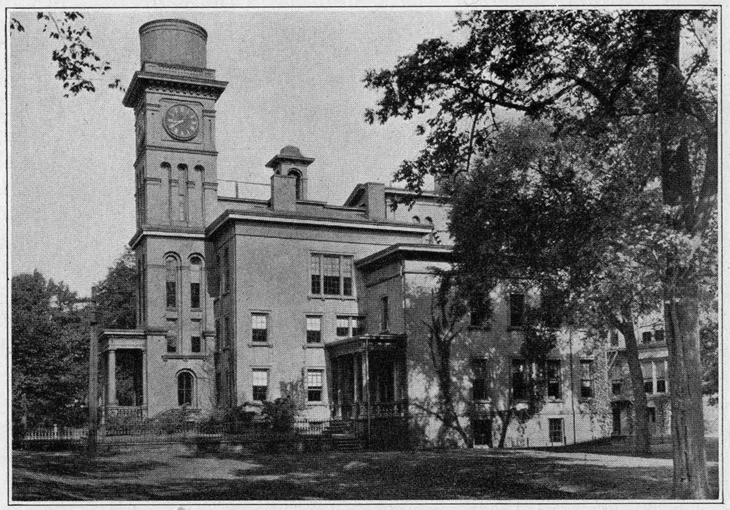
It is interesting to recall that the Department of Agriculture and the agricultural colleges were provided for by Congress in the same year, 1862. The establishment of the Department was a realization of President Washington's hope, and a response to public opinion sponsored by the U. S. Agricultural Society. The colleges were founded on confidence in science and the ability of its teachings to advance the art and make it more self-reliant. Both the Department and the colleges fostered research, although they made relatively slow progress in it.

Farming in this country had depended largely on looking backward, on following the experience and traditions of the past. In contrast to this, the experiment station was a proposal to look forward. To some extent the facts of science were being brought to bear on agricultural questions, but they were mostly derived from borrowed science developed under quite different conditions and frequently misapplied. Here was a plan to anticipate practical experience, to aid in its correct interpretation, and to get new scientific facts applying to our own conditions. Public support for it grew slowly until the State of Connecticut had the courage and the vision to take the first step.

At that time the Department of Agriculture had a total appropriation of but little over $300,000, the largest items of which, aside from salaries, were for seeds, the collection of statistics, and printing. There were allotments of $24,000 for the experimental garden and grounds, $4,500 for the museum and herbarium, and $1,300 for the maintenance of a laboratory. These represented the scientific activities of this National Department when the movement in Connecticut was at its height, and nowhere else were any public monies provided for agricultural investigation. Against such a background, the establishment of this station and the winning of support for this new idea stand out in their true significance.

Once the example was set and the initial step taken, other States followed one by one, and a movement was soon set on foot for Federal aid to provide stations in all the States. In this Dr.

Johnson was active. A bill introduced in Congress in 1883 was without result, and in the summer of 1885 the Commissioner of Agriculture called a convention of agricultural colleges and experiment stations in Washington to promote the movement. The convention endorsed a new measure which had been introduced, and appointed a committee to follow it up; and two years later, in 1887, the Hatch Act was passed, which laid the foundation for a national system with an annual appropriation of $15,000 to each State.



SHEFFIELD LABORATORY, YALE UNIVERSITY, NEW HAVEN.

Here the Station was quartered for five years, 1877-1882. The rooms used by the Station were on the ground floor of the wing and are shown at the right of the picture.

This nation-wide subsidizing of research in agriculture was evidence of the change which had come in the conception of the relationship of the Federal Government and the States. It was a recognition of a joint responsibility in developing the industry of agriculture on a high stage of efficiency, and it was a new expression of what the general Government may do under the Constitution for the promotion of public welfare. The appropriation of money for use of the States was a new departure; and the amount carried was considerably more than most of the dozen existing stations were then receiving. Indeed only one had a State appropriation equal to the new Federal grant; most of them had less than half.

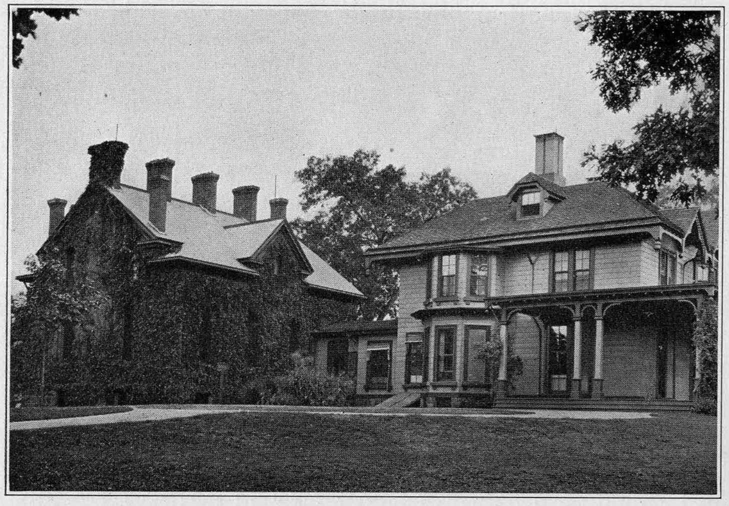
The Hatch Act came twenty-five years after the Land-Grant Act providing for agricultural colleges, and it was only a beginning. Nineteen years later the Federal support was doubled under the Adams Act, and in nineteen years more, in February last, the then prevailing amount was trebled by the Purnell Act. When this latest Act comes into full maturity each State will receive $90,000 a year, or six times its original donation in 1887. It was a very significant thing, as the Secretary of Agriculture remarked, that "at a time when the Federal Government is working under an administrative policy which calls for strict economy in the appropriation and use of public funds, both the President and the Congress have given their support to a substantial increase in the Federal funds for the use of the agricultural experiment stations in all the States." It was a fitting climax for this anniversary year.

The official relationship between the Federal Department of Agriculture and the experiment stations dates from the establishment of the national system. Provision was then made for a central office in the Department to aid and promote the work of the stations in all possible ways. It is worthy of mention that the first director of that office was Dr. W. O. Atwater, under whom the station in this State was originally organized. His vision was a broad one and his belief in the possibilities of the new system was well-nigh boundless. His influence in advocating proper standards and ideals was very large in those formative years.

The relationship of the Department has been progressive with the growth of the enterprise. Naturally such sums of public funds as were involved were found to deserve a measure of oversight which would secure their adequate use in accordance with the plans and purposes originally designed; and there were methods and standards and policies to be established. One can not speak of this official relationship without referring to the spirit and purpose which have characterized it from all sides, for these have been fundamental in preserving the harmonious, sympathetic feeling which has prevailed. I remember the quite natural feeling of uncertainty and apprehension which the more definite provision for supervision in the early nineties caused in some quarters, but this was soon allayed by the fair-minded, considerate course pursued by Dr. True, who had these matters in charge for so many years.

The administration of the Federal funds has been actuated by no desire of the Department to assume any of the functions or responsibilities of the State in the management of the stations, or to determine the lines of work to be followed. There has been no suggestion of coercion or control, no purpose to dominate or subordinate, no stipulation of State appropriations. The stations are recognized by law as State institutions, and special effort has been directed toward maintaining their individuality and strengthening their organizations. This policy of helpfulness and co-operation has been the guiding motive through all the years; and as one fully realizing the opportunity for misunderstanding, may I say, to the credit of the experiment stations, that I can conceive of no finer relationship between the Federal Government and the States.

In such a nation-wide system, with the varied conditions found in the States, there are some things a central agency can do more effectively than the individual institutions. One of these is the



GENERAL OFFICE AND LIBRARY.

Director's residence and office at right, General Library at left. Property purchased in 1882. The brick building was erected in 1882, equipped as a chemical laboratory and used for that purpose until the completion of Johnson Laboratory in 1910. Then it was fitted with book shelves and has since been used as the General Library of the Station.

shaping of policies and guarding from harmful interference. The Federal laws and their interpretation have given a basis for sound policies and practices, and have set off the field of research from other types of activity. While such interpretations carry no authority beyond the funds from the general Government, the local authorities have applied them in large measure to the entire institution. This served in the early years to build up a sentiment and custom which have safeguarded the stations and their personnel. Local politics, which for a time menaced the management in some sections, have practically been eliminated. A power and authority which have rarely needed to be invoked have had a steadying influence, exercised through counsel rather than force.

The Federal relation also has been directed toward the development of standards for the work of the stations, viewing it from a broad viewpoint. This was especially the case during the formative period, when the local conception of their field and function was less clear and when the methods were in an initial stage. Much of the work was of elementary character, and sometimes tarried unduly in that stage. There were few leaders and many leaners, with the result that there was much imitation and duplication. Such duplication was frequently unwarranted because it was not co-ordinated or correlated, and hence did not advance the subject or lead progressively to the next stage as it should.

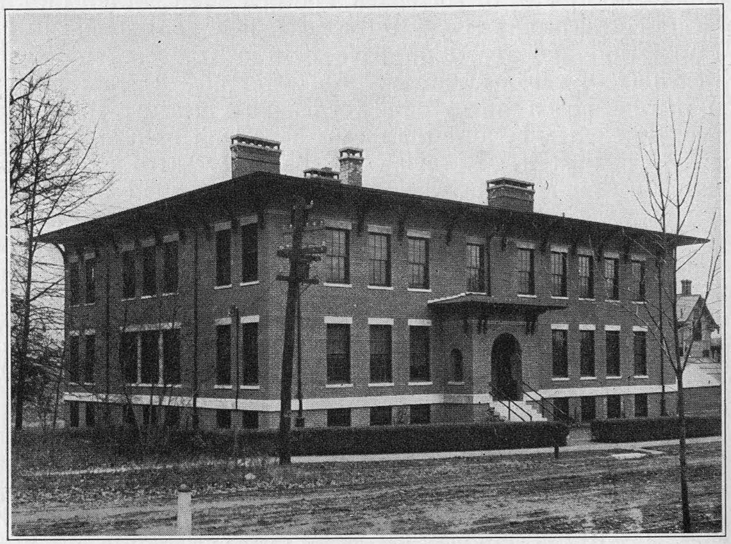
Duplication and repetition have been a frequent subject of criticism from various sources. As distinguished from replication, there has been some ground for it. In a measure, it has been difficult to excuse, because the means have long been at hand for guarding against it. A review of the progress of agricultural research throughout the world has long constituted one of the Department's contributions in aid of investigation, and latterly lists of the projects of all the stations, classified and subdivided by topics, have been prepared annually for circulation. Still work has sometimes continued after it was calculated to add substantially to what is known, beyond a further confirmation often amounting only to a local demonstration. This, happily, is passing, and the condition is one of the evidences of increased strength and progress.

Furthermore, there has sometimes seemed to be a feeling that agricultural science is different from other science, and that research in agricultural subjects is different in quality and essentials from that in other lines. This view affected much of the earlier work of the stations—expressed in the attempt to get quick returns by short cuts. Because the aim was immediately practical there was sometimes a feeling that thoroughness and completeness were not essential, and that superficial efforts were quite as appropriate to the subject as more profound ones which could not be understood by the general public.

Empirical findings often served a temporary purpose at that stage, but it was soon found that the end of borrowed science and short-cut tests was reached, and many perplexing exceptions began to arise. The need was evident for broad truths and a better understanding of things observed. It was discovered that the farmers could not be given infallible rules and formulas, as had sometimes been expected, but that the reasons and limitations must be worked out to give an intelligent basis for individual judgment. The farmer must be a man of self-reliant judgment, able to use discriminatingly the tools which are prepared for him. He can be taught new facts but he never can be freed from the making of the applications to his own case and conditions.

There is an important difference between reducing experimental results to practice—testing their applicability and working out their practicability, and the attempt to make rules and formulas for general application. One is interpretation, the other is predigested information without caution as to its use.

It is the glory of the experiment stations that their most scientific inquiries have a practical objective, and their work does not end until it has been shown how it fits into practice. But many of their investigations will, for the time being, seem to be of a



JOHNSON LABORATORY.

The present building occupied by the Departments of Analytical Chemistry, Biochemistry, Botany, Entomology and Forestry. The easterly wing was erected in 1905, and the larger portion of the building completed in 1910.

theoretical nature, and require tolerance and confidence on the part of the public.

Much that is designed to be strictly practical misses the mark. The very directness of its aim runs it to the ground. One of the things learned in these years of experience is that more often the shot with the high trajectory makes the decisive hit.

We need to increase the product of research. Changing conditions bring a constantly increasing group of problems which crowd for solution. A scientific fact remains unchanged, but it may be brought into new applications, and new facts will be needed to add to it and increase its potency. What we do not understand to-day we hope to understand to-morrow, through the agency of

new research, and this will make practice more enlightened and effective.

This is the basis of the Purnell Act, and of responsibility for the selection of live projects on the basis of permanent as well as temporary and local needs. The feeling that research is a creative function and not alone routine, and certainly not demonstration, finds general acceptance, and it is guiding the Department and the stations in the development of plans under the new Act. It constitutes a further enlargement of relationships, with new standards and policies to be worked out.

The Purnell Act is designed to give further aid to a group of institutions in existence from 35 to 50 years. It is to enable them to build upon what has been done—to broaden and strengthen the foundations where necessary, and progressively to carry the superstructure higher. Usually it will be some years before the roof can be put on, but the lower stories can be underpinned to make the structure secure, and one story after another added. The duplication of structures on an insecure foundation or according to plans shown to be inadequate is of course to be guarded against.

All research, whether actively co-operative or not, needs to be co-ordinated in the sense that it is planned and proceeds on the basis of what others have done and are doing—i. e., in accordance with the general status of the subject. If the work is constructive it will be guided by a constructive purpose; the defects or deficiencies or the limitations of what already exists will be the basis for the further effort. This may mean the necessity for laying the foundations deeper. It may mean rebuilding in part, or remodeling—sometimes only renovating; but in any event it will bear relation to what already stands, unless it be a new structure on a new site, in which case it will represent a new vision.

Despite all the uncertainties of research it is believed these things can be largely determined in advance and stated in the proposal. Clearness about them is evidence of preparation, and justification for the new undertaking. These are first steps in starting a new project; and so in passing upon such new proposals stress is being laid on a clear objective, a point of departure which takes account of the general status of knowledge in the subject, and procedure which is adequate at the start. The point of view and the method often will change as the investigation progresses, but at the outset it seems reasonable to expect that they should be forward-looking and constructive. Such a standard of quality is in the interest of all concerned. It will help to meet the high responsibility which the large sums of money received for research now entail.

In a further attempt to promote forward-looking and conclusive investigations under this new fund, more extensive co-operation in research has been strongly urged by Department and station people, and is more definitely in mind than ever before. The Department has a great variety of work which needs to be brought into harmony and relation with similar work in the stations. The Secretary of Agriculture is anxious that this should be done. He has declared his belief that "co-operation is good for research people as well as for farmers. Waste and needless duplication are just as reprehensible in research as in the handling of farm products, and the Department of Agriculture and the experiment stations should set farmers an example in the elimination of wasteful methods."

Co-operation is not here used in the restricted sense of organized effort under a definite agreement and assignment of parts, but to refer to co-ordinated or correlated effort as contrasted with every man for himself. Research is an individual product, true enough, but in the experiment station it is a public enterprise, not a private one. Without repressing individuality and without dampening the incentive which comes from individual attainment—all highly important, a good deal is believed to be practicable in arranging co-operation on many-sided problems, in effecting an increased measure of co-ordination or correlation, and in bringing workers into closer association.

This view and objective have led to something of an extension of the Department's relations with the experiment stations. A number of subjects which lend themselves to co-operation have been selected by the stations, and these have been outlined by committees of specialists. Most if not all of them involve lines in which the Department is active, but this will not mean the assumption of direction or leadership. Many workers already have set up projects under these topics which will fit into the broader inquiry. Similarly, more local or regional subjects have been selected for co-operative or co-ordinated study. In the newer fields of agricultural economics, home economics, and sociology, in which there now is rapid expansion, the opportunity is especially inviting.

Not everyone will care to join in such enterprises; many workers already have lines of inquiry under which they will wish to continue; others may prefer to do their work independently. There will be no coercion—at least from the Department, anxious as it is that co-operation should have a fair trial and that much of its own work should be joined up with that in the States.

These things have no claim to novelty. They are only given a new setting and a new emphasis by the advanced stage which has been reached and the new epoch of expansion. They were more or less definitely in the minds of the early founders, and they were exemplified by them and by their successors. They are cited to illustrate the close relationship of the Federal Department and the experiment stations, and the common ends toward which they are striving.

Influence of Experiment Stations on American Agriculture

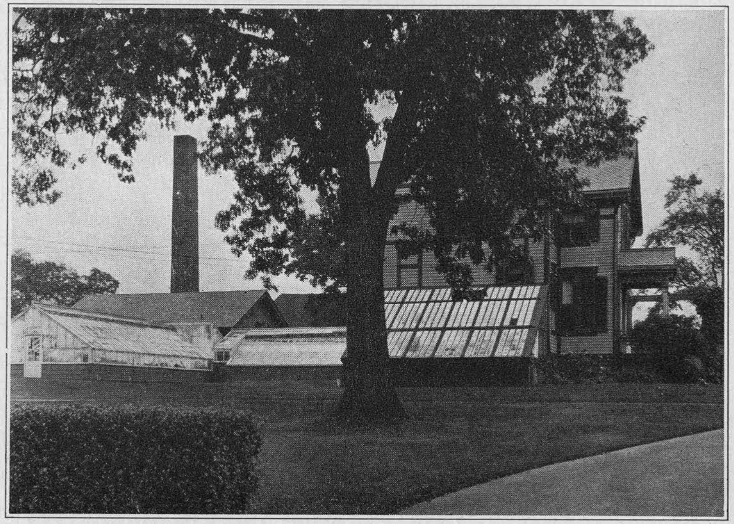
By Dr. R. W. Thatcher.

Fifty years ago the first of this month the Connecticut Agricultural Experiment Station was organized. Within the next ten years, a dozen or more states had followed this example. The success of these new ventures was so immediate and so generally recognized that there was no very great difficulty in securing the passage by Congress of the Hatch Act to provide Federal aid for the establishment of similar stations in each state in the Union. With the establishment of the station in Wyoming in 1891, only sixteen years after the organization of the Connecticut station, the chain of Federally-supported state agricultural experiment stations was complete. I cite this familiar history of an almost unparalleled development of a national policy for the promotion of agricultural welfare, in order to point out and to emphasize the wisdom of the founders of this Connecticut station and as the starting point for this discussion of the influence of the experiment stations upon American agriculture.

In most of the states, these stations were organized as a unit of the land-grant college and under the administrative supervision of the same officers who administered the teaching functions of the institution. In a few states, there were organized experiment stations which were entirely separated in their location, administration, functions, and activities from the teaching service. These separate stations apparently reflect a recognition at the time of their establishment of the need for agricultural research as a part of the State's agricultural development rather than as an adjunct to the teaching of agriculture in the college. Such an individual function of the station is now very generally recognized in all of the states. But in most cases, the agricultural research work is closely associated with the teaching duties of the faculty of the agricultural college, and in about one-half of the states the college itself is an integral part of the state university, with its graduate school which also has general research possibilities.

Under these circumstances, there has often been a failure to differentiate sharply between the experiment station research function and the university research function. Also, since the development of the extension service has taken over, in recent years, most of the opportunity and responsibility for direct contact of the research workers at the stations with the ultimate users of the constructive results of their efforts, there is often a failure by the general public to recognize the source of this new information and to "give credit where credit is due." For this reason, it has seemed to me that it is wholly fitting and proper to use this anniversary occasion to point out just what is the contribution which the experiment stations have made, can make and will make in the future to agricultural welfare.

Reference has been made frequently to the fact that the earlier activities of the first experiment stations were largely in connection with the securing of data which led to the passage of various laws for the protection of farmers from fraud in the sale of



THAXTER LABORATORY, GREENHOUSE AND HEATING PLANT.

The wood building at the right houses on the first floor the Department of Soil Research and on the second floor the Department of Plant Breeding. The building was erected in 1888 for the Botanical Department and later the Entomological Department used the second floor, both Departments moving into Johnson Laboratory on its completion in 1910. The greenhouse was erected in 1895, and the central heating plant marked by the tall chimney was constructed in 1917; this contains a small assembly room.

fertilizers, feeding stuffs, etc., and later in aiding in the enforcement of these laws. Sometimes it has been said that these activities hardly justified the name "experiment station," and in later years it has become fairly customary to look upon these regulatory activities of the stations as of a somewhat lower order of service to agriculture than the research work of the station. But I am inclined to think that this earlier type of service reflects an attitude by and toward the station which we ought to cherish and strengthen in every way; namely, the recognition of the station as

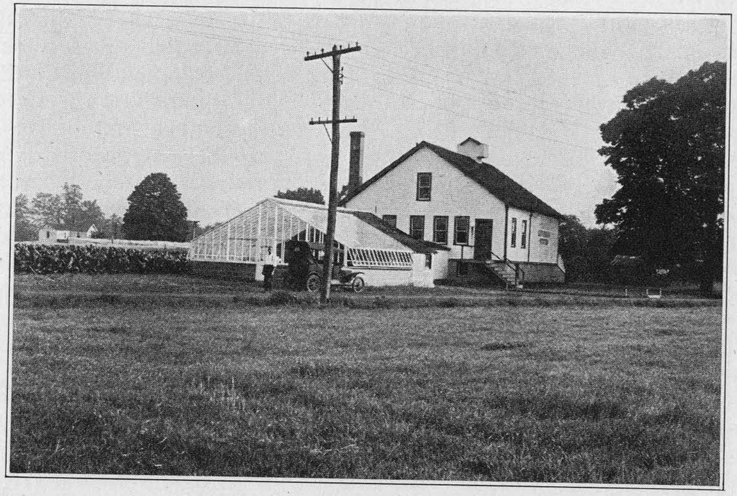
an unbiased and unimpeachable fact-finding and truth-reporting agency for agricultural and public welfare.

In the early days, there was also another aspect of station activities which has disappeared to a considerable degree with the increasing efficiency of organization of land-grant college work which yet had in it certain elements which we ought to cherish and preserve as best we can. I allude to the fact that, prior to the organization of the agricultural extension service, the scientists at the experiment station were called upon to give both resident and field instruction in agricultural practice, often to an extent much beyond that which could be justified as the making public or putting into effect of the results of their own investigations. The sharper differentiation between the teaching and the research function in recent years, and particularly, the organization of the extension service, has diminished the demand upon station workers for extraneous teaching services; but it has also shut off to a very considerable extent the direct contact of these station workers with the farmers of the state; and there is a real serious difficulty confronting the station administration to keep alive any appreciative recognition of the source of the knowledge which is being imparted through extension teaching. There is also a real loss to the research worker if the lack of opportunity to present the constructive results of his studies diminishes his sense of responsibility to secure such results and of that achievement which comes from the presentation of these results to appreciative audiences.

At the time of the preparation of this paper, I was not quite sure what would be the nature of the audience to which it would be presented. Hence, I was at a loss to know whether the most effective discussion of the topic would be a presentation of a series of striking contributions of experiment stations to agricultural science and practice which would be interesting and perhaps convincing to a farmer audience, but more or less stale repetition of familiar material to other scientists; or whether a more academic discussion of the place of station research in the public economy would be of more interest and use to this audience. It seemed to me, however, that there could be no question as to the propriety of emphasizing on this occasion the place and importance of the leadership which experiment stations have had and should have in the agriculture of the state and nation.

The retirement from active service during the past five years of such imposing figures in American agricultural history as Experiment Station Directors Woods of Maine, Brooks of Massachusetts, Jenkins of Connecticut, Jordan of New York, Armsby of Pennsylvania, Thorne of Ohio, and Davenport of Illinois has given excellent opportunity for the evaluation of personal and individual leadership in these fields. More than this, it has called attention to the guiding principles upon which their unquestioned leadership was based. It would be impossible, in the brief space of this paper, to adequately review the publicly expressed opinions of all of these men concerning the service which they have sought to have their institutions render to the cause of agricultural development. But a few quotations selected at random from the many gems of concise and illuminating statements which came from their pens will serve to illustrate the viewpoints which these sages of American agricultural research brought to their work.

Dr. Armsby is quoted as having said, after first pointing out the purpose of the station to select for study problems which appear to



TOBACCO EXPERIMENT FARM, WINDSOR.

Thirteen acres purchased in 1921. View showing laboratory and greenhouse erected in 1924.

be of most immediate practical importance: "It will seek to do thorough, conscientious work; to do a few things well, rather than many superficially." Concerning the function of the Experiment Station, he maintained that this is not the impossible task of giving the farmer recipes suited to every conceivable emergency—not a device to save the farmer the trouble of thinking—but rather to enlarge the farmer's knowledge, to make him think more; and he maintained that it is only to the extent that the farmer can by his own thinking digest and utilize the Station's help that the latter may expect to assist him permanently and effectively; he said "The true field of the experiment station is the farmer's mind, not his acres."

Dr. Thorne's view may be fairly well summarized in the following quotation: "The agricultural experiment station is a necessary

and indispensable complement to the college of agriculture, for the experiment station is both the crucible in which theories are tested and the fine gold of truth is separated from the dross of error, and the instrument of research by which further progress is made into the realm of the unknown. After all is said, it is to the soil and its secrets that we must turn for the material progress of the race; and when material progress ends the intellect will also stagnate."

Dr. Jordan's views are well known to most of you. They may be summarized in the following sentences quoted from different addresses made by him on several occasions: "The greatest and most permanent acquisitions that have come to agriculture as an art during the past fifty years are the outcome of profound scientific study." "We should guard against centering an experiment around facts or conditions which are of merely local or temporary importance." To this he added that agricultural literature "is already cluttered with so-called practical conclusions that in a brief time will be swept into the rubbish corner." He held that experiments should "deal with matters of general and permanent utility," and that the contributions which have really enriched agricultural practice "are mostly those which have been proclaimed from the inner temple of science," and that "the discoveries of scientific truth which are to-day blessing the farmer in his daily toil are mostly those which have been reached through the severest and most searching investigations."

Expressed in other terms than those which I have just quoted, I think that it may be said that it is the duty and the opportunity of a state experiment station to contribute to the agriculture of the State and nation such information concerning the problems of agriculture as can be ascertained by *the scientific method* of investigation rather than the results of practical experience in farm operation. Presumably, it is not necessary to explain to this audience what I mean by the *scientific method;* but a word as to its application to the problems of agriculture may not be amiss.

Briefly, it may be said that modern science seeks to understand the laws of nature rather than simply to learn her facts. The scientific method consists in bringing together as many related facts or phenomena as possible in order to develop therefrom a theory as to the probable cause for the observed facts, then to test this theory by every possible critical analysis to the end that the theory may finally be recognized and adopted as an hypothesis or law on which later plans may be safely based. In substance, the scientific method is to study facts with the view to the discovery of fundamental laws, in order that working practices may be based on these laws, rather than upon empirical recipes or so-called "rules-of-thumb."

Of course, a knowledge of the facts themselves is a necessary part in the development of agricultural practice, and the calls for information which come to the experiment station are usually requests for such facts or for rules of practice which can be followed without any particular thought concerning the fundamental principle involved. While this kind of information may satisfy the immediate needs of the individual farmer or fruit-grower, progress in the development of a sound agricultural practice and an intelligent farming population is much more to be expected from a more fundamental and better established knowledge of the laws of nature with reference to crop growth, animal production, etc.

STATION FARM, MOUNT CARMEL.

View during Field Day, August 1924. This farm contains thirty-five acres, of which twenty acres were purchased in 1911, and fifteen acres in 1915. On this farm are conducted many experiments in plant breeding, spraying and fertilizing of orchard, field and garden crops.

In the earlier stages of agricultural experiment station work, before these principles were so well appreciated, the investigations were largely elementary in character and based largely on observations, comparative trials, and simple field experiments which did not seriously attempt to establish the underlying principles. The results of these early experiments have been very useful and have supplied a fund of information on which much of the successful agricultural practice at the present time is based. There will almost certainly continue to be need for carefully controlled experiments of this kind in order to furnish accurate information to farmers concerning matters of farm practice about which their own individual experiences lead them to be in doubt. But there ought to be a continually increasing fund of fundamental knowledge of agricultural science going abroad in the land, so that there will be steadily less and less of these questions which the intelligent farmer is unable to understand and answer for himself.

Having dwelt thus at some length on the necessity for research which shall be fundamental in character so that it will lead to intelligent knowledge rather than "rule-of-thumb" recipes as the basis for farm practice, I turn now to a consideration of the means to be used, or the general method of attack upon problems of this kind. Here, I find myself apparently somewhat at variance with the attitude which seems to have been taken by some of my illustrious predecessors in administration of agricultural research. For a long time, there has been among university scientists a school of workers who have held that real advance in human knowledge can be made only by the study of purely natural phenomena. These scientists have scrupulously avoided the study of plants and animals which have economic uses and have confined their researches to those phenomena which have had no artificial influences in their development. Such men will have nothing to do with a study of cultivated varieties of fruits, for example, saying that the natural basis for their classification has been disturbed by the domestication process. To men of this type, the so-called "practical application" of science is a commercial, non-intellectual process which is beneath the dignity of a true scientist. Such conceptions used to be common and discussions of the relative merits of so-called "pure science" and "applied science" were numerous and acrimonious. I have thought that I have observed an influence of the earlier academic viewpoint upon some of the announced plans for the development of agricultural research. Fortunately, however, Dr. Armsby's statement that experiment station problems must be those which are of most immediate practical importance has generally been the guiding principle in the selection of the problem to be worked with and generally also in the selection of the material with which the investigations are to be made.

There are still many college faculties which insist on the preservation of the A.B. degree as an insignia of true education and culture and hold that the B.S. degree should indicate the completion of a course of vocational study which is in itself less intellectual or less cultural than the non-vocational arts course. These ideas, which were more prevalent and more pronounced twenty-five years ago than they are now, have undoubtedly had some influence upon the minds of some of the men whose opinions with reference to the character of the best research work in agricultural science I have quoted above. Personally, I came up through the science course of a university with a fixed conviction that all of the necessary elements of a real education can be obtained through the study of the materials and facts of every-day life and surroundings as well as, or better than, through the study of dead languages, ancient art, or foreign physical surroundings. I have felt that the same powers of memory and of reasoning can be developed through the study of current literature, laws and customs as well as of those of by-gone ages. I have believed that just as keen an appreciation of beauty of form, of expression and of life can be developed through a sympathetic study of Nature as she manifests herself in the forest, lakes, mountains and fields about us and of the wonderful creations of men in our cities, transportation lines, etc., as by the study of the paintings of old Masters,

EXPERIMENTAL FOREST, LOCKWOOD FIELD, WINDSOR.

This field was purchased in 1900, with additions in 1905 and 1908 totaling about 100 acres. In background at left, red pine and at right Scotch pine, seventeen years after setting. In foreground, white pine, six years after setting.

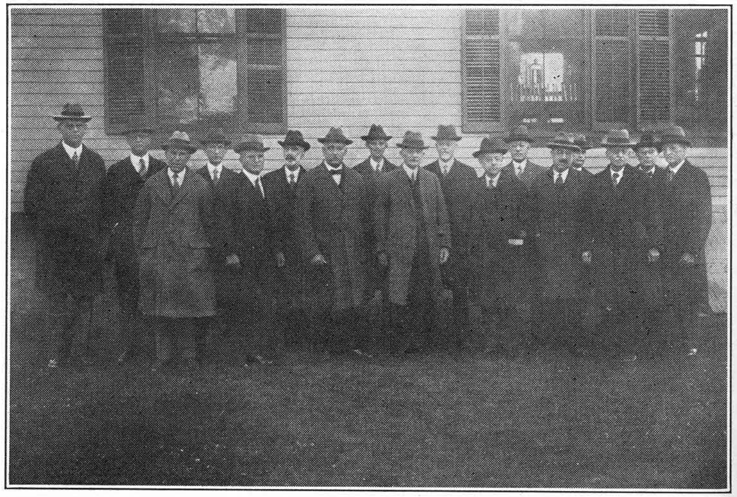
the ancient cathedrals or the splendors of profligate civilization of by-gone days. I have steadily held the conception that the powers of accurate observation, logical reasoning, and sound deduction can be just as well developed by the study of the phenomena of nature with which we are surrounded and in every-day contact as by any degree of profound consideration of those things which are without any taint of economic use or practical application. In short, I have grown up with the conviction that a *real* education may be obtained using the facts, phenomena, and materials of every-day life as the materials with which to illustrate or from which to derive the principles which are to be learned.

With these ideas in my mind, I naturally feel that the materials with which we are to work at the experiment station should be those which are of common occurrence and of practical use on the farms and in the orchards, etc., of our own State. The study, by the scientific method, of any problem in agricultural science or practice will, I believe, be as certain of giving accurate data for the solution of the problem in question and at the same time will yield a fund of practical working information such as cannot be secured if the materials worked with are foreign to our every-day working conditions. For example, it seems to me that the study of a problem in plant breeding may better be carried on with wheat, raspberries, or some other economic crop and be so planned that the results of the investigation may yield an improved new strain of field or garden crops, than with larkspurs, sweet peas, or skunk cabbage. Similarly, other things being equal, I should prefer to use swine instead of guinea pigs for studies of animal nutrition, chickens instead of pigeons, for studies of deficiency diseases, etc. To be sure, it is sometimes simpler and easier, and often cheaper, to use non-economic plants or animals for studies of general fundamental principles of heredity, nutrition, disease-resistance, etc. But as a general principle, it seems to me to be wise to have a definite economic improvement of the species, or some profitable end in view, at the same time that the data necessary from the establishment of the fundamental principle in question is being sought.

In other words, I would have the Station worker seek to secure fundamental scientific principles, but at the same time "keep his feet on the ground" in choosing his material and planning his analytical studies.

Perhaps I can best illustrate the service which the station renders to agriculture by using the simile of the doctor as an agency for promoting human health. Each community needs to have its local doctor who can be called upon at any time to give advice and render assistance for immediate needs, bringing to the community the best that is known concerning sanitation, campaigns against communicable diseases, and the curing of the ills of his constituents. But the local practitioner is not a research investigator, the latter is always located at some hospital or city laboratory where the necessary clinical material and specialized equipment for the study of new diseases or new methods of combating known ones are available. The medical research worker conducts his experiments with all the scientific skill which he possesses, until the new operation the new method of treatment or the new plan of protection of public health is well established; then he publishes his findings and intelligent citizens everywhere follow his advice so far as they are able to understand it and apply it. But when their individual problem gets beyond the scope of their own learning or ability, they call upon the local doctor, who brings to their service the results of the researches at as many laboratories as possible, as well as those of his own experience in dealing with these matters of health.

Now, if we apply this simile to agricultural needs, it is plain that the local doctor represents the local agricultural extension worker, the county agent, or his assistant. He ought to be near at hand and always available with skillful advice and assistance as needed. He should conduct demonstrations, give public instruction, and personal assistance in all matters which are sufficiently established to be past the experimental stage. He may even conduct simple experiments of his own, provided he does not undertake experiments which may result disastrously to his constituents, or interfere with his readiness to render the service for which his constituents call rightfully upon him. The research worker is located at the experiment station where the clinical material and right equipment for his study are available. The research worker, if he is to render real service, must not let his investigations lead him off into realms which have no connection with the agricultural needs of his constituency, but he must be free to prosecute his investigations without interruptions by calls to attend individual needs for assistance. These latter ought to be provided for by the local practitioners. But the research worker ought to be in close enough touch with the people and conditions which his study is to benefit so that he will not be led away from a constant attempt to meet a definite need for fundamental, sound, and scientific

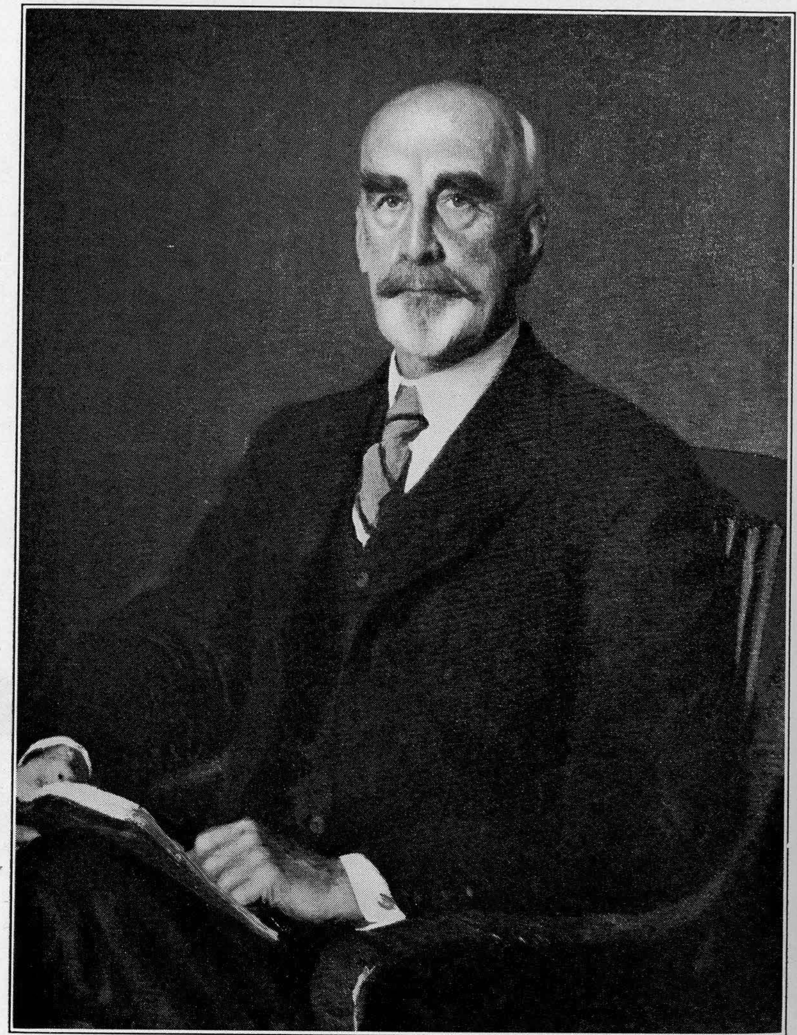


A Group of Station Directors at the Semicentennial.

information which will be applicable to the conditions which he is seeking to alleviate or improve.

I am in doubt that this admittedly academic discussion of the relation of experiment station work to agricultural development has been altogether appropriate to this occasion. I was emboldened to undertake it because it seemed to me to be so clearly the lesson of experience of half a century of experiment station work, and that the historic figures of the Connecticut station were such shining examples of the successful application. I know that I have not done justice to the clear-minded convictions and brilliant achievements of Johnson and Atwater, of Jenkins and Osborne and Mendel; but I have tried to raise aloft the lamp which it seems to me has guided their feet and illumined their pathway to noteworthy achievements and world-wide honor and respect. I hope that I have been able to say some things which modesty might have prevented their saying.

In closing, I wish to voice the debt of gratitude which we of the next younger generation of station workers owe to the pioneers in this field, not the least of whom are the members of the staff of this Connecticut station whose fiftieth anniversary we are to-day celebrating. The earliest of our stations naturally had no other experience to guide them. We have had their example. Fortunate has it been for us that the standards which they set were so high and the ideals which they cherished so noble. Our contributions to the exercises of to-day are but a feeble attempt on our part to recognize this debt. We salute you, we congratulate you, we wish for you years of added success and achievement.



EDWARD HOPKINS JENKINS

PRESENTATION
OF
PORTRAIT OF DR. JENKINS

By DR. HENRY S. GRAVES

It is my happy privilege to speak on behalf of the friends of Dr. Jenkins in presenting a portrait of him to the Agricultural Experiment Station. This I am particularly glad to do, not only because of my admiration for him and for his many public services, but also because of our personal friendship of many years' standing and an affectionate regard for him that is shared by a great host of friends in this community and throughout the States.

It is in no sense of fulsome praise that I say that Dr. Jenkins has made the greatest individual contribution to the economic development of Connecticut. The very structure of Connecticut Agriculture has been built upon the sound foundations laid through his efforts and those of his associates.

His leadership has rested upon his ability as a scientist and executive; but he has also been a great educator of the people of the State. Tens of thousands of farmers and men connected in various ways with the agricultural industry have been his pupils and are applying in practice what they have learned from him and those working with him.

Few men have had the opportunity to carry on a public work for so long a period and to see their efforts crowned with such success. Few men have been able in so great a measure to command the confidence of the community. A man of simple and straightforward character, of rare judgment in public matters, and seeking only what is in the interest of the community and state, he has enlisted the support of the people in his work to an extent possible only by a great public servant. Is it any wonder that the legislature could not refuse his requests for the support of his work or that the people could not fail to listen to his instruction?

His tact and fine judgment enabled him to bring together in effective effort the two branches of the experimental organization in Agriculture and to harmonize the research and educational undertakings of the State.

Associated with the early research enterprises in Agriculture with Professor S. W. Johnson, nearly fifty years ago, he soon became a leader whose influence was felt in the national work of building up our agricultural experiment stations.

We love him for his service to the public, but even more for his personal qualities. Possessed of rare wit and felicity of expression, he has always been under pressure to speak at public gatherings. Inspiring as a speaker and writer, with a broad vision in public affairs and with a natural sympathy with the viewpoint of the average man, he has unfailingly been able to command the attention of those who have had the good fortune to hear him speak or to read his written messages. It is quite characteristic that after a half century of arduous work devoted to public service he should continue his writing, as is illustrated by his admirable work on Connecticut Agriculture in Mr. Norris G. Osborn's History of Connecticut. His influence continues, stimulating those who have taken up his official work and those who are seeking to measure up to his high standards of achievement in the service of the State.

It is with a deep sense of appreciation of what he has accomplished and with warm personal affection for him that his friends present this portrait to the Agricultural Experiment Station.

Memorials

TO ALL ASSOCIATED WITH THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

The Director and Staff of the Rothamsted Experimental Station, desire to take the opportunity presented by the occasion of the Fiftieth Anniversary of the foundation of the Connecticut Agricultural Experiment Station, to express to all connected therewith the high esteem in which it is held among those interested in agricultural science in this country. We recall with interest that it was the first Agricultural Experiment Station to be set up in the United States in those early days when Rothamsted was but thirty two years old.
We still read with pleasure the writings of its first Director, S. W. Johnson. Among the chemists who have worked there stand out the names of, H.P. Armsby, Milton Whitney and T.B. Osborne

who in their several fields have contributed largely to the advance of science and have brought much fame not only to the Institution and themselves, but to their country. It will always be remembered that Osborne's work on proteins was carried out at the Connecticut Experiment Station. The work of the second Director, Dr. Jenkins, in developing agricultural research is too well-known to need comment. It would be invidious to particularise further, but we fervently hope that your Station may in the future maintain and if possible enhance its high reputation in the scientific and agricultural world.

Signed on behalf of the Rothamsted Experimental Station.

E J Russell

7th October, 1925 Director.

The Governing Board of the Sheffield Scientific School of Yale University

extends its congratulations to the

Connecticut Agricultural Experiment Station

on the occasion of the celebration of the

Fiftieth Anniversary

of the founding of the Station, on Monday, October the twelfth, one thousand nine hundred and twenty-five.

It is a matter of no little satisfaction to the Governing Board to recall that it has played, through the work and influence of a number of its members, an important part in the development of agricultural science in the United States and particularly the work of the Connecticut Agricultural Experiment Station. SAMUEL WILLIAM JOHNSON, for fifty-four years a member of the faculty of the Sheffield Scientific School, was a pioneer in agricultural science and was largely responsible for the establishment of the State Board of Agriculture and the first Agricultural Experiment Station, which to-day celebrates its semi-centennial. JOHN PITKIN NORTON, JOHN ADDISON PORTER, and WILLIAM HENRY BREWER are among those who took a keen interest in the work of the Agricultural Experiment Station and rendered it valuable service. There are also among the members of the Governing Board at the present time several who are in one way or another contributing to the development of agricultural science. It is the wish and hope of this Board that the close affiliation that has always existed between the Connecticut Agricultural Experiment Station and the Sheffield Scientific School may continue in future years.

Charles H Warren
President

Avard L. Bishop
Secretary

Printed at the Yale University Press, in New Haven, Connecticut, in the year of Our Lord the one thousand nine hundred and twenty-fifth and in the year of Yale University the two hundred and twenty-fifth.

THE TRUSTEES AND FACULTY

of the

Connecticut Agricultural College

Extend their Congratulations to the

Connecticut Agricultural Experiment Station

on the occasion of the Celebration of the

FIFTIETH ANNIVERSARY

of the Founding of the Station

on Monday, October the twelfth, one thousand nine hundred and twenty-five

THE anniversary celebration of an institution that has completed fifty years of successful work is a just reason for pride and satisfaction to its board of control and to the members of its staff, but we feel that there is a special honor due to the Connecticut Agricultural Experiment Station in having inaugurated a movement for organized agricultural research that has been followed by every state in the nation.

It is our hope that the institution, so well founded as to become an example, and so wisely directed as to attain such notable distinction, may continue its contribution for the future years.

Signed,

Charles L. Beach,
For the Trustees and Faculty
Connecticut Agricultural College.

Connecticut Agricultural Experiment Station

New Haven, Connecticut

GENERAL INDEX

TO

REPORTS OF THE

STATE ENTOMOLOGIST

OF

CONNECTICUT

1901-1925

W. E. BRITTON, Ph.D.

State Entomologist

CONNECTICUT AGRICULTURAL EXPERIMENT STATION

OFFICERS AND STAFF
as of
August 1926

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

REPORTS OF THE STATE ENTOMOLOGIST

The report of the State Entomologist has been issued each year, beginning with the establishment of the office in 1901. Consequently the number of each report is the same as that of the year which it covers, in this the twentieth century. Thus the 1st Report covers the year 1901, and the 25th Report the year 1925. For the sake of brevity the first two figures have been omitted, thus '01, '25. As the Annual Reports of the Station contain the Reports of the State Entomologist, in this index it seemed best to cite the number of the year instead of the report number, so that the index may be used as well for entomological matter in the full Station Reports as for the Reports of the State Entomologist.

As there are now many entomologists who keep files of these Reports, and as certain scientific and public libraries bind them separately, though each has its own index, a general index is a great help to ready reference and will make the set far more useful. Nearly half of these Reports, particularly the earlier numbers, are out of print and cannot be furnished except as occasionally copies are returned. These are reserved to complete sets for institutions and entomologists.

Acknowledgment should here be made to other members of the Entomological Department, for assistance in planning this index and in preparing the manuscript.

ERRATA

1903

Page 217, seventh line from bottom, for "*Chinaspis*" read *Chionaspis*.
Plate viii, b and c, show work and pupa of *Sesia tipuliformis*, Linn., instead of *Psenocerus supernotatus* Say.

1904

Page 201, fourteenth line from top, for "20000" read 2000.

1905

Page 256, third line from bottom, and index, for "*hamadryella*" read *hamadryadella*.

1906

Page 223, second line, for "has" read have, and for "are" read is.
" 240, second line, for "if needed" read where necessary.
" 243, sixth line, for "was" read were.
" 253, twentieth line, for "137" read 138.
" 301, twelfth line from bottom, for "850" read 350; fifth line from bottom, for "were" read was.
" 306, tenth line, for "larva" read larvae.

1907

Page 271, second line, for "weight" read weigh.

1908

Page 777, last line, for "Ridley" read Riley.

1909

Page 674, sixteenth line from top, for "xxiii" read xxviii.
" 678, seventh line from bottom, for "xxiii" read xxviii.
" 696, subtitle, and 697, seventh line, legend under Fig. 18, page 698, eleventh line, and legend under Plate xxix, c, for "*Hemiscopis*" read *Hemiscopsis*.

1920

Pages 142 and 143, top of third column, for "average" read acreage.

1925

Page 228, seventeenth line from bottom, for "*abbietis*" read *abietis*.
" 278, eleventh line from bottom, for "*Toxoptera graminum*, Rondani," read *Rhopalosiphum prunifoliae*, Fitch (*Aphis avenae*, in part, of American authors).
" 321, tenth line, and in legend under Plate xvii, b, for "*salicifolia*" read *Thunbergi*.

INDEX TO ILLUSTRATIONS

MAPS

TEXT FIGURES

PLATES

GENERAL INDEX

The principal references are indicated by bold-faced type.

INDEX

1925

The numerals marked T refer to pages of the report of the sub-station which immediately follows this index.

TOBACCO STATION BULLETIN 6 MARCH, 1926

Connecticut Agricultural Experiment Station

New Haven, Connecticut

TOBACCO STATION OFFICES, SORTING SHOP, AND GREENHOUSE.

REPORT OF TOBACCO STATION AT WINDSOR

1925

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

Report of Tobacco Station—1925

P. J. Anderson, et al.

INTRODUCTION

When the writer assumed charge of the work of the Tobacco Station, April 1, 1925, there were certain old lines of investigation which had been in progress for one, two or three years. Most of these were planned as long time experiments and in the main have been continued with but slight modification. Several new lines of work have been started and the old projects expanded. There are so many unsolved problems in the growing, curing, and fermenting of tobacco that it is obviously impossible with the present resources at our disposal to work on all of them. It is better to concentrate on a few than to do a little on all. Therefore a few of the problems, the solution of which seemed to offer most hope of permanent benefit to the grower and for which there was the most insistent demand were selected. It is realized however, that there are many other important ones and these will be undertaken as fast as time and resources will permit.

In the following pages, progress of the work up to date, on each line of investigation, is described in some detail. Few of these projects are complete and the present should be considered only a report of progress. It has seemed best to make these reports annually rather than to wait until the conclusion of each project because a part of the findings are immediately applicable and because a full discussion of the work while in progress invites suggestion and criticism which is helpful in further planning.

A list of the lines of investigation which are now being carried out at the Station is included here. This is followed by a detailed discussion of each one which has progressed far enough to warrant a report.

LIST OF TOBACCO STATION PROJECTS.

1. *Fertilizer Experiments.* A continuation of the old project but with some modifications and additions. Fully explained in the following pages except for the experiments on the effect of magnesium, chlorine and sulfur which are in coöperation with the United States Department of Agriculture.
2. *Strain tests of Havana seed and Broadleaf tobaccos.* Second year of these tests. Fully discussed in the following pages.
3. *Improvement of Shade Tobacco by breeding and selection.* In coöperation with Dr. D. F. Jones of the Plant Breeding Department. Partly an old project, partly new in 1925.
4. *The value of cover crops for tobacco.* New project begun in 1925. Since the cover crops were not planted until the fall of 1925, there are no results to report.

5. *Brown Rootrot.* In coöperation with Dr. G. P. Clinton of the Botany Dept. and Mr. H. F. Murwin of the U. S. Dept. of Agriculture. Results not reported here, but a general statement of the problem on page 66.
6. *Relation of soil reaction to black rootrot and optimum growth of tobacco.* In coöperation with Prof. M. F. Morgan of the Soils Department. Fully discussed in this report. Started in 1925.
7. *Investigation of cigarette types of tobacco for the Connecticut Valley.*
8. *Use of artificial light in the growing of Shade tobacco.* In its second year. Completed in 1925.
9. *Tests of chemically treated shade cloth.* Project in its third year.
10. *The role of humidity and temperature in curing.* This project was started in 1925 late in the season because of delays in installing the Carrier curing chambers. Not discussed in this report.
11. *The role of nitrogen and sulfur in the metabolism of the tobacco plant.*
12. *Topping and suckering experiments.* Effect on yield and quality.
13. *Relation of acid and alkaline fertilizers to Black Rootrot.* Project of the Botany Dept. under Dr. Clinton with field plots at the Tobacco Station. Not reported here.
14. *Control of wireworms.* In coöperation with the Dept. of Entomology and with the American Cyanamid Co. Emergency project begun in June, 1925. Preliminary report on page 74.
15. *Miscellaneous tobacco disease investigations.* This is a general project flexible enough to permit investigation of outbreaks of diseases which cannot always be predicted.

In addition to the above there are two lines of investigation of tobacco diseases undertaken by the botany department independent of the tobacco station, but of vital interest to the tobacco grower. These are the cause of the *mosaic disease* by Dr. Clinton and the life history of the *black rootrot fungus* by Dr. McCormick.

The function of the Tobacco Station is twofold. In the preceding paragraphs we have been considering only the first and primary function, viz., the research work, which attempts to find out something new and helpful to the grower, improve the quality or yield, or cut the cost of production. The second function is to carry the results of this investigation, augmented by all the information we can secure from other sources, directly to the grower. The first method of putting the information at the disposal of the farmer is through publication of results. Since the establishment of the Station, five bulletins have been published and the reports have been necessarily brief. This report is as complete as possible at the present time and covers all projects. Later bulletins dealing more fully with specific lines of investigation are also planned.

The fourth annual field day, attended by over four hundred growers, was helpful in bringing the growers and the Station into closer contact. Results of the investigations have been presented to gatherings of growers in a number of other public meetings. Many growers have visited the Station for personal consultations and many more have asked that members of the Station staff make visits to their farms. No request of this kind

has been refused during the year. Such personal visits and consultations are, we believe, generally more helpful than public meetings, not only to the grower but to the station members who thus gain valuable first-hand knowledge of field conditions which is important if our work is to keep in vital touch with the grower. In this field work we have had the close coöperation of the Hartford County Farm Bureau and the Field Service Department of the Connecticut Valley Tobacco Association.

Considerable time has also been spent in more direct personal

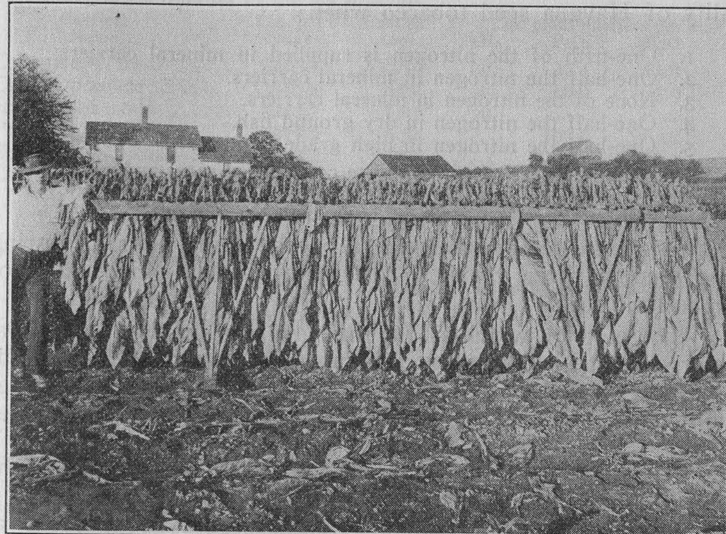


FIG. 1.—Long tobacco on the "hurdles." Fertilizer plots on station farm. 1925. This tobacco never touches the ground after spearing.

service such as testing and separation of seed, testing soil samples, diagnosis of diseases, and the like.

The work has been made possible not only by the appropriations of the State Legislature, but also by the generous support of the Connecticut Valley Tobacco Improvement Association and the Connecticut Valley Tobacco Association. Both of these organizations, because of their loyal support, deserve great credit. Growers and dealers, too numerous to mention by name here, have aided by their coöperation, support and kindly advice. The following farmers coöperated during 1925 by growing tobacco on their farm for the strain tests described later: J. B. Stewart of Windsor, Stanton Brown of Poquonock, Howard Ensign of Silver Lane, Ed. Handel of Glastonbury, Horace Vibert of South Windsor, Albert Oakes of Windsor, L. A. Bates of East Granby, and W. W. Sanderson of South Deerfield.

FERTILIZER EXPERIMENTS

P. J. Anderson and N. T. Nelson

The Old Nitrogen Series

This is a continuation of the series which has been in progress since 1922. For a detailed description and the results of the first three years the reader is referred to Bulletin 5 of the tobacco station. The objects of this series were to compare the yield and quality of Havana seed tobacco when:

1. One-fifth of the nitrogen is supplied in mineral carriers.
2. One-half the nitrogen in mineral carriers.
3. None of the nitrogen in mineral carriers.
4. One-half the nitrogen in dry ground fish.
5. One-half the nitrogen in high grade tankage.

The other carriers of nitrogen are cotton seed meal and castor pomace, which are considered standard.

Although the experiments were on the same plots as during the preceding three years, a few modifications were made for 1925 as follows:

1. The plots on which all the nitrogen was supplied in mineral carriers have been discontinued because the results of the preceding years showed that the tobacco grown with this fertilizer ration is so coarse and inferior in quality as to discourage further trials.

2. Nitrate of potash has been omitted in 1925 because the supply on the market seems to be limited and uncertain and it is questionable whether results obtained would be of practical benefit to tobacco growers.

3. Instead of combining nitrate of soda and sulfate of ammonia in one mixture as sources of mineral nitrogen, the two have been used independently on different plots. In this way the effects of each may be observed independently.

4. Acid phosphate has been omitted from the formula and the extra phosphoric acid supplied from precipitated bone which is considered a better source in tobacco fertilizers because it contains little if any sulfate. This also has the advantage of simplifying the formula.

5. In the preceding years, the acre applications of the three fertilizer plant nutrients have been: ammonia, 260 lbs.; phosphoric acid, 225 lbs.; and potash, 240 lbs. In 1925 this was reduced to 200-160-200 respectively. This was done first because the amounts previously applied were considered excessive on this land and it was feared that the effects of one nitrogen carrier would be masked by the excessive amount of another and secondly, because the adopted rates correspond in amount of plant nutrients to the standard 5-4-5 grade used at the rate of two tons per acre.

6. The potash was supplied equally from carbonate and high grade sulfate instead of all from the latter as previously. In this way the amount of sulfate in the mixtures was again reduced.

The composition of the fertilizer ration for each plot is shown in the following tables.

Nitrogen Series—Fertilizer Applications, 1925.

Plot N1. 1/5 ammonia in nitrate of soda.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash	132.5	9.94	...	....	86.1	...
Total	2,846.9	$75.66	200	160.0	200.0	14.9

Plot N2. 1/2 ammonia in nitrate of soda.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	914.6	$22.87	75	26.5	13.7	6.4
Castor pomace	367.7	5.52	25	6.6	3.7	2.9
Nitrate of soda	531.4	18.06	100	....	....	...
Precipitated bone	329.6	9.89	...	126.9	....	...
Sulfate of potash	172.0	4.73	...	....	86.0	...
Carbonate of potash	132.3	9.92	...	....	86.0	...
Double sulfate	40.7	.71	...	....	10.6	4.6
Total	2,488.3	$71.70	200	160.0	200.0	14.9

Plot N3. 1/5 ammonia in sulfate of ammonia.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Sulfate of ammonia	160.0	6.00	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash	132.5	9.94	...	....	86.1	...
Total	2,794.2	$74.43	200	160.0	200.0	14.9

Plot N4. 1/2 ammonia in sulfate of ammonia.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	914.6	$22.87	75	26.5	13.7	6.4
Castor pomace	367.7	5.52	25	6.6	3.7	2.9
Sulfate of ammonia	400.0	15.00	100	....	....	...
Precipitated bone	329.6	9.89	...	126.9	....	...
Sulfate of potash	172.0	4.73	...	....	86.0	...
Carbonate of potash	132.3	9.92	...	....	86.0	...
Double sulfate	40.7	.71	...	....	10.6	4.6
Total	2,356.9	$68.64	200	160.0	200.0	14.9

Plot N5. All ammonia in cottonseed meal and castor pomace.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,829.3	$45.73	150	53.0	27.4	13.0
Castor pomace	735.3	11.03	50	13.2	7.4	5.8
Precipitated bone	243.7	7.31	...	93.8	....	...
Sulfate of potash	165.2	4.54	...	....	82.6	...
Carbonate of potash ...	127.1	9.53	...	....	82.6	...
Total	3,100.6	$78.14	200	160.0	200.0	18.8

Plot N6. 1/2 ammonia in dry ground fish.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	731.7	$18.30	60	21.2	10.9	5.1
Castor pomace	294.1	4.41	20	5.3	2.9	2.3
Dry ground fish	957.8	35.92	100	72.7	....	...
Nitrate of soda	106.4	3.61	20	....	....	...
Precipitated bone	158.0	4.74	...	60.8	....	...
Sulfate of potash	169.0	4.65	...	....	84.5	...
Carbonate of potash ..	130.0	9.75	...	....	84.5	...
Double sulfate	66.4	1.16	...	....	17.2	7.5
Total	2,613.4	$82.54	200	160.0	200.0	14.9

Plot N7. 1/2 ammonia in tankage.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	731.7	$18.29	60	21.2	10.9	5.1
Castor pomace	294.1	4.41	20	5.3	2.9	2.3
Nitrate of soda	80.0	3.00	20	....	....	...
Tankage	769.2	21.15	100	53.3	....	...
Precipitated bone	208.3	6.25	...	80.2	....	...
Sulfate of potash	169.0	4.65	...	....	84.5	...
Carbonate of potash ...	130.0	9.75	...	....	84.5	...
Double sulfate	66.4	1.16	...	....	17.2	7.5
Total	2,448.7	$68.66	200	160.0	200.0	14.9

All treatments were in triplicate on the same 1/40 acre plots as in preceding years. Fertilizer was spread by hand in the early morning of May 22, when there was no wind to blow it, and harrowed in immediately. On May 27 the entire field was set with Havana seed plants of the Duncan Bros. strain. All plots were cultivated alike throughout the season, were topped July 20, and harvested August 10, 11, 12. Cutworms were a little worse on the first of the three series of plots and necessitated more restocking there. Otherwise the field was very uniform throughout the season. The N5 plots, however, appeared to be somewhat more backward than the others. Also, plots N3 did not grow quite as well as those adjacent.

All the tobacco in this and the following series was assorted and sampled in the Tobacco Station shop and graded on basis of selected samples by the grading department of the Connecticut Valley Tobacco Association. The price per pound for each plot was calculated by the accounting department of the Association from the sorting records and the grading. Since the loan value is estimated at one half the value of the tobacco, this figure was doubled for all grades except the dark stemming stock (11½ cents per pound) and brokes and fillers (9 cents). Twelve cents per pound was deducted for sorting, packing and overhead charges on the better grades and 3½ cents for the dark stemming, brokes, and fillers.

The sorting records of the 21 plots are presented below in Table I. The calculated yield per acre, pool record, and net return per acre are given in Table II.

TABLE I. PERCENTAGE OF GRADES IN THE NITROGEN SERIES, 1925.

Plot	Light wrappers	Medium wrappers	Long darks	Dark stemming	Long seconds	17" seconds	15" seconds	Brokes	Fillers
N1	12	9	32	7	19	4	0	11	6
N1*	14	11	29	9	17	3	0	12	5
N1**	8	9	34	6	25	1	0	13	4
N2	9	12	35	5	20	2	0	11	6
N2*	8	15	35	4	18	1	0	14	5
N2**	13	12	35	4	20	3	1	8	4
N3	10	12	36	5	20	2	0	10	5
N3*	12	17	32	5	17	2	0	11	4
N3**	8	11	38	6	19	2	0	11	5
N4	9	12	36	5	20	2	0	11	5
N4*	4	7	37	4	26	1	0	17	4
N4**	5	5	42	4	25	2	0	14	3
N5	7	11	34	6	21	1	0	14	6
N5*	6	8	36	5	20	1	0	19	5
N5**	5	9	36	5	24	1	0	15	5
N6	8	9	37	6	20	1	0	13	6
N6*	7	9	33	6	23	1	0	16	5
N6**	14	11	34	4	21	2	0	11	3
N7	14	14	28	6	20	1	0	12	5
N7*	6	9	38	6	22	2	0	11	6
N7**	11	14	30	5	19	1	0	15	5

* = first replication.
** = second replication.

Discussion of results. The value of any fertilizer ration is measured by the net return per acre after deducting price of the fertilizer, sorting, packing and overhead charges. (It is assumed that no other expenses vary with the fertilizer used although the labor item must be somewhat larger for stripping a higher yielding plot.) Therefore, the value of these seven treatments may be compared by reference to Table II.

When nitrate of soda is used as the mineral source of nitrogen it seems to make little difference whether it furnishes ⅕ of the nitrogen or ½ of it. The differences in acre yield, price per pound, percentage of grades and net return are too small to be of significance. All six plots were graded in Pool A. On the other

TABLE II. SHOWING ACRE YIELD, NET PRICE PER POUND AND NET RETURN PER ACRE, 1925.

Plot	Special form of NH_3(a): Carrier	Special form of NH_3(a): Lb. NH_3 per A.	Cost of fert. per acre	Yield per acre (Lbs.): Per plot	Yield per acre (Lbs.): Average	Net price per lb. (b): Per plot	Net price per lb. (b): Average	Net return per acre (c): Per plot	Net return per acre (c): Average	Pool rating
N1	Nitrate sode	40	$75.66	1814	1838	.34245	.34418	$545.54	556.42	A
N1*	"	"	"	1787		.36065		568.82		A
N1**	"	"	"	1914		.32945		554.91		A
N2	"	100	71.70	1729	1808	.33595	.34853	509.16	558.99	A
N2*	"	"	"	1844		.33385		543.92		A
N2**	"	"	"	1851		.37580		623.90		A
N3	Sulf. amm.	40	74.43	1681	1811	.34580	.34748	506.86	557.09	A
N3*	"	"	"	1975		.37875		673.60		A
N3**	"	"	"	1778		.31790		490.80		A
N4	"	100	68.64	1747	1913	.33660	.29397	519.40	487.21	A
N4*	"	"	"	1945		.26205		441.05		B
N4**	"	"	"	2047		.28325		501.17		A
N5	C. S. M. and C. P..	200	78.14	1709	1819	.28520	.28840	409.27	446.60	B
N5*	"	"	"	1863		.28200		447.23		A
N5**	"	"	"	1884		.29800		483.29		A
N6	D. gr. fish	100	82.54	1993	1892	.30675	.33220	523.81	543.39	A
N6*	"	"	"	1826		.31005		483.61		A
N6**	"	"	"	1857		.37980		622.75		A
N7	Tankage	100	68.66	1771	1846	.38855	.34893	619.46	574.07	A
N7*	"	"	"	1879		.30115		497.20		A
N7**	"	"	"	1888		.35710		605.54		A

(a) Cottonseed meal and castor pomace used to complete the formula up to the requirements of 200 lbs ammonia per acre.
(b) After deducting the cost of sorting, packing, sampling and overhead.
(c) After deducting the cost of the fertilizer.

hand, the final figures in the N1 and N2 plots do not show that any significant financial saving resulted in 1925 from the substitution of a larger amount of nitrate. The difference was somewhat larger in 1924. In comparing yields for the four years we find that it has been 60 lbs. less on the N2 plots than on the N1 plots. Neither the sorting records nor the notes which were taken during the sorting indicate that there was any difference in quality between the two. The same was true for the 1923 and 1924 crops, but in 1922 Dr. Chapman considered the N2 tobacco of not quite as good quality as N1.

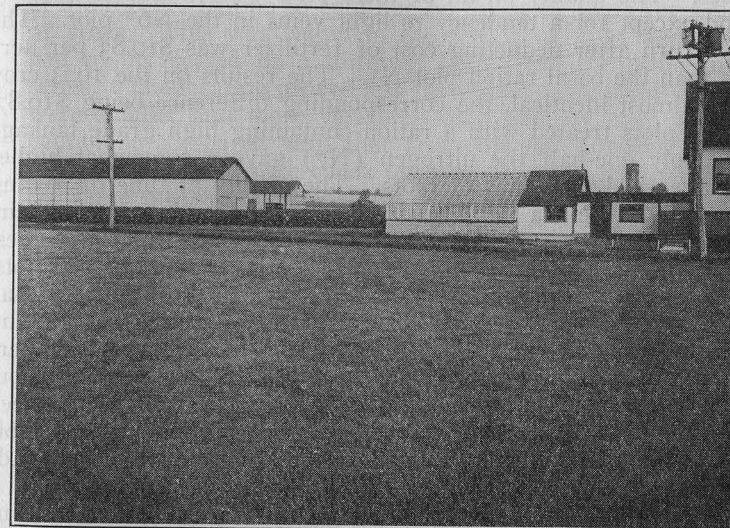


FIG. 2.—General view of station farm showing greenhouse and two of the curing sheds.

Comparing sulfate of ammonia with nitrate of soda as a mineral source of nitrogen we note that the results are about equal when only 1/5 of the nitrogen is from mineral carriers (compare N1 and N3). Neither were any differences in quality observed. When, however, 1/2 of the ammonia was supplied from sulfate of ammonia the average yield was the highest of any of the plots but the net return was next to the lowest because a smaller percentage of leaves came in the higher grades. In two of these plots there was considerable white-vein which was largely responsible for the lower rating.

When *no* mineral nitrogen-carrier was used (cottonseed meal and castor pomace only—N5), the average yield was next to the lowest and the net return was the lowest of any of the plots. Two of these plots also had considerable white-vein and one had more than the usual amount of green tobacco. This latter defect accounts for the higher percentage of brokes in N5*. The common belief of tobacco growers that the best quality is secured by the exclusion of all mineral carriers of nitrogen is not supported by the results of this test. It should be remembered, however, that this is only one year's results and that during the preceding three years these plots had *all* their supply of nitrogen from mineral sources.

The plots on which one-half the ammonia was from dry ground fish (N6) produced the heaviest yield, save one, in the whole series. The quality on all of these plots was judged to be very good except for a tendency to light veins in the N6* plot. The net return after deducting cost of fertilizer was $10.83 per acre less than the basal ration plot N1. The results on the 1924 crop were almost identical, the corresponding difference being $10.87.

The plots treated with a ration containing high grade tankage to supply one-half the nitrogen (N7) gave a somewhat higher average yield than the N1 plots. The quality at time of sorting was rated as extra good. It was thin and had no white-vein. The net return after deducting cost of fertilizer was the highest of any of the plots of the nitrogen series, exceeding the N1 plots, by $15.56 per acre. These plots have yielded more tobacco than the N1 plots every year except the first year of the experiment. During the first year the N1 plots yielded over 100 lbs. per acre more than the N7 plots. The average for the four years is about 20 lbs. more for the tankage plots. The use of tankage has been avoided by many because it was thought to contain considerable chlorine. In the chemical analysis of this year's fertilizers made by the chemistry department of the Agricultural Station, it is interesting to note that tankage shows only .31% of chlorine which is about the same as that found in fish or nitrate of soda and less than one-fifth as much as occurs in high-grade sulphate of potash and in double manure salts. Tankage has also been objected to because it produces tobacco which burns with an unpleasant aroma. At the time of writing, the tobacco has not yet come out of the sweat room and therefore the burning qualities of the different plots have not been compared. No data on aroma was secured on the previous crops. This will be discussed in a later report.

Synthetic Urea as a Source of Nitrogen.

Synthetic urea contains a very high percentage of nitrogen (ammonia equivalent, 56%), is prepared from the free nitrogen of the air, contains no residues which could be harmful by accumulation in tobacco soils, and has several advantages if it could be used in tobacco fertilizer mixtures. It has been used with favorable results on tobacco in Germany. The supply, unlike that of cottonseed meal, is likely to become more plentiful and it should become less expensive with more general use. The present supply comes from Germany and is put on the market here, after paying the import duty, at about $200 per ton. The cost per unit of ammonia is thus about the same as nitrate of soda and considerably cheaper per unit than cottonseed meal or castor pomace at the prices quoted in the spring of 1925. It is chemically an organic compound but is said to be quickly available like nitrate of soda without being as subject to quick leaching as the latter. Since its effect on the yield and quality of our cigar types is not known, it seemed worth while to start a thorough test at the tobacco station to continue on the same plots for a number of years. This was begun in the season of 1925 and the plots had to be located on a different field from the other nitrogen series. The location proved less favorable, consequently the yields were smaller and more variable. The tobacco from these plots cannot be compared with that from the old nitrogen series but must be compared with check plots on the same field treated with the same ration as the older N1 plots but designated as N1***** and N1******. The plots were in duplicate and two formulas containing urea were used. In one formula urea was the only source of ammonia (N9 and N9*); while in the other formula it was used to supply one-half of the ammonia (N8 and N8*), the other half being in cottonseed meal and castor pomace in the same proportions as in the N1 plots.

The composition of the rations applied to plots N8 and N9 are as follows:

Plot N8. 1/2 ammonia in synthetic urea.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	914.6	$22.87	75	26.5	13.7	6.4
Castor pomace	367.7	5.52	25	6.6	3.7	2.9
Urea	178.4	17.84	100	....	....	...
Precipitated bone	329.6	9.89	...	126.9	....	...
Sulfate of potash	172.0	4.73	...	....	86.0	...
Carbonate of potash ...	132.3	9.92	...	....	86.0	...
Double sulfate	40.7	.71	...	....	10.6	4.6
Total	2,135.3	$71.48	200	160.0	200.0	14.9

Plot N9. All ammonia in synthetic urea.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Urea	357.0	$35.70	200	....	....	...
Precipitated bone	415.5	12.47	...	160.0	....	...
Sulfate of potash	165.8	4.60	...	....	82.9	...
Carbonate of potash ...	127.4	9.55	...	....	82.8	...
Double sulfate	131.8	2.31	...	....	34.3	14.9
Total	1,197.5	$64.63	200	160.0	200.0	14.9

The fertilizer was applied broadcast on May 23 and the entire field set with Havana seed plants on June 1. Dates of topping, harvesting, stripping and details of sorting and pooling are as above for the nitrogen series. No significant differences in growth or maturity were noted throughout the season. About the middle of the season it was discovered that a part of this field was affected with brown rootrot but the diseased area bore no obvious relation to the fertilizer treatment since it was present in both the check plots and the plots treated with the urea ration. The worst affected areas were eliminated at harvest and not included in calculating the results.

The sorting data on these six plots are presented below in Table III. The price per pound, acre yield, rating and net return per acre are given in Table IV.

TABLE III. PERCENTAGE OF GRADES IN SYNTHETIC UREA PLOTS, 1925.

Plot	Light wrappers	Medium wrappers	Long darks	Dark stemming	Long seconds	17" seconds	15" seconds	Brokes	Fillers
N8	3	6	21	16	20	4	1	19	10
N8*	0	3	35	19	17	6	1	10	9
N9	0	0	26	26	15	2	0	17	14
N9*	3	5	30	16	22	5	2	9	8
N10	12	9	33	5	23	3	1	11	3
N10*	15	6	34	5	21	3	0	12	4
N1***	15	14	33	9	12	5	0	7	5
N1****	12	8	33	9	18	5	1	8	6
N1*****	0	3	26	24	16	5	1	17	9
N1******	12	9	27	16	14	7	2	5	8

At the time of sorting, the quality of the tobacco from the N8 plots (½ ammonia from urea) was judged to be about the same as that from the check plots. The pool rating also indicates the same. The acre yield was approximately the same. The tobacco from the plots where all the ammonia was from urea (N9) was not of such good quality since a much larger percentage of the leaves had prominent and white veins. The pool rating was also lower on these plots.

On account of the small number of replications and the lack of uniformity on this field, it is too early to draw any final conclusions from these tests of one year. The indications up to the present are (1) that urea may be used to supply one-half the ammonia of the fertilizer ration without impairment of quality or yield and that (2) its use as the sole source of ammonia in the mixture reduces the quality of the tobacco as evidenced by white and prominent veins.

CONCENTRATED FERTILIZERS.

That the yield is not reduced but probably increased by the use of urea is indicated by a further test which was made in a small way on another field where the soil was more uniform and the

TABLE IV. SYNTHETIC UREA PLOTS, 1925. ACRE YIELD, POOL RATING, NET PRICE PER POUND, AND NET RETURN PER ACRE.

Plot	Lbs. NH_3 per acre as: Urea	C. S. meal	Cost of fertilizer	Yield per acre: Per plot	Average	Pool rating	Net price per lb. (d): Per plot	Average	Net return per acre (e): Per plot	Average
N1*****	none	200 (a)	$75.66	1364	1462	A	.17840	.23722	$167.68	$277.08
N1******	"	"	"	1561		B	.29605		368.48	
N8	100	100 (b)	71.48	1356	1476	A	.24155	.21167	256.06	237.66
N8*	"	"	"	1597		B	.18180		219.27	
N9	200	none	64.63	1347	1406	C	.13755	.18540	120.65	198.86
N9*	"	"	"	1465		B	.23325		277.08	
N1***	none	200 (a)	75.66	1646	1717	A	.37120	.35345	535.33	529.95
N1****	"	"	"	1788		A	.33570		524.57	
N10	160 (c)	none	60.29	1702	1734	B	.32870	.34430	499.16	537.22
N10*	"	"	"	1766		A	.35990		575.29	

(a) 40 lbs. NH_3 per acre as nitrate of soda, 160 lbs. NH_3 as cottonseed meal and castor pomace.
(b) No nitrate in this formula.
(c) 40 lbs. NH_3 as nitrate of potash.
(d) After deducting the cost of sorting, packing, sampling, and overhead.
(e) After deducting cost of fertilizer.

yield good. The original purpose of this experiment was to see what effect a highly concentrated fertilizer would have on the yield and quality of Havana seed tobacco. If our fertilizer mixtures could be reduced to smaller volume and still supply the same quantity of plant nutrients there would be a considerable saving in labor of transportation and application. The formula mixed for this trial was as follows:

Plots N10 and 10. Concentrated formula.*

Carrier Name	Lbs. per acre	Cost per acre	Lbs. plant nutrient—A NH_3	P_2O_5	K_2O
Urea 56%	286	$28.60	160	...	...
Treble superphosphate 40%	400	12.00 (a)	...	160	...
Nitrate of potash	267	10.01	40	...	116
Carbonate of potash	129	9.68	...	...	84
Total	1,082	$60.29	200	160	200

(a) Figured at same price as precipitated bone.

This formula furnishes the same amount of nutrients per acre as two tons of a 5-4-5 mixture but the amount of material to be

FIG. 3.—A good type of wagon for drawing tobacco to the sheds. Loaded from the ground. Station farm, 1925.

handled is reduced from 4000 to 1082 lbs. The grade is 18.5-14.8-18.5. In this way possible harmful residues are reduced to a minimum and the acre cost is very low. Duplicate plots (N10 and N10*) were treated with this formula while alternating check plots (N1*** and N1****) received the same basal ration as N1. During the growing season the tobacco on the N10 plots seemed a little more rank in growth and darker green than on the check plots. The harvested weights, however (Table IV), show only a very slight gain for the "concentrated" plots. The sorting records (Table III) show no significant differences in grades but during the sorting it was noted that the tobacco from the N10 plots had a strong tendency to white-veins. A great many leaves otherwise of medium wrapper quality were thrown into cheaper grades because of this defect. No other harmful effects from the use of the concentrated formula were observed at any time during the year. The plants started to grow just as quickly as on the check plots without any evidence of root injury. There was no yellow tobacco to indicate a leaching of the fertilizer or a lack of nitrogen. On the contrary, it has been suggested by the manufacturers of urea that the objectionable prominent veins may be due to an *excess* of nitrogen rather than the *form of the carrier.* They claim for this material that the nitrogen is used by the plant to a greater extent than is the case with such organic substances as cottonseed meal, the ration being about 4:3 in favor of urea. According to this interpretation we should use only about 150 lbs. of ammonia in a urea formula to be compared with our basal ration. The average price per pound calculated by the accounting department of the Association was nearly the same for the check and urea plots. The net return per acre was slightly higher for the urea plots but the difference is too small to be of significance.

The first year's results are surely encouraging enough to warrant further testing of synthetic urea.

SOILGRO.

It is claimed by the manufacturers of this product that, although Soilgro is not really a fertilizer, it serves the same purpose because it furnishes and stimulates the growth of certain efficient nitrogen fixing bacteria in the soil. At the tobacco station it was tested during 1925 in three ways:

1. In combination with ½ our basal ration formula.
2. Without any fertilizer.
3. With a full ration of phosphoric acid and potash as in the basal ration but without any source of ammonia, depending on the soilgro to furnish the ammonia.

Some was introduced into the water used at setting time, some was applied to the roots by soaking overnight, some was applied by drenching the soil after the plants started. All three of the methods in combination were tried on some of the plants.

All the plants started well and little difference was noticed during the first three weeks. After that, however, the rows which had received no nitrogen began to lag behind and after some heavy rains in midseason they began to turn yellow and top out short. Only the rows which received the half ration of regular fertilizer kept the normal dark green color. Apparently the addition of phosphoric acid and potash had little if any effect and the soilgro failed to supply the deficiency of nitrogen since these plants were as yellow and starved in appearance as those which received no fertilizer at all. The rows were harvested separately but no sorting records were taken because all of the tobacco except that from the rows treated with regular fertilizer was yellow and lifeless and fit only for brokes. It was sold for stemming without sorting. The tobacco on the regular fertilizer rows was of somewhat less than average quality, probably due to short rations, but was far superior to that which depended on Soilgro.

It was very obvious that this substance is worthless for tobacco. For further tests of Soilgro for other crops, see Journal of Agronomy 17 : 10. 1925.

Phosphoric Acid Series.

The object of this series which has been in progress since 1922 is to determine what *quantity* of phosphoric acid is best for the production of good Havana seed tobacco. (For a more detailed description of the experiment and the results of the first three years' trials, the reader is referred to Tobacco Bulletin No. 5 of this station.) In 1925 the location of plots and the general plan was the same as in the preceding years, but a few minor changes seemed advisable:

1. The check plots (P1) received the same fertilizer ration as the N1 plots in the nitrogen series.
2. Acid phosphate was omitted from the formulas completely, precipitated bone only being used.
3. Ammonia and potash were applied at the basal acre rate of 200 lbs. each to all the plots of this series but phosphoric acid at the rate of 53, 100, 160, and 240 lbs. It was not thought worth while to continue the trial of 306 lbs. per acre, the maximum amount of 1922-24, because the preceding years' trial had shown that the tobacco produced on this ration was inferior to the others.

The plots were on the same field as the nitrogen series and alternated with them. Treatment throughout the season was the same and needs no further description than that given in discussing the nitrogen series. No significant differences in growth or maturity were noticed in these plots during the growing season.

The plots were in triplicate. The fertilizer mixture for each of the four treatments was as follows:

Plot P1. Basal ration with 160 lbs. P_2O_5 per acre.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash ...	132.5	9.94	...	....	86.1	...
Total	2,846.9	$75.66	200	160.0	200.0	14.9

Plot P2. Basal ration but no precipitated bone added. 53 lbs. P_2O_5 per acre.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash ...	132.5	9.94	...	....	86.1	...
Total	2,569.0	$67.32	200	53.0	200.0	14.9

Plot P3. Basal ration but with phosphoric acid reduced to 100 lbs. per acre.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	122.1	3.66	...	47.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash ...	132.5	9.94	...	....	86.1	...
Total	2,691.1	$70.98	200	100.0	200.0	14.9

Plot P4. Basal ration with 240 lbs. P_2O_5 per acre.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	485.7	14.57	...	187.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash ...	132.0	9.94	...	....	86.1	...
Total	3,054.2	$81.89	200	240.0	200.0	14.9

The sorting records are presented in Table V and the acre yield, pool rating, price per pound and net returns in Table VI.

TABLE V. PERCENTAGE OF GRADES IN THE PHOSPHORIC ACID PLOTS, 1925

Plot	Light wrappers	Medium wrappers	Long darks	Dark stemming	Long seconds	17″ seconds	15″ seconds	Brokes	Fillers
P1	17	16	27	7	14	4	0	10	5
P1*	6	5	35	6	22	1	0	20	5
P1**	11	11	26	12	16	5	2	9	8
P2	14	17	29	5	18	2	0	10	5
P2*	7	10	34	8	21	2	0	13	5
P2**	10	13	24	13	17	5	1	10	7
P3	10	10	26	9	23	3	0	14	5
P3*	8	7	35	6	25	2	1	11	5
P3**	6	5	32	14	23	4	2	8	6
P4	11	12	30	9	19	2	0	11	6
P4*	8	7	35	6	23	2	0	12	7
P4**	10	14	26	11	22	1	0	9	7

Examination at the time of sorting showed the quality to be very good on nearly all the twelve plots. Some light vein was noted only in Plots P3*, P3** and P4. The tobacco with the highest percentage of phosphoric acid was compared carefully for objectionable red or double colors. It was the general opinion both in the sorting shop and at the grading department that the dark wrappers did show more of a cinnamon red than the other plots but there was no objectionable red or double color. Neither was the tobacco from the plots which received the least phosphorus objectionably green.

It seems rather significant that the tobacco from the low phosphorus plots (P2 plots) not only were rated the best at time of sorting, but also were pooled highest by the Association grading department. This not only gave as high a yield as any of the other treatments, but had the highest average price per pound and the lowest fertilizer cost. In addition, the net acre return was $51.03 higher than from any other plots.

In view of the good showing of these plots at the end of 4 years without any phosphoric acid other than that in the cottonseed meal and castor pomace, and in view of their record during the preceding three years when they were so near the top in yield, quality and net return that they were well within the range of experimental error, one could be pardoned for questioning the need of any additional phosphoric acid in the fertilizer on this soil. Analyses of this soil by Professor Morgan of the Soils Department of the Station indicate it to be well supplied with fairly available phosphorus. Certainly it would be safe on the station plots to cut down the application considerably below our basal rate of 160 lbs. per acre. There are probably many other tobacco soils which are annually oversupplied with phosphoric acid. A few growers of good tobacco have told the writers that they have omitted special carriers of phosphoric acid from their fertilizer for one or more years without injurious results. It is conceivable, however, that the continuous omission of phosphorus through a long series of years might deplete the soil to

TABLE VI. PHOSPHORIC ACID PLOTS, 1925. POOL RATING, ACRE YIELD, NET PRICE PER POUND, AND NET RETURN PER ACRE.

Plot	Lbs. P_2O_5 per acre	Cost of fertilizer	Yield per acre: Per plot	Yield per acre: Average	Pool rating	Net price per lb. (a): Per plot	Net price per lb. (a): Average	Net return per acre (b): Per plot	Net return per acre (b): Average
P2	53	$67.32	1879	1812	A	.40005	.34953	$684.37	$566.86
P2*	"	"	1885		A	.30980		516.65	
P2**	"	"	1673		A	.33875		499.57	
P3	100	70.98	1742	1785	A	.34395	.30865	528.18	472.32
P3*	"	"	1899		A	.32070		538.03	
P3**	"	"	1614		B	.26130		350.75	
P1	160	75.66	1894	1788	A	.40545	.32648	692.26	512.10
P1*	"	"	1753		A	.27235		401.77	
P1**	"	"	1717		B	.30165		442.27	
P4	240	81.89	1826	1814	A	.34745	.32777	552.55	515.83
P4*	"	"	1886		A	.30995		512.68	
P4**	"	"	1731		B	.32590		482.25	

(a) After deducting cost of sorting, packing, sampling and overhead.
(b) After deducting cost of fertilizer.

an extent which would be unfavorable for the best growth of tobacco. Furthermore it is not safe to conclude that all the Connecticut Valley tobacco soils would be as indifferent to phosphoric acid fertilizers as the soil of this field at the tobacco station.

The Old Potash Series.

The purpose of the old potash series was to compare sulfate of potash with double sulfate of potash and magnesia as sources of potash in the fertilizer ration. (See Tobacco Station Bulletin 5, p. 24 for a more detailed discussion.) The three plots have been in duplicate on the same field as the nitrogen plots for three years. Location of plots for 1925 and the general plan of the experiment was the same as in the previous years. The only modifications made were the reduction of quantity of fertilizer applied per acre to 200-160-200 of ammonia, phosphoric acid and potash respectively, as previously explained under the other series and the elimination of acid phosphate. The composition of the mixtures was as follows:

Plot K1. Basal ration with all mineral potash in sulfate of potash.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Sulfate of potash	344.4	9.47	...	....	172.2	...
Total	2,886.6	$70.45	200	160.0	200.0	14.9

Plot K2. Basal ration with all mineral potash in double sulfate of potash and magnesia.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Double sulfate	662.3	11.59	...	....	172.2	74.8
Total	3,204.5	$72.57	200	160.0	200.0	89.7

Plot K3. Basal ration with mineral potash, 1/2 in High Grade sulfate and 1/2 in double sulfate of potash and magnesia.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace........	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Double sulfate	331.2	5.80	...	....	86.1	37.4
Total	3,045.6	$71.52	200	160.0	200.0	52.3

All cultural operations were the same as described previously for the other fertilizer experiments.

The sorting records for the plots are presented in Table VII and the acre yields, pool ratings, average price per pound, and net acre returns are given in Table VIII.

Table VII. Potash Series, 1925. Percentage of Grades.

Plot	Light wrappers	Medium wrappers	Long darks	Dark stemming	Long seconds	17″ seconds	15″ seconds	Brokes	Fillers
K1	14	17	29	5	19	3	0	8	5
K1*	16	14	30	5	18	3	0	8	6
K2	15	16	33	4	17	3	0	8	4
K2*	15	17	23	6	19	2	0	12	6
K3	13	10	33	4	24	2	0	9	5
K3*	14	19	25	6	20	3	0	8	5
K4	2	2	24	19	18	6	1	18	10
K4*	13	7	24	16	14	5	1	13	7
K5	4	4	21	18	15	4	1	24	9
K5*	11	11	24	15	13	4	1	17	4
K6	3	2	45	7	24	4	1	11	3
K6*	2	4	44	12	20	5	1	8	4
K7	11	11	20	18	13	6	1	13	7
K7*	11	8	22	17	16	5	1	13	7
K8	5	9	27	16	19	5	1	15	3
K8*	10	10	25	11	15	4	1	17	7
K9	4	4	29	15	23	4	2	13	6
K9*	10	9	31	12	10	4	2	16	6
K10	3	3	18	18	18	3	0	26	11
K10*	7	6	30	11	24	2	0	15	5

No differences in growth were noticed on these plots (K1, 2 and 3) during the summer. The growth was rapid and uniform from the first. Nothing resembling magnesia hunger was observed on any of these plots at any time. At the time of sorting, the quality of the tobacco from all the plots was rated as excellent. The leaves were thin and there were no evidences of white-vein, premature yellowing, or dead tobacco on any of the plots. All were put in the A grade by the Association grading department. The percentage of light and medium wrappers was uniformly high as was also the calculated average price per pound. Differences among them are too small to be of significance. The highest yield and highest net return per acre were on the plots treated with high grade sulfate. The lowest yield and lowest net return per acre were on the plots treated with double manure salts. The plots treated with a mixture of the two yielded midway between the others. The average yields for the three years of the experiment are: High grade sulfate, 1824; double manure salts, 1764; combination of the two, 1806.

Although the differences between the three are rather small, they have been in favor of the high grade sulfate during two out of the three years of the experiment. The main reason advanced

TABLE VIII. POTASH SERIES, 1925. POOL RATING, YIELD PER ACRE, NET PRICE PER POUND, AND NET RETURN PER ACRE.

Plot	K_2O applied (a) as	K_2O applied (a) Lbs. per acre	Cost of fertilizer	Yield per acre Per plot	Yield per acre Average	Pool rating	Net price per lb. Per plot	Net price per lb. Average	Net return per acre Per plot	Net return per acre Average
K1	K_2SO_4	172.2	$70.45	2054		A	.40665		$764.81	
K1*	"	"	"	2061	2057	A	.40230	.40447	758.70	$761.75
K2	Doub. sulf.	"	72.57	1932		A	.39530		691.14	
K2*	"	"	"	1892	1912	A	.41040	.40285	703.91	697.52
K3	{ K_2SO_4 / Doub. sulf. }	{ 86.1 / 86.1 }	71.52	2029		A	.37790		695.24	
K3*	"	"	"	1929	1979	A	.42155	.39972	741.65	718.44
K4	K_2SO_4	172.2	70.46	1418		B	.19010		199.10	
K4*	"	"	"	1553	1486	C	.26260	.22635	337.36	268.23
K5	K_2CO_3	"	80.86	1425		B	.19875		202.36	
K5*	"	"		1545	1485	B	.28580	.24227	360.70	282.53
K7	{ KNO_3 / K_2CO_3 }	{ 115.7 / 56.5 }	70.19	1434		B	.28750		342.09	
K7*	"	"	"	1695	1570	B	.28380	.28565	410.85	376.47
K8	{ K_2SO_4 / K_2CO_3 }	{ 86.1 / 86.1 }	75.66	1458		B	.25530		296.57	
K8*	"	"	"	1497	1478	C	.25680	.25605	308.77	302.67
K9	{ K_2SO_4 / K_2CO_3 / KNO_3 }	{ 57.4 / 57.4 / 57.4 }	72.14	1563		C	.21915		270.39	
K9*	"	"	"	1524	1544	A	.28430	.25172	361.13	315.76
K10	Marl	?		1324		C	.16230			
K10*	"	"		1641	1483	C	.25305	.20767		
K6	K Cl	172.2		1685		B	.24315			
K6*	"	"		1799	1742	B	.22820	.23567		

(a) Balance of potash (27.8 lbs. K_2O per acre) supplied in C. S. meal and castor pomace.
NOTE: K1, K2, and K3 are the old potash plots in field No. 1.
Treatments K4, K5, K7, K8, and K9 are in a different field and were begun in 1925.

for using double sulfate, however, is that it prevents the chlorotic condition of the plants commonly known as "sand-drown" or magnesia hunger. If, however, the grower uses considerable organic material such as cottonseed meal or castor pomace in his fertilizer mixture, as most growers do, he will have enough magnesia present and there would seem to be no need for using double manure salts. Our basal ration without any double manure salts contains about 15 pounds of magnesia to the acre and this seems to be sufficient to satisfy the needs of the plant for this material since magnesia hunger has not been observed on any plots which had that amount applied. The absence of magnesium starvation cannot be explained satisfactorily on the ground that this soil naturally contains a sufficient supply of available magnesia. We have two excellent demonstrations that the case is quite the contrary: (1) Within a distance of less than five rods from the old potash plots there is a series of plots on which "magnesia hunger" is being studied. Certain of these plots have not received any magnesia for four years. During the season of 1925 these plots were seriously affected with magnesia hunger. The same plots had magnesia hunger three years previously. (2) In the old nitrogen series there were certain plots (N3 and N5) which formerly received all their nitrogen in mineral carriers, and none of the fertilizer ingredients had more than a trace of magnesia. These plots were affected with magnesia hunger in 1922 (Bulletin 5, p. 8).

Summarizing the results of the old potash series we may say that up to the present no reason for substituting double manure salts for high grade sulfate has been found, either from the standpoint of preventing chlorosis or from the standpoint of improvement of quality or increase in yield. If, for any reason, a grower planned to reduce to a very low percentage the amount of cottonseed meal or other organic carrier of magnesium applied to the soil, it is conceivable that a mineral magnesia carrier would be advisable. But as long as the growers continue to apply manure, cottonseed meal, castor pomace, linseed meal, fish, wood ashes and tobacco stems in the quantities now used, there would seem to be some disadvantages and no real advantages in using the double sulfate of potash and magnesia.

THE NEW POTASH SERIES.

There are other carriers of potash besides high grade sulfate and double manure salts which may be used in fertilizer mixtures. The most important of these is carbonate. Nitrate may also be used but, as previously mentioned, the supply of this material is uncertain. There is pretty good evidence that aside from muriate, the worst form in which we can supply potash is sulfate (either in high grade or double sulfate), especially if we wish to improve the quality of our tobacco rather than to increase the yield. In the five years fertilizer experiment at Poquonock, 1892-96, it was found that the best quality of tobacco was produced on those plots which had the potash supplied in the form of carbonate, although the highest yields were produced where the sulfate was used. Later chemical work by Garner (U. S. D. A., B. P. I., Bulletin No. 105, 1907) indicates that the burn is greatly influenced by the ratio of sulfate and potash and that an excess of sulfate in the leaf should be avoided. The compounds in the leaf, which are of importance in producing good burn, are the potash salts of the organic acids, such as malate and

FIG. 4.—Duncan Brothers type of Havana Seed. Tobacco station farm, 1925.

citrate; but these salts are formed only from the potash which remains over after mineral radicals, such as the sulfates, have been neutralized. Hence, it is advisable to reduce, as much as possible, the sulfates supplied to the plant. The advantage of using carbonate of potash probably lies in the fact that it introduces potash without an unnecessary or harmful quantity of sulfates. In former years large quantities of carbonate were used on tobacco land mostly in such carriers as cotton hull ashes or wood ashes, but also to some extent as pure carbonate. Old tobacco growers state that the leaf grown in those days was superior in quality and burn to that which we raise now. It is rather difficult to prove that such was really the case and that

such superiority, if real, was due to the form in which the potash was supplied.

In view of the favorable influence of carbonate of potash on quality, why is it that nearly all fertilizer mixtures have their potash in the form of sulfate and why do most growers who mix their own fertilizers use sulfate? There are at least three contributing reasons (1) Cotton hull ashes, which was the standard source of carbonate of potash, went off the market. (2) Pure carbonate is an expensive form of potash. (3) Black rootrot was said to be favored through the use of carbonate.

The seriousness of the black rootrot menace first became apparent and attracted wide attention during the first decade of the century. Growers had been using large quantities of carbonate of potash and when it was found that an alkaline condition of the soil favored development of the disease, considerable blame was laid on the carbonate. Is it not more likely that the preceding era of heavy liming had more to do with bringing the tobacco field into this condition than the carbonate of potash? Canada ashes and cotton hull ashes also contain considerable lime in addition to carbonate of potash. Plant pathologists and other agricultural experts advised so strongly against carbonate that growers and fertilizer manufacturers have now almost ceased to use it. Meanwhile the tobacco soils have been dosed for many years with large quantities of sulfate.

One of the main objects of the potash series was to determine what effect a yearly application of the required potash in the form of pure carbonate would have on the reaction of the soil. During the last year we have determined pretty definitely the degree of acidity which is necessary in a soil in order to prevent rootrot. Most of the tobacco soils are so acid that there would seem to be little likelihood of reducing the acidity to a dangerous degree by the annual application of carbonate of potash to supply 200 lbs. of potash per acre. In order to test this, a new series of plots was laid out on a different part of the experiment station farm where tobacco has been grown for many years. This field is not so favorable for growing tobacco as the field where the old fertilizer plots are located. The soil is a lighter sand, more inclined to leaching ,and has never produced as much or as good tobacco. The plots are 1/40 acre in size and in duplicate. The fertilizer rations applied to each are as follows:

Plot K4. All mineral potash in H. G. sulfate.

Carrier Name	Lbs. per acre	Lbs. per 1/40 acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	36.6	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	14.7	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	5.3	7.23	40	...	...	...
Precipitated bone ..	277.9	6.9	8.34	...	107.0	...	...
Sulfate of potash ..	344.4	8.6	9.48	...	...	172.2	...
Total	2,886.6	72.1	$70.46	200	160.0	200.0	14.9

Plot K5. All mineral potash in carbonate.

Carrier Name	Lbs. per acre	Lbs. per 1/40 acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	36.6	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	14.7	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	5.3	7.23	40	...	...	...
Precipitated bone ..	277.9	6.9	8.34	...	107.0	...	...
Carbonate of potash.	265.0	6.6	19.88	...	...	172.2	...
Total	2,807.2	70.1	$80.86	200	160.0	200.0	14.9

Plot K7. 2/3 mineral potash in nitrate; 1/3 in carbonate.

Carrier Name	Lbs. per acre	Lbs. per 1/40 acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	36.6	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	14.7	8.82	40	10.6	5.9	4.7
Nitrate of potash ...	266.6	6.7	9.92	40	...	115.7	...
Precipitated bone ..	277.9	6.9	8.34	...	107.0	...	...
Carbonate of potash.	87.0	2.2	6.52	...	...	56.5	...
Total	2,683.1	67.1	$70.19	200	160.0	200.0	14.9

Plot K8. Mineral potash divided equally between sulfate and carbonate of potash.

Carrier Name	Lbs. per acre	Lbs. per 1/40 acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	36.6	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	14.7	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	5.3	7.23	40	...	...	...
Precipitated bone ..	277.9	6.9	8.34	...	107.0	...	...
Sulfate of potash ..	172.2	4.3	4.74	...	...	86.1	...
Carbonate of potash.	132.5	3.3	9.94	...	...	86.1	...
Total	2,846.9	71.1	$75.66	200	160.0	200.0	14.9

Plot K9. Mineral potash divided equally between sulfate, nitrate, and carbonate.

Carrier Name	Lbs. per acre	Lbs. per 1/40 acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	36.6	$36.59	120.0	42.4	21.9	
Castor pomace.	588.2	14.7	8.82	40.0	10.6	5.9	
Nitrate of soda	107.4	2.7	3.65	20.2	...	...	...
Precipitated bone ..	277.9	6.9	8.34	...	107.0	...	...
Sulfate of potash ...	114.8	2.9	3.16	...	...	57.4	...
Carbonate of potash.	88.3	2.2	6.62	...	...	57.4	...
Nitrate of potash ...	132.3	3.3	4.96	19.8	...	57.4	...
Total	2,772.3	69.3	$72.14	200.0	160.0	200.0	...

It will be noted from the above that not only carbonate, sulfate and nitrate are being tested but various combinations of them.

No significant differences in growth were observed during 1925, the first year of the experiment. After the heavy rains in July there was considerable indication of leaching and the lower leaves showed considerable yellowing before harvest.

Growth was not entirely satisfactory; and besides, a spotting of the lower leaves resembling in all outward symptoms the southern bacterial disease, "angular leaf spot," caused considerable damage on one end of the field.

All sorting and pooling data are presented in Tables VII and VIII.

Comparison during the sorting placed the tobacco from the sulfate plots (K4) as the poorest of all. The leaves were inclined to be yellow, boardy, and lacking in life and elasticity. The plots having carbonate of potash alone (K5) were of better quality and the net return was higher although the yield was about the same. The highest yield and highest net return per acre were on the plots where ⅔ of the mineral potash was from nitrate and the other third from carbonate (K7 and K7*). (It was not possible to use nitrate as the only source of potash because the mineral nitrogen would thus have been raised above the requirements of the formula.) The average price was also highest on these and at the time of sorting the quality of both was rated as good. The plot, however, which rated highest was K9*. This tobacco was thin, elastic and showed no white-vein nor yellowing. Angular leaf spot was more serious on this than on any of the other plots in this field, and was responsible for the high percentage of brokes. Otherwise it would have made a much better showing. The duplicate plot K9, however, was not considered as good. Since this was the first year of the experiment and the growth on all the plots was not considered entirely satisfactory, it is best not to draw any conclusions.

The effect of the different carriers of potash on the reaction of the soil is of interest and importance. In May, before the fertilizers were applied, samples of the soil from each plot were taken and the reaction tested. Again in September after the crop was harvested, the soil was tested. Without presenting the results of these tests in detail it may be stated that the change in acidity on any of the plots was not perceptible within the limitations of the method. It will be necessary, however, to continue the determinations on the same plots through a series of years before generalizing on the effects of using different potash carriers on tobacco soils.

Soil tests on the fertilizer plots at the Rhode Island Station (R. I. Bul. 189) after 26 years of application of carbonate of potash and of soda are sometimes cited as proving that carbonate of potash has a strong tendency to make the soil alkaline. It should be noted, however, that in addition to the regular ration of carbonate of potash, these plots received a heavy application of carbonate of soda (620 lbs. per acre during the spring when the tests were made).

In view of the natural leaching of certain basic elements in average soils and the amount of potash which is removed by the tobacco crop every year, there would seem to be little danger of so reducing the acidity as to bring on rootrot by the annual application of two to three hundred pounds of potassium carbonate per acre. A long series of years of this treatment, however, might endanger some soils. Carbonate should be avoided on low, heavy soils where the seepage water from higher ground is apt to stand and from which there is little leaching. In many tests which were made during the past few seasons in tobacco fields it has been found that such low spots in the field are more alkaline than the lighter, higher soils and that rootrot is most serious in such places.

Greensand marl. This is a natural sand containing from 5 to 7% potash. It is claimed by the producers that it also furnishes sufficient phosphoric acid and that the addition of nitrogen is not necessary. Tests during 1923 and 1924 on plots where this was the only fertilizer used showed that it did not possess enough available plant nutrients to produce a normal development of tobacco. It was thought best in the tests of 1925 to supplement it by the addition of cottonseed meal. A mixture was therefore applied at the rate of 3200 lbs. of greensand marl and 800 lbs. of cottonseed meal per acre. The two plots (K10 and K10*) thus treated were in the same field and adjacent to plots N1*** and N1****. The results on the marl plots should be compared with these check plots and not with the other potash plots which were in a different field. The sorting records of the two marl plots and checks along with the yields and net return per acre are presented in Table IX.

TABLE IX. GREENSAND MARL AND CHECK PLOTS.

	Percentage of grades									
Plot	M. W. and L. W.	Long darks	Dark stem	Long sec.	Short sec.	Fillers & brokes	Pool rating	Yield per acre	Average price per. lb.	Net return after deducting sorting charge
K10	6	18	18	18	3	37	C	1324	.25230	$237.07
K10*	13	30	11	24	2	20	C	1641	.34305	409.27
N1***	29	33	9	12	5	12	A	1646	.47335	610.99
N1****	20	33	9	18	6	14	A	1788	.43615	600.23

These data show that the check plots sorted out with more high grades, the quality was rated higher, the acre yield and average price were higher than the marl plots. The net return was nearly $300 less per acre on the marl plots. The addition of marl as a source of potash would make the mixture too bulky and the expense would be no less than that of using a higher grade potash carrier.

FRACTIONAL APPLICATION SERIES.

The two objects of this series were (1) to determine whether a given amount of fertilizer is more efficient when applied all at

once or when only ⅓ of it is applied before setting, ⅓ as soon as the plants are well started and ⅓ two weeks later; (2) to compare a full ration applied at setting with a reduced amount applied fractionally. The plots were in duplicate on the same field as the nitrogen series with the exception of F4 and its duplicate which were on the same field as N1*** and N1**** and these must be compared with the latter plots.

Formulas for the mixtures are as follows:

Plot F1. Same as N2 but plant food reduced to 150-120-150 and applied in three applications.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	685.9	$17.15	56.25	19.9	10.3	4.8
Castor pomace	275.8	4.14	18.75	4.9	3.8	2.2
Nitrate of soda	398.5	13.54	75.00	...	...	...
Precipitated bone	247.2	7.42	....	95.2	...	...
Sulfate of potash	129.0	3.55	....	...	64.5	...
Carbonate of potash ..	99.2	7.44	....	...	64.5	...
Double sulfate	30.4	.53	....	...	7.9	3.5
Total	1,866.0	$53.77	150.0	120.0	150.0	10.5

Plot F2. Same as F1 but all applied broadcast before setting.

Plot F3. Same as N2 but plant food reduced to 125-100-125 and applied in one application.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	571.6	$14.29	46.9	16.6	8.5	4.0
Castor pomace	229.8	3.45	15.6	4.1	2.3	1.8
Nitrate of soda	332.1	11.29	62.5	...	...	...
Precipitated bone	206.0	6.18	....	79.3	...	...
Sulfate of potash	107.5	2.96	....	...	53.8	...
Carbonate of potash ..	82.7	6.20	....	...	53.8	...
Double sulfate	25.4	.44	....	...	6.6	2.9
Total	1,555.1	$44.81	125.0	100.0	125.0	8.7

Plot F4. Same formula as F3 applied fractionally in three applications.

Sorting records for these plots are presented in Table X and the pool ratings, average price, acre yield, and net return per acre, are in Table XI.

TABLE X. FRACTIONAL APPLICATION PLOTS. SORTING RECORDS, 1925.

Plot	Light wrappers	Medium wrappers	Long darks	Dark stemming	Long seconds	17" seconds	15" seconds	Brokes	Fillers
F1	4	5	28	13	17	2	0	23	8
F1*	3	11	29	9	21	2	0	17	8
F2	6	12	24	14	14	2	0	19	9
F2*	8	12	25	10	18	0	0	20	7
F3	4	8	30	12	14	3	0	23	6
F4	20	17	27	10	8	6	2	7	3
F4*	17	10	31	5	17	3	1	11	5

TABLE XI. FRACTIONAL APPLICATION SERIES, 1925. POOL RATING, YIELD, NET PRICE PER POUND AND NET RETURN PER ACRE.

Plot	Method of application	Lbs. plant nutrient per acre			Cost of fertilizer per acre	Yield per acre (lbs.)		Pool Rating	Net price per lb.		Net return per acre	
		NH_3	P_2O_5	K_2O		Per plot	Average		Per plot	Average	Per plot	Average
F1	Fractional (three)	150	120	150	$53.77	1607	1747	B	.21145	.24375	$284.18	$375.66
F1*	"	"	"	"	"	1887		A	.27605		467.15	
F2	Broadcast (single)	"	"	"	"	1592	1645	A	.27480	.27702	383.71	402.19
F2*	"	"	"	"	"	1699		B	.27925		420.67	
F3	"	125	100	125	44.81	1667	1667	B	.21725	.21725	317.34	317.34
F4 (a)	Fractional (three)	"	"	"	"	1650	1746	B	.37530	.36135	574.44	584.77
F4* (a)	"	"	"	"	"	1842		B	.34740		595.10	

(a) These two plots were on a different field and compared favorably with the check plots N1*** and N1****. (See Table IX.)

The duplicate plots F1 received exactly the same mixture and quantity as duplicate plots F2, the only difference being that the fertilizer on F1 was applied in three different portions while that on F2 was applied broadcast all at once at the time of fitting the ground. Comparing the average net return, however, we find that there has not been a gain but an actual loss of $17.09 per acre from the fractional application besides the extra expense of the labor for making the three applications. In 1924 there was an advantage for the fractional application of $4.01 per acre which would not pay for the extra work. In 1923 the advantage was with the single broadcast application.

Three years of testing on these same plots have failed to show that there is anything to be gained by dividing the fertilizer and making later applications. It was suggested, in writing up the results of the 1924 tests, that perhaps the results would be more favorable for fractional application during a season of more rainfall. But the rainfall in 1925 was above the average and still the results were less favorable for fractional application than in the preceding year. It does not necessarily follow, however, that the results would be the same on all tobacco fields. The soil where these plots are located is not of the light "leachy" type where one might expect the greatest benefit from fractional application. It is planned to repeat these tests during 1926 on such a soil.

The effect of *reducing the amount* of fertilizer is indicated by comparing plots F2 and F3. It will be noted that the saving in cost of fertilizer was more than counterbalanced by the reduction in net return. Effects of reducing the application for three years in succession may be seen by comparing Plot F2* with Plot K1 of the potash series. These two plots are immediately adjacent, being separated by only one row of tobacco. The differences in proportions of ingredients in the mixtures applied were very slight, but K1 received ammonia, phosphoric acid and potash at the basal rate of 200-160-200 while F2* received the same at the reduced rate of 150-120-150. The differences were in about the same proportion during the two preceding years. The net return of this year for the K1 plot was $764.85 as contrasted with a net return of $423.68 for the F2* plot.

The F4 plots were on a different field and were only started in 1925 after heavy applications in the dry year of 1924, hence the results are not comparable with the other plots of the fractional application series. The N1 plots on this field, however, averaged a net return of only $529.96 per acre, as compared with $584.77 from the fractional plots.

SOME GENERAL CONSIDERATIONS ON TOBACCO FERTILIZERS.

Four plant nutrients which must be furnished in the tobacco fertilizer are ammonia, phosphoric acid, potash, and magnesia. These four materials are not purchased in a "free" condition but each is a part of some common substance known as a "carrier." Any one of the four may be supplied in a variety of carriers; e. g., ammonia may be supplied in cottonseed meal, fish, nitrate of soda, or a dozen other carriers. Or, one carrier may furnish more than one element, e. g. cottonseed meal furnishes all four of them.

In deciding on the fertilizer to be used, the grower is confronted with two questions: (1) How much of these nutrients shall be applied to each acre? (2) What carriers can be used to the best advantage in the mixture? In the light of the experiments described in the preceding pages let us try to answer simply and briefly these two questions:

How Much Fertilizer Should Be Used?

It is unfortunate that many growers still think of their fertilizer applications only in terms of the number of pounds of total mixture which they spread on an acre. Such a practice is largely responsible for the inclusion of large quantities of useless "filler" in the mixture by fertilizer manufacturers. By doing this they can furnish a large bulk of mixture at a low price but the bulk applied to an acre does not necessarily bear any definite relation to the amount of nutrients furnished, their chemical form, or the nature of the carriers. The grower should think of his fertilizers in terms of the amount of nutrients supplied to each acre of tobacco without any regard to the weight of the mixture.

Ammonia. During the first three years of the experiments the quantity of ammonia in the standard mixture was about 260 pounds per acre. When this was reduced, the loss in yield and net return more than counterbalanced the saving in fertilizer cost. The same principle held in 1925 when we experimented with applications less than 200 lbs. It will be noticed in the tables presented in the preceding pages that the plots which produced the *most* tobacco also usually produced the *best* tobacco, i. e., there was a larger proportion of leaves in the higher grades and the average price was correspondingly high. The impression of many that a big growth of tobacco produces a heavy inferior leaf is not borne out by the actual sorting records on these experiments up to date. This was also the conclusion of Dr. Jenkins after the five-year Poquonock experiment of thirty years ago. In those experiments it may also be mentioned that it was found profitable to increase the nitrogen to 210 pounds (255 lbs. ammonia per acre). On the basis of experiments up to date and supplementary experience of many successful growers, we are led to believe that the proper amount of ammonia to be applied is in the neighborhood of 250 pounds per acre. It has been previously mentioned, however, that different fields may vary markedly as to fertilizer needs. Intelligent experience is the best guide for any grower and if years of experience have proved that he can raise the best tobacco on some of his fields with less than 250 lbs, while others need more, he will do well to avoid too radical a change. Those who think this amount too expensive should consider that there is money in outdoor tobacco only in the big yield. On the average it takes 1500 pounds of tobacco to pay the expenses of producing. The money the grower gets for those pounds in excess of that amount is his profit. He cannot afford to neglect any practice which will add to that excess. When pounds are all profit it does not take many to pay for a little extra fertilizer.

Phosphoric acid. The fact that we can grow the best tobacco where no mineral phosphorus carrier has been used for four years leads us to believe that many old tobacco fields are consistently oversupplied with that element. Although we are not ready to recommend that mineral carriers of phosphoric acid be omitted from all soils, we do believe that our basal ration of 160 lbs. per acre is too high and that growers could well afford to test their land by leaving off phosphorus carriers from parts of their fields for a few years to see whether there is any deterioration in quality or yield. A saving of $10.00 an acre might be made with a little intelligent experimentation.

Potash. Four years test in the Poquonock experiments showed no loss from reduction of the potash to 150 pounds. No other experiments to determine the actual amount of potash required for Connecticut Valley tobacco soils are on record. In the absence of carefully conducted long continued experiments of this kind our recommendations are largely guesses. At present we are using 200 pounds of potash per acre.

Magnesia. Fifteen pounds of magnesia per acre has prevented the appearance of any symptoms of magnesia shortage. The large amounts of double manure salts used by some growers and put in some prepared mixtures, are excessive and useless if not actually injurious.

What Carriers Are Best.

Since any one of the four tobacco nutrients may be obtained in a variety of different carriers, the grower who mixes his own fertilizer is next confronted with the necessity of deciding which ones he should use. His choice will be influenced partly by the relative cost and the supply and ease of mixing, but more particularly should he be guided by what experience and experiment have shown to be the effect of a given material on the quality and yield of tobacco. Apparently the tobacco plant responds differently to different carriers of the same nutrient. For instance, we know that tobacco grown with nitrate of soda as the only source of nitrogen is different from tobacco grown on cottonseed meal although there is no known difference in the nitrogen which is derived from the two. Concerning the effect of some of the carriers there is considerable knowledge but very few and insufficient tests have been made with others. Under the circumstances we believe that the grower will do well to use only those which long use has shown to be satisfactory and to avoid new or little tried materials until their worth has been demonstrated by unbiased and competent experimenters.

Ammonia. It is generally believed that a part of the ammonia should be derived from mineral sources but the larger part from organic sources. The mineral carriers are more active and are included usually as a starter. Also nitrogen from this source is less expensive. The recent station experiments indicate that mineral carriers may be used to furnish up to one-half the ammonia of the formula without injury to quality or yield. Some successful growers however, use no mineral carriers at all. Of the organic carriers, cottonseed meal is the most extensively used and regarded as standard. The grower can make no mistake in using this as his principal ammoniate. Castor pomace is used almost as extensively and it is questionable whether there is any difference in the effects of the two on quality of the tobacco. There is a general belief that it should be used more extensively on the lighter soils. Linseed meal seems to be about as good as either of the above, but experiments indicate that the yield is not quite as good. Dry ground fish is used in smaller quantities by most growers either in the original mixture or as a side dressing. There is an impression in some quarters that it is not best for the burn and aroma if too much is used. The same may be said of tankage. Of the mineral carriers of ammonia, nitrate of soda is standard. Sulfate of ammonia, which is sometimes used, is subject to the objection of adding too much sulfate to the soil. It could probably be used to advantage, however, where the soil has been made too nearly neutral and it is desired to make it more acid. Nitrate of potash should be an excellent source of mineral nitrogen if the supply was dependable. Ammonium phosphate ("Ammophos") should also be a good carrier since it carries two essential plant elements and the residue is small. It should be tried more extensively in an experimental way, however, before making sweeping recommendations. The same may also be said concerning synthetic urea and a whole list of other "air-nitrogen" materials.

Phosphoric acid. Precipitated bone is the standard. Acid

phosphate contains too much sulfate but the high grade treble superphosphate should be nearly free from this objection. Fish is a commonly used source of phosphoric acid. Ammophos as previously mentioned should be tested more extensively. In view of the previously mentioned low response of our tobacco soils to lack of this element, it is possible that raw rock phosphate, the cheapest of all sources of phosphorus, would furnish all that is necessary.

Potash. Carriers of potash have been fully discussed on a previous page. High grade sulfate is most extensively used but we believe that on the more acid soils carbonate in the pure form or in ashes could be substituted to advantage. Another very excellent source of potash is tobacco stems. In this source the grower not only gets potash but also phosphoric acid and nitrogen. Besides the four elements under discussion, it is possible that tobacco stems also furnish other things which are advantageous for the growth of tobacco but of which we have no specific knowledge. It is pretty safe to assume that whatever is needed by the tobacco plant will be found in "stems,"

In conclusion we believe that it is a good principle not to depend always on one carrier for each nutrient but to mix several carriers. On the same principle it is well to vary the formula from year to year.

STRAIN TESTS OF OUTDOOR TOBACCO.

P. J. Anderson and N. T. Nelson

It is a fact well known among tobacco growers and dealers that neither the Broadleaf nor the Havana tobacco grown in New England are all of the same strain. The differences in the Broadleaf are more pronounced and the different kinds have received distinctive names, such as the John Williams Broadleaf, Hockanum Broadleaf, etc. The distinctive features of some of these types are readily apparent even to the inexperienced, as for example, the long, pointed leaf shape of the Bantle Broadleaf. Some of the other types, however, are distinguished by characteristics which are apparent only to the eye of experts long accustomed to judging Broadleaf Tobacco. Even though the differences may not be apparent in the field, they may be quite plain on the sorting bench. A third way in which these differences are manifested is in the adaptability of certain strains to certain localities, for example, the John Williams strain in the South Windsor section. Nearly any experienced Broadleaf grower will tell you that *his* farm is better adapted to one particular type than to another.

The origin of these distinctive strains is not as clear as might be desired. In fact we know very little about the origin of Connecticut Broadleaf. Were these differences already there when the seed was originally brought to New England or have they developed since then? It is doubtful whether Connecticut Broadleaf had a common source. Undoubtedly different types were introduced at different times and the source is not recorded. For example, we are told that the John Williams Broadleaf was so called because a grower of that name living in Manchester obtained some seed from Washington, D. C. grew it and distributed seed to neighbors who liked the type he grew better than their own. Whether it was originally a Maryland Broadleaf, Pennsylvania, Ohio, or something else can only be guessed. Other strains have been introduced in the same unrecorded way and are still being introduced, but nothing is put on record lest the buyers should think it was not really Connecticut Broadleaf and would not pay so much.

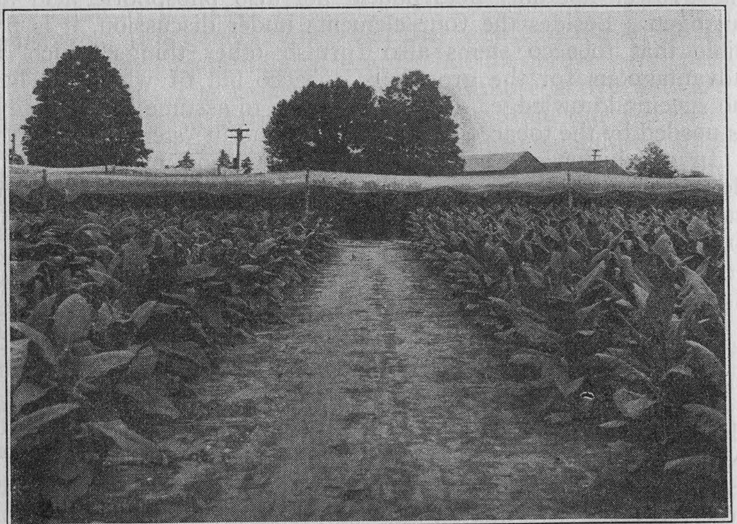


FIG. 5.—Strain test plots on station farm. Broadleaf to left, Havana seed to right and Cuban Shade strains ahead.

It is entirely possible that differences have developed and become fixed in types of tobacco subsequent to their introduction here. Whether one believes that the differences in strains which he observes are due to small mutations or to segregation after fortuitous crossing is not of so much importance as the fact that these differences do exist and that they are inherited. Many growers have kept their own particular seed for twenty, thirty, or even forty years, always selecting the best plants for seed and as a result have won a reputation in their own neighborhood for growing a superior type. In some cases this reputation is probably not due to the seed but to the type of land on which the crop is grown; or, the cultural practices may be so judicious that it is difficult to distinguish the results of such differences in handling from those which are inherent in the strain. Progressive growers are constantly trying to improve their type of tobacco by selection of their seed plants or by getting better seed from some other source.

If such differences do exist it is reasonable to believe that some strains are better than others and will yield a larger profit to the grower when grown under similar conditions. The differences in which the grower and dealer are most interested are those which appear in the sorted tobacco. They should be measured by the sorting record and the expert's judgment of quality.

In order to see whether there are such differences it is necessary that the strains to be compared be grown on the same land side by side and with the same cultural treatment throughout and then sorted and judged together.

Such strain tests were started by the Tobacco Station in 1924 with the object of (1) determining definitely whether there are strain differences in the Broadleaf and Havana seed which will remain constant, (2) measuring such differences, if present, in terms of sorting and pooling, (3) picking the best strains for seed distribution, and (4) selecting strains for possible further improvement through individual plant selection. The seed lots for the original trials were selected by Mr. Hickey of the Connecticut Valley Tobacco Association. The lots were selected on the basis of the crop records of the growers rather than on any known differences. It seemed best to make the tests not only on the station farm but also on other farms to see whether the differences observed in one place would be the same elsewhere. Also it seemed essential in the case of the Broadleaf to grow each of the well recognized types in the section in which it was most extensively grown.

The tests have continued through only two years; results have been delayed through the unusually dry weather of the first year and in some cases by unfortunate selection of the fields for the tests. Nevertheless a preliminary report is offered at this time which should be considered only as a report of progress and not final.

HAVANA SEED STRAIN TESTS.

*Tests of 1924.**

Some preliminary tests on a few strains of Havana seed were made at the Tobacco Station in 1922 and 1923. Although no

* Report by N. T. Nelson.

deailed records of yield and quality were kept, it was the opinion that the observed variability in type and quality of Connecticut tobaccos was more attributable to environmental differences than to the seed. In 1924 a larger number of seed lots was tested and sorting and pooling records taken. The tests were made both on the Tobacco Station farm and on the farm of Mr. Howard Henshaw in Suffield. The extremely dry summer in Windsor, however, resulted in a crop of such poor quality that records were taken only on the tobacco grown by Mr. Henshaw. Seed was furnished by the following growers:

W. K. Rice	Bloomfield
N. E. Kendall and Sons	Granby
Howard Henshaw	Suffield
L. C. Mills	Westminster
E. B. Graves	Canton
Lyman Crafts	Whateley
Larkin Proulx	Hatfield
Stanton Brown	Poquonock
M. Duda and Sons	Easthampton
L. J. Pelissier	Hadley
J. W. Alsop	Avon
Duncan Brothers	New Milford
George A. Peckham	Suffield
T. L. Warner	Sunderland
Howard Sikes	Suffield
F. A. Johnson	Southwick
J. E. Phelps	Suffield

The yield, sorting and pooling data are presented below in Table XII.

TABLE XII. HAVANA SEED STRAIN TESTS AT SUFFIELD, 1924. COMPARATIVE YIELDS, QUALITY AND RETURN PER ACRE.

Grower	Yield per acre	Price per pound	Total return per acre	Relative rating Yield	Relative rating Quality
Rice	1344	$0.2164	$280.71	69	51
Kendall	1764	0.3424	603.99	91	81
Henshaw	1596	0.4199	670.16	82	100
Mills	1596	0.3834	611.91	82	91
Graves	1428	0.3332	475.81	74	80
Crafts	1806	0.3904	704.06	93	93
Proulx	1596	0.3639	580.78	82	86
Brown	1932	0.4007	774.15	100	96
Duda	1596	0.3543	565.46	82	84
Pelissier	1764	0.3931	693.43	91	93
Alsop	1596	0.3218	513.59	82	70
Duncan	1764	0.3470	612.11	91	81
Peckham	1512	0.3420	517.10	78	81
Warner	1680	0.3054	513.07	87	73
Sikes	1596	0.2594	414.00	82	62
Johnson	1764	0.3708	654.09	91	88
Phelps	1386	0.2177	300.73	71	52

The price per pound is based on sorting percentages, pooling, and corresponding 1923 prices without deducting for sorting, packing and storage. The return per acre is the product of the yield and the price per pound. The yields ranged between 1344 and 1932 pounds per acre. Relative ratings were calculated by calling the best 100 and figuring the others on percentage of the best. Rating them in order of total return per acre, the relative rank of the first six is: Brown, Crafts, Pelissier, Henshaw, Johnson, and Duncan. The results of 1924, although preliminary, indicate good possibilities for improvement and selection on the average Havana now grown in the Valley.

Tests of 1925.

In 1925 the tests were conducted on a rather light sandy soil at the station farm. This field proved to be a rather unfortunate selection since there was apparently considerable leaching of the fertilizer just after the heavy rains of mid-season and the lower leaves turned yellow before harvesting. As a result the strains sorted out poorly. Nevertheless, this test has the advantage of showing what the different strains will do under adverse conditions. The tobacco was sorted and pooled as described under the fertilizer tests. The pool rating, acre yield, price per pound and return per acre are presented in Table XIII.

TABLE XIII. HAVANA STRAINS AT TOBACCO STATION—1925. POOL RATING, ACRE YIELD, PRICE PER POUND, AND NET RETURN.

Strain	Rating	Acre yield	Average price	Total Value	Sorting and Overhead	Net Value
Shean	C	1385	$0.2609	$361.35	$106.16	$255.19
Crafts	D	1410	0.2735	385.42	111.67	273.75
Proulx	C	1276	0.2298	293.22	90.21	203.01
Brown	D	1367	0.2317	316.67	100.13	216.54
Pelissier	C	1147	0.2022	231.87	72.33	159.54
Viets	D	1250	0.2273	284.13	87.31	196.82
Warner	D	1244	0.2312	287.55	76.69	210.86
Duncan	C	1311	0.3021	396.05	81.90	314.15
Johnson	C	1194	0.2371	283.04	72.06	210.98
Alsop	D	1209	0.1763	213.15	62.75	150.40
Graves	D	1214	0.2112	256.40	74.05	182.35
Henshaw	C	1240	0.2121	262.94	72.42	190.52
Peckham	D	1396	0.2803	391.23	96.04	295.19
Kendall	C	1218	0.2716	330.81	80.63	250.18

Using total return per acre as basis of rating, as for the 1924 series, the first six are: Duncan, Peckham, Crafts, Shean, Kendall, Brown. Three of the first six were the same for both years, viz., Brown, Crafts, and Duncan.

Final conclusions as to the relative value of the strains, however, must wait until after more comprehensive tests of longer duration.

Broadleaf Strain Tests.

*Tests of 1924.**

Very little work was done on Broadleaf during 1922 and 1923. In 1924 the Broadleaf project was expanded through the coöperation of the Connecticut Valley Tobacco Association and the Hartford County Farm Bureau. Several lots of seeds representing each of the leading types of Connecticut Broadleaf were secured and tested in their respective districts. The results of these tests are given in Table XIV. The only fair comparisons are between the different strains of one type. The different types cannot be compared for they were grown on different farms.

Table XIV. Comparative Yields, Quality and Return Per Acre on Broadleaf Lots in Farmer's Coöperative Trials—1924.

Type	Strain	Yield per acre Lb.	Price per pound $	Return per acre $	Relative rating Yield %	Relative rating Quality %
John Williams Broadleaf at H. Vibert's So. Windsor	Cannon	1834	.3995	732.68	91	73
	Hambach	1799	.4378	789.60	90	79
	Cavanaugh	1785	.3863	789.55	89	70
	Foran Bros.	1890	.5062	956.72	94	92
	Vibert	1750	.4420	773.50	87	81
	Killam	1659	.3933	652.48	83	72
	Riordan	1715	.4011	687.89	86	73
	Bancroft	1554	.5488	737.84	78	100
	Miskill	2009	.4748	953.87	100	86
	Grant	1895	.4183	792.68	96	76
Frank Roberts Broadleaf at F. H. Ensign's Silver Lane	Roberts	1960	.2493	488.63	100	74
	Hills	1925	.2782	535.54	98	83
	Oliver	1645	.1338	220.10	74	39
	Heller	1610	.2785	448.39	72	83
	McIlvane	1610	.2097	337.62	72	62
	Ensign	1855	.2185	405.32	95	65
	Vogel	1680	.1292	212.06	76	38
	Forbes	1890	.3367	636.36	96	100
	Evans	1680	.2065	346.92	76	61
Hockanum Broadleaf at J. M. Herr Hockanum	Geiselman	1715	.0871	149.38	99	34
	Cooley	1722	.2516	433.26	100	99
	Hamilton	1575	.1685	265.39	92	66
	Dusch	1440	.1325	194.78	84	52
	Brewer	1484	.2309	342.66	86	91
	Hollister	1624	.2232	352.48	94	87
	Dunham	1610	.2543	409.42	93	100
	Horton	1659	.2349	389.70	96	92
	Herr	1715	.2432	417.09	99	96
Barber Broadleaf at Burnham Liebler's So. Glastonbury	Demar	1952	.1483	289.63	100	93
	H. Smith	1922	.1073	206.23	98	67
	Liebler	1798	.1372	245.69	92	86
	Bachl	1488	.1032	153.56	75	65
	G. Smith	1643	.1434	235.61	84	89
	Hoffman	1829	.1598	292.27	93	100

* Report by N. T. Nelson.

An examination of Table XIV shows the wide variation within each type, some strains returning twice the value per acre of others. How much of this was due to inherent strain differences, how much to soil variation or to other sources of error cannot be stated. The tests of 1924 indicated the need for a continuation of this work as reported below.

John Williams Broadleaf Tests of 1925.

The John Williams strain trials were conducted on the farms of Mr. Horace Vibert of South Windsor, Mr. E. Handel of Glastonbury and at the Tobacco Station. This type did not do well as Handel's although other types alongside it on the same field of apparently quite uniform soil did very well. Mr. Handel, in former years, had tried the John Williams tobacco on his farm but had discarded it for the Hockanum type because the John Williams was unsatisfactory there. The growth was only fair at the Station Farm but was quite satisfactory in South Windsor where this type is generally recognized as being at its best. For this reason more weight should be attached to these tests in that locality than at the other two. All tests were on single rows of 100 plants each.

The percentage of grades is presented in Table XV and the rating, acre yield, average price per pound, and net return in Table XVI.

Table XV. John Williams Strains of Broadleaf. Percentage of Grades, 1925.
(T = Tobacco Station, V = Vibert, H = Handel)

Strain	L. W.			M. W.			Long Sec.			Sh. Sec.			Long Dks.			Dk. Stem.			No. 2 Sec.			Brk. and Filr.		
	T	V	H	T	V	H	T	V	H	T	V	H	T	V	H	T	V	H	T	V	H	T	V	H
Cannon	6	1		4	3		15	32		1	8		20	22		27	13		10	10		17	11	
Hambach	4	0	5	2	5	3	17	24	22	1	8	3	19	25	25	24	8	15	7	19	12	26	11	15
Cavanaugh	2			1			13			0			19			28			17			20		
Vibert	2	2	0	3	3	0	19	18	20	2	4	3	23	25	27	20	22	18	15	15	6	16	11	26
Riordan	5	5	10	3	7	10	18	26	24	1	8	3	20	21	25	18	11	11	14	11	5	21	11	12
Bancroft	4	4	0	2	8	0	15	27	20	0	3	2	20	22	17	22	11	16	14	16	17	23	9	28
Miskill	6	0	2	6	4	1	18	18	25	1	5	1	21	24	24	21	21	14	12	17	18	15	11	15
Grant	3			4			19			1			16			22			13			22		

Table XVI. John Williams Broadleaf Strain Tests, 1925 Pool Rating, Acre Yield, Average Price, and Net Returns.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Vibert Farm, South Windsor.						
Cannon	B	2164	$0.37145	$803.82	$182.64	$621.18
Hambach	B	2010	0.3604	724.40	176.28	548.12
Vibert	C	1991	0.2866	570.62	156.40	414.22
Riordan	C	1984	0.35335	701.05	170.03	531.02
Bancroft	B	2063	0.38975	804.05	179.58	624.47
Miskill	C	2317	0.28405	658.14	183.51	474.63
Handel Farm, Glastonbury.						
Hambach	B	1126	$0.34225	$385.37	$ 90.66	$294.70
Vibert	A	1008	0.3041	306.53	70.94	235.59
Riordan	B	1230	0.40515	498.33	105.61	392.72
Bancroft	C	1025	0.2543	260.66	73.19	187.47
Miskill	B	1156	0.332	383.79	93.81	289.98
Tobacco Station Farm.						
Cannon	B	1338	$0.30075	$402.40	$ 95.04	$306.36
Hambach	A	1352	0.314	424.53	91.26	333.27
Cavanaugh ...	C	1156	0.2397	277.09	79.53	197.56
Vibert	B	1053	0.3073	323.59	80.66	242.93
Riordan	C	1270	0.2857	362.84	94.81	268.03
Bancroft	A	1140	0.35(?)	399.00	80.66	318.34
Miskill	A	1327	0.38165	506.45	101.64	404.81
Grant	C	1206	0.2752	331.89	86.11	245.78

The Foran strain which made a good record in 1924 was not planted on account of lack of seed. The Cavanaugh strain was found to be the same seed as the Vibert strain and hence was not tested at Vibert's or Handel's. The seed of the Grant and Cannon strains did not come well in the seed beds and hence there was a shortage of plants, which accounts for the fact that they were not set at all three farms. In point of yield alone, the Miskill strain has made much the best showing. It was highest in the 1924 test, highest at Vibert's in 1925, second at Handel's and within 25 lbs. of the highest at the station farm. It was within $3.00 per acre of the highest in net return in 1924, highest in net return at the station farm in 1925. The net return at Vibert's, however, was much less than some of the others because of the high percentage of dark grades. In point of quality the Bancroft strain has made an excellent showing being rated as best in 1924, best at Vibert's, second at the Station Farm, but poorest at Handel's.

Frank Roberts Broadleaf Strains in 1925.

These tests were on the farms of Mr. Howard Ensign at Silver Lane, at the Station Farm, and at Handel's. Growth was best at Ensign's where the tests of 1924 were also conducted.

TABLE XVII. PERCENTAGE OF GRADES IN THE FRANK ROBERTS BROADLEAF STRAIN TESTS OF 1925.
(T = Tobacco Station, E = Ensign, H = Handel)

Strain	L. W.			M. W.			Lg. Sec.			Short Sec.			Long Dk.			Dk. Stem.			No. 2 Sec.			Brk. and Flr.		
	T	E	H	T	E	H	T	E	H	T	E	H	T	E	H	T	E	H	T	E	H	T	E	H
Roberts	2	4	9	1	6	16	14	25	23	1	1	2	16	30	26	25	12	7	13	7	8	28	15	9
Hills	0	1	5	0	4	8	9	23	21	0	2	3	11	28	29	37	17	10	15	7	11	28	16	12
Heller	0	3	6	0	3	8	8	19	22	0	1	2	12	28	31	29	25	9	14	8	14	37	15	9
McIlvane	0	4	5	0	5	11	10	24	29	0	1	1	10	26	27	31	20	9	14	5	10	35	15	8
Ensign	3	6	4	1	10	8	10	26	20	1	2	1	16	32	28	31	8	15	15	4	14	23	12	10
Vogel	0	1	7	0	2	11	12	25	29	0	1	2	19	25	29	28	22	9	18	9	6	23	15	7
Forbes	0	6	2	0	4	4	9	22	22	0	1	2	12	28	24	34	19	16	11	6	10	34	14	20
Evans	0	2	4	0	2	9	10	27	23	1	2	3	13	30	27	33	17	12	17	8	10	26	12	12

The Station tobacco of this strain sorted out very poorly and the results cannot be considered as indicative as the others, particularly at Ensign's.

The final data on these tests are presented in Tables XVII and XVIII.

TABLE XVIII. FRANK ROBERTS BROADLEAF STRAIN TESTS, 1925. POOL RATING, ACRE YIELD, AVERAGE PRICE PER POUND AND NET RETURN.

Handel Farm.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Roberts	B	1381	$0.42835	$591.55	$122.74	$468.81
Hills	C	1230	0.3401	418.32	105.41	312.91
Heller	C	1331	0.34515	459.39	117.53	341.86
McIlvane	C	1390	0.37365	519.37	123.64	395.73
Ensign	C	1181	0.32385	382.47	103.34	279.13
Vogel	C	1348	0.38335	516.76	120.78	395.96
Forbes	C	1196	0.2906	347.56	91.61	255.95
Evans	D	1268	0.3084	391.05	107.02	284.03

Ensign Farm.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Roberts	B	1626	$0.3545	$576.42	$134.06	$442.36
Hills	B	1494	0.32815	490.26	117.35	372.91
Heller	B	1747	0.28945	505.67	129.28	376.39
McIlvane	B	1560	0.3341	521.20	107.38	413.82
Ensign	B	1698	0.3928	666.97	147.73	519.24
Vogel	B	1647	0.3150	518.80	125.09	393.71
Forbes	B	1682	0.33885	569.95	132.12	437.83
Evans.........	B	1693	0.33735	571.13	137.39	433.74

Tobacco Station Farm.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Roberts	D	1219	$0.21615	$263.49	$80.91	$182.58
Hills	C	1110	0.18975	210.62	64.10	146.52
Heller	D	1190	0.17185	204.50	67.95	136.55
McIlvane	D	1103	0.17755	195.84	63.08	132.76
Ensign	C	1230	0.22645	278.53	79.83	198.70
Vogel	D	1231	0.2053	252.72	82.42	170.30
Forbes	D	1143	0.1721	196.71	63.78	132.93
Evans	D	1095	0.18975	207.78	67.61	140.17

Hockanum Broadleaf Strain Tests of 1925.

The best test of the strains of the Hockanum type was at the Handel farm in Glastonbury where the Hockanum is said to grow at its best and where, on the Handel farm, it was very plainly better than the other types. Growth at the Station Farm was not as good as for the John Williams type. Sorting and pooling data are presented in Tables XIX and XX.

TABLE XIX. HOCKANUM BROADLEAF TESTS, 1925. PERCENTAGE OF GRADES.
(T = Tobacco Station. H = Handel Farm.)

Strain	L. W. T	L. W. H	M. W. T	M. W. H	Long Sec. T	Long Sec. H	Short Sec. T	Short Sec. H	Long Darks T	Long Darks H	Dark Stem. T	Dark Stem. H	No. 2 Sec. T	No. 2 Sec. H	Brk. and Flr. T	Brk. and Flr. H
Cooley	0	22	0	28	8	17	0	2	18	22	23	0	18	4	33	5
Hamilton	0	10	0	16	9	22	0	2	13	24	38	12	18	7	22	7
Dunham	0	21	0	30	7	16	0	1	12	20	23	2	14	4	44	6
Horton	0	12	0	23	6	20	0	1	8	27	32	6	14	6	40	8
Herr	0	20	0	19	6	26	0	1	8	19	25	4	14	3	47	8
Geiselman	0	14	0	18	5	22	0	1	12	26	32	4	19	10	32	5
Hollister	4	9	0	14	15	27	1	2	12	24	24	10	13	7	31	7
Dusch	4	10	0	10	12	31	0	1	16	26	28	7	19	7	21	8

TABLE XX. HOCKANUM BROADLEAF STRAIN TESTS, 1925. POOL RATING, ACRE YIELD, PRICE PER POUND, AND NET RETURN.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Handel Farm.						
Cooley	A	1612	$0.6315	$1,017.98	$155.96	$862.02
Hamilton	B	1590	0.4255	676.55	139.36	537.19
Dunham	B	1485	0.58 ?	861.30	140.78	720.52
Horton	B	1832	0.4631	848.40	170.10	678.30
Herr	B	1544	0.5077	883.89	142.36	741.53
Geiselman	B	1711	0.4697	803.66	161.09	642.57
Hollister	B	1323	0.4332	573.12	117.68	455.44
Dusch	B	1354	0.43965	595.29	122.17	473.12
Tobacco Station Farm.						
Cooley	D	1242	$0.18615	$231.20	$78.99	$152.21
Hamilton	C	1191	0.1995	237.60	72.65	164.95
Dunham	D	1203	0.16625	200.00	67.91	132.09
Horton	D	1275	0.1584	201.96	67.83	134.13
Herr	C	1349	0.16605	224.00	71.77	152.23
Geiselman	C	1162	0.1801	209.28	67.86	141.42
Hollister	D	1156	0.2201	254.44	74.27	180.17
Dusch	C	1290	0.2421	312.31	87.91	224.40

Among the strains of this type are two which stand out as preëminently the best, viz., the Cooley and the Dunham strain. After the completion of the 1925 tests it was learned that these two strains have a common origin in the same lot of seed within recent years.

Bantle Broadleaf Strain Tests of 1925.

These tests were also conducted at the Tobacco Station and at the Handel Farm in Glastonbury. Sorting and pooling data are presented in Tables XXI and XXII.

Table XXI. Percentage of Grades in Bantle Broadleaf, 1925.
(T = Tobacco Station. H = Handel)

Strain	L. W.		M. W.		Long Sec.		Short Sec.		Long Dark		Dark Stem.		No. 2 Sec.		Brk. and Flr.	
	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H
Bidwell	1	7	0	8	8	28	0	2	25	26	21	11	21	8	24	10
Lorenze	2	7	1	9	14	29	1	2	27	31	19	10	21	7	15	5
Bantley	3	15	3	19	17	22	1	2	27	29	19	4	13	3	17	6
Fox	0	14	1	19	14	24	1	1	24	21	22	10	20	4	18	7
Benton	3	13	2	17	19	24	0	1	19	24	24	8	13	6	20	7
Bantle	4	7	1	13	16	29	0	1	23	24	22	9	16	9	18	8
Hickey	2	23	0	18	15	17	1	1	21	24	25	8	15	2	19	7
Estrom	1	10	0	11	12	29	0	1	18	28	24	7	19	8	26	6

Table XXII. Bantle Broadleaf Strain Tests, 1925. Pool Rating, Acre Yield, Price per Pound, and Net Return.

Handel Farm.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Bidwell	B	1244	$0.39985	$497.41	$107.42	$389.99
Lorenze	B	1260	0.4163	524.54	113.72	410.82
Bantley	C	1454	0.4292	624.06	135.95	488.11
Fox	C	1415	0.4204	594.87	126.51	468.36
Benton	B	1412	0.4551	642.60	127.43	515.17
Bantle	B	1352	0.42535	575.07	120.26	454.81
Hickey	C	1263	0.4386	553.95	113.99	439.96
Estrom	B	1490	0.44065	656.57	136.41	520.16
Tobacco Station Farm.						
Bidwell	D	1140	$0.20635	$235.24	$ 81.66	$153.58
Lorenze	C	1152	0.26595	306.37	89.74	216.63
Bantley	B	1395	0.30265	422.20	106.86	315.34
Fox	C	1163	0.2476	287.96	86.06	201.90
Benton	C	1157	0.2686	310.77	82.61	228.16
Bantle	C	1183	0.2685	317.64	87.54	230.10
Hickey	C	1318	0.25445	335.36	94.10	241.26
Estrom	D	1209	0.2096	253.41	81.61	171.80

Barber Broadleaf Strain Tests of 1925.

These tests were conducted at the same places as the Bantle and Hockanum. Results are presented in Tables XXIII and XXIV.

Table XXIII. Barber Broadleaf Strains, 1925. Percentage of Grades. (T = Tobacco Station. H = Handel.)

Strain	L. W.		M. W.		Long Sec.		Short Sec.		Long Darks		Dark Stem.		No. 2 Sec.		Brk and Flr.	
	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H
Liebler	3	8	1	15	15	21	0	1	21	32	20	6	14	9	26	8
Bachl	0	8	0	16	8	29	0	2	13	24	27	8	14	4	38	9
G. Smith	2	18	0	18	11	21	0	2	18	19	29	11	19	5	21	6
Hoffman	0	13	0	19	7	24	0	2	17	27	25	6	14	5	37	4

Table XXIV. Barber Broadleaf Strain Tests, 1925. Pool Rating, Acre Yield, Price per Pound, and Net Return.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Handel Farm.						
Liebler	C	1444	$0.3787	$546.84	$131.27	$415.57
Bachl	B	1590	0.4385	697.22	141.43	555.79
G. Smith	A	1882	0.55805	1,050.25	167.40	882.85
Hoffman	B	1652	0.4712	778.42	154.46	623.96
Tobacco Station Farm.						
Liebler	D	1296	$0.2312	$299.64	$90.85	$208.79
Bachl	C	1254	0.18375	230.42	72.52	157.90
G. Smith	D	1319	0.21185	279.43	89.03	190.40
Hoffman	D	1300	0.17425	226.53	77.61	148.92

IMPROVEMENT OF SHADE TOBACCO BY HYBRIDIZATION AND SELECTION.

D. F. Jones, P. J. Anderson and N. T. Nelson.

The testing of Cuban strains and hybrids which has been in progress under the direction of D. F. Jones in charge of Plant Breeding since the establishment of the Tobacco Station, has been continued during the season of 1925. Sixty-three strains were grown under cloth, including selections by Beinhart and Chapman, selections from a strain grown by Clark Bros. of Windsor, selections from imported Partidos and Vuelta Abajo seed, Big Cuban, resistant Cuban and various hybrids originated by Jones. As a check with which to compare these, every fourth row in the tent was set with plants from seed of a good local strain furnished by Mr. J. B. Stewart of Windsor. This is the strain which Mr. Stewart originally selected from imported Cuban seed and which he developed while in the employ of the United States Department of Agriculture and has carefully guarded by constant selection during the last twenty years. Each row was harvested separately. After bulk sweating in the usual way, all strains were sorted by an experienced sorter and complete records made on percentage of all grades and general notes on quality, burn, etc. Sample hands from the best three grades (L, LL, LV) were kept out and have been submitted to experienced judges of shade tobacco for their opinion. Since neither the sorting records and notes nor the opinion of the experts indicates that any of these strains is superior to the Stewart strain, there seems to be no object in publishing here the rather lengthy sorting records of these tests. These records are tabulated and filed at the Tobacco Station where they may be consulted by any growers or others who may be interested in them.

When the Cuban variety of tobacco now commonly grown in the Connecticut Valley was first grown under shade cloth here, it was found that it lacked the uniformity which the manufacturer desires and which is necessary to make the raising of this most expensive type profitable. There were too many plants which either yielded no leaves of the high grades or so few that there was no profit. The variety was made uniform or standardized by several years of selection and breeding from plants with a high record for production of better grades. Yet there are few shade growers who are satisfied that the strain they are growing is either as uniform or as good as they would like. Any shade grower can point out in his fields several types of plants. How many of these are genetic differences which will breed true? If they do breed true, which type will produce the highest percentage of good grades? Are some of these types inferior and responsible for a high percentage of the low grades which we would like to keep out of the sorting shop? These questions can be answered only by keeping separate records of the leaves from individual plants through the sorting, saving the seed of each one and keeping year after year the sorting records of the progeny. This involves a considerable amount of tedious work which very few growers care to undertake, especially since it comes in the very busiest season when they have little time to think of anything except getting the crop harvested.

Believing that there is a possibility for the improvement of the Cuban variety through this method of selection the writers began by keeping individual records on 1000 plants of the Stewart strain in 1925. Each priming of each plant was labelled permanently so that when the cured and fermented leaves came to the sorting bench it was possible to tell the plant from which every leaf came. After taking the sorting and sizing record of every leaf of the thousand plants, all the leaves from each plant were assembled and the product of each one of the 1000 appraised as a whole. The most promising of these individual plant selections will be grown and compared on the basis of their progeny performance record. Additional selections will be made within certain lines to test their uniformity and fixity of type.

The points for which we are selecting and which we hope to attain by this method are:

1. Larger number of L's per plant
2. Thinner leaves
3. Better shape
4. Better burn
5. Less prominent vein
6. Those other characteristics of the leaf which we group under the undefinable term "quality" but which are hard to separate and enumerate but are very evident to every experienced tobacco man.

Wide variations were found in the product of different plants. Contrasted with some plants which did not bear a single L were others with 10 L's. Some had thin leaves almost up to the top of the plant, others were thick throughout. The plants with thin leaves at the bottom suddenly becoming thick at about the 12th leaf predominated. Whether the exceptions are due to inherent differences in the seed or to place effect is the question on which the possibility of improvement by this method hinges. Not only were the best plants selected for further progeny test, but also some of the poorest plants. It was also found that quality in the cured product was correlated with certain observable differences in the field.

COVER CROPS FOR TOBACCO

P. J. Anderson.

It was stated in the introduction that there are no results as yet on the cover crop project since this was not started until the fall of 1925. However the cover crop problem is one which is the subject of considerable discussion at present, not only in the tobacco sections of New England but also in other parts of the country, and a brief statement of what the problem is and its present status seems worth while.

When the present generation of tobacco growers were boys, the planting of a winter crop on the fields was unknown. The fields were left bare from the time the crop was harvested until the next crop was set in June. With the beginning of the present century, however, there was a widespread movement, fostered largely by agricultural experts, for seeding the land each fall to some crop to keep the ground covered through the winter and spring. Within a few years this practice became quite general until it is safe to estimate that now more than half the tobacco land is seeded every fall. Probably ninety per cent of the crop is timothy, five per cent rye and the rest more unusual crops such as winter vetch, barley, oats, etc. The leguminous crops, other than vetch, have been used very little, probably because experience has shown that they do not winter well or they do not thrive on the acid tobacco land.*

A puzzling feature about this wholesale adoption of the cover crop practice is the entire absence of any published experimental data to show that the succeeding crop of tobacco derives any benefit from it. At least three reasons have been assigned for the use of these crops on tobacco land:

* The fact that some of them are known to be hosts of the black rootrot fungus has also had its influence against them.

(1) On light lands it prevents the land from blowing. This is probably correct to a large extent but it gives no reason for the use of a cover crop on some thousands of acres of land which rarely, if ever, blows.

(2) It holds nitrogen which would otherwise leach away and furnishes it to the next crop of tobacco. It unquestionably does take up nitrogen but whether this nitrogen is used to advantage by the succeeding tobacco crop is open to question.

(3) The reason most frequently given for the cover crop is that it adds a large amount of humus to the soil. It is doubtful whether many growers would take the trouble to put in cover crops except on some light "sand blows" if it were not for this last supposed benefit. This third reason is based on the assumption that the addition of organic matter is always *per se* a direct benefit to soil.

One also frequently hears it said by farmers that a cover crop adds nitrogen or other fertilizer elements to the soil. It is probably superfluous to point out that the cover crop returns to the soil only such fertilizer elements as it took from the soil in the first place and adds nothing to them, unless it be a leguminous crop such as vetch in which case it may add some nitrogen. The main element which it *adds* to the soil is *carbon* (derived from the air), concerning which we shall speak below.

Five years ago the writer had occasion, in connection with some black rootrot experiments in Massachusetts, to compare the effect of timothy cover crop and no cover crop on alternating one-quarter acre strips of land. This experiment was not planned to test the value of timothy as a cover crop but rather the effect of the timothy cover crop on black rootrot. It was assumed at the outset that the timothy would increase the yield or improve the quality of the tobacco—or both. When, however, the harvesting records of the plots were computed and compared it was a surprise to find that the most outstanding result of the whole experiment was the fact that the timothy had *reduced* the yield of tobacco. The experiment was continued for the two following years on the same plots and each year the depressed yield was observable in the field and measurable on the sorting bench. In a later, more comprehensive experiment on a different field at the Massachusetts Agricultural Experiment Station, J. P. Jones found that ten plots without timothy cover crops yielded an average of 165 pounds per acre more than ten adjacent plots with cover crops and that the quality was in about the same ratio.*

* Jones, J. P. Havana seed Tobacco as Influenced by Timothy Cover Crop. Mass. Agric. Expt. Sta. Circ. 73. 1925.

Such, in summary, is the experimental data on which our present estimation of the value of the timothy cover crop is based. In the absence of any conflicting data of scientific experimental calibre, the conclusion seems warranted that timothy not only does not benefit tobacco but is on the contrary detrimental, at least under the conditions of these trials.

In what way could the cover crop produce an injurious effect on the tobacco crop? The cover crop idea has been adopted with entire disregard of two fairly well known agricultural facts:

1. Certain crops do have an injurious effect on the succeeding crops.
2. Organic matter added to the soil is not always beneficial, but may be absolutely harmful.

Space is lacking to review the literature on these points but a brief statement on each may be worth while:

Influence of one crop on another. Almost a hundred years ago, DeCandolle began to experiment and theorize on the toxic influence of one crop on another showing that it was then recognized. Various other investigators, too numerous to mention here, have worked and theorized on the same peculiarity. Very conveniently, within the last year, there has been published a very comprehensive review of the literature of this subject and the theories as to the cause,* and the reader is referred to this publication, for further information. The principal theories advanced have been (1) the soil toxin theory, (2) the fertilizer exhaustion theory, (3) the plant pathogen theory. Although these experimenters do not decide which of these theories is responsible, their experimental work does show "that the tobacco plant is particularly sensitive to the effects of preceding crops and attempts to apply intensive methods, as turning under soil improvement crop freely . . . . are likely to fail. The growth of the tobacco plant may be seriously retarded as a result of the effects of preceding crops of tobacco itself or of various other plants." Although their results were not always consistent, they were not able to find that any of the cover or rotation crops could be depended on to improve the tobacco and that usually they were positively injurious. They found that the harmful factor was the roots of the preceding crops rather than the tops. This is rather significant to the farmers of the Connecticut Valley in view of the fact that the use of timothy as a cover crop has been urged because of the organic matter furnished by its unusually large root development.

But our tobacco farmers do not need such far away exper-

* Garner, W. W., W. M. Lunn, and D. E. Brown. Effects of crops on the yields of succeeding crops in the rotation, with special reference to tobacco. Jour. Agric. Res. 30: 1095-1132. 1925.

imental evidence to prove the sensitiveness of tobacco to a preceding crop. It is pretty general knowledge among growers that tobacco does not do well on a grass sod of the previous year. Neither the yield nor the quality is good under these conditions and most of the growers admit that they do not expect good tobacco the first year.* Yet by some obscure mental hocus pocus these same growers believe that the same grass crop when used as a cover crop will have a different effect from what it would if used as a rotation crop. If there is such a difference, its effect would probably aggravate rather than alleviate the ill effect of a grass crop.

Vegetable organic matter not always beneficial. It is a more recently established fact that the addition of plant materials with a high carbohydrate content such as straw, green manure, sawdust, etc., to the soil may materially depress the growth of following crops. It is therefore not at all safe for the grower to assume that he is improving his land by turning green manure crops into it. The experimental evidence on this problem has recently been reviewed by Collison and Conn† and new light shed on it by their experiments with straw. They find that plant residues incorporated in the soil have a harmful influence in two ways; (1) by giving rise to a toxic substance which acts deleteriously on the roots of the plants, and (2) by stimulating (by means of their carbonaceous energy-forming material) the growth in the soil of a class of organisms which require more nitrogen than the decomposing straw or plant residue can furnish and thus they deplete the soil of nitrates. If these principles hold true for the timothy cover crop on tobacco soils, then we may expect that the timothy not only does not furnish nitrogen to the tobacco plants, but that it produces effects which actually rob the plant of the nitrogen which is put into the soil in the fertilizer. They, and others, have found that the deleterious effect would be partially, at least, overcome by supplying sufficient nitrate in readily available form to supply both the plants and the denitrifying organisms. Thus the grower who uses a cover crop should add more nitrogen in his fertilizer than the one who uses no cover crop. If however, these plant residues have had a long time to rot, the effect gradually disappears; thus the growers previously mentioned, who find that they get better results by plowing under a grass sod in the fall and adding heavy applications of manure, are escaping the injurious effects of a cover crop plowed under immediately before setting the crop. In some experiments at

* Heavy applications of manure and fall plowing of grass sod have been found by some to overcome this, at least partially. The reason is explained below.

†Collison, R. C. and Conn, H. J. The effects of straw on plant growth. N. Y. (Geneva) Agric. Expt. Sta. Res. Bul. 114. 1925.

the Tobacco Station in 1925 it was noted on plots where some of the cover crop was plowed under on April 1 and the rest six weeks later that there was a remarkable difference in favor of the early plowed when no fertilizer was added. But on plots which were heavily fertilized the difference was not so noticeable. If the grower is going to use cover crops he will do well to plow them under early and give them abundant opportunity to rot before the tobacco is set.

In the Massachusetts experiments previously mentioned the writer found, on examining the roots of the tobacco, that those on the timothy plots were more seriously affected with brown rootrot. This is also confirmed by considerable observational field evidence showing that the timothy, whether in rotation or as a cover crop, "predisposes" the following tobacco crop to brown rootrot. Since however, we know nothing about the cause of brown rootrot it is hardly an illuminating explanation of the effect of timothy on tobacco, to say that is produces brown rootrot. Brown rootrot may be merely the expression on tobacco roots of the toxic effect of a preceding crop comparable to the effects of plant residues described by Collison and Conn on other plants.

This brief review shows how far we are from a solution of the cover crop problem. It was in an attempt to learn more about it that the cover crops plots were started at the Station in 1925.

BLACK ROOTROT AND SOIL REACTION.

P. J. Anderson and M. F. Morgan.

In 1908 Briggs* first called attention to the fact that the application of lime, wood ashes, alkaline fertilizers, or other substances which tend to make the soil alkaline, favor the development of black rootrot and that this disease, which had become very serious in the Connecticut Valley at that time, could be kept in check by avoiding such substances. He apparently did not measure the actual degree of acidity in the soils under experiment. Johnson and Hartman† in Wisconsin, and Chapman‡ in Massachusetts confirmed the general conclusion of Briggs that rootrot is favored by the application of substances which reduce the acidity of the soil. The former by plot experiments and the latter by field survey attempted to measure in terms of lime requirement the degree of acidity which is necessary to prevent damage

*Briggs, L. J. The field treatment of tobacco rootrot. U. S. Dept. Agr. Bureau Plant Industry, Cir. 7, 1908.

†Johnson, J. J. and Hartman, R. E. Influence of soil environment on the rootrot of tobacco. Jour. Agr. Res. 17:41-86, 1919.

‡Chapman, G. H. Tobacco investigations. Mass. Agr. Exp. Sta. Bul. 195. 1920.

from rootrot. Johnson and Hartman found the disease practically absent in soil with a lime requirement of 9.38 tons, considerable infection at 7.19 tons and heavy infection at 4.6 and all more alkaline soils. Chapman found heavy infection usually present in soils with a lime requirement of 3000 to 8000 pounds, but very little in soils either more acid than the 8000 pound requirement or less acid than the 3000 pound requirement. The latter finding is not in agreement with the Wisconsin results.

It has been mentioned previously in this report that most growers, constantly warned against the danger of using lime, wood ashes or carbonate of potash, have ceased altogether to use them. On the other hand there is good evidence both from experience of growers and scientific experiment that a moderate amount of all three of these substances is beneficial for tobacco. Many have decided that they have gone too far in the omission of alkaline substances and are returning to the practice of liming or using wood ashes. In some cases this has been attended with favorable results. In other cases the results have been disastrous in bringing on rootrot and rendering the land unfit for tobacco. More puzzling to the grower is the fact that the same application of lime on two fields may benefit one and ruin the other.

In the face of the fact that some soils apparently need these substances and others do not, how shall the grower know what practice to follow? Is there not some simple soil tests by which we may quickly determine what treatment a field should receive? It was in an attempt to answer this question, to find such a test, that the writers began the investigation now to be discussed. This investigation has been in progress only one year and is far from complete, but it seems advisable to make yearly reports of progress because we believe that the results already secured will be of benefit to the growers and because it is hoped that they will be in better position to coöperate with us in this work if they understand from the annual reports the purpose and progress of the investigation.

It is obvious from the work previously mentioned that lime, wood ashes and carbonate of potash do not directly affect the organism causing rootrot by furnishing elements of food or through a direct stimulating effect, but they merely reduce the acidity of the soil which would otherwise be detrimental to its growth or ability to attack the tobacco roots. In other words, damage from infection can occur only when the roots of the plant are in a soil the acidity of which has been reduced beyond a certain critical point. Just where is that critical point? To answer this question was the first and most important task of the investigation. First of all, the answer should be sought through a wide soil survey. It is planned to take and test for degree of acidity, soil samples from at least 1000 tobacco fields scattered throughout the Connecticut and the Housatonic Valleys, making

a record in each case of the presence or absence of rootrot on each field and the severity of infection if present. With this information before us we should be able to determine what correlation exists between rootrot and soil reaction. Incidentally it is also hoped that we may learn whether there is an optimum reaction for the growth of tobacco and where that optimum lies.

Since there are several methods of measuring and expressing soil reaction, we were confronted at the outset with the problem of deciding which one to use. The lime requirement method as used by Johnson and Chapman is subject to the objection that it measures amount of acidity and not intensity of acidity. It is reasonable to believe that the activity of the parasite varies with the intensity of acidity. The so-called "hydrogen ion" method was therefore selected. The concentration of hydrogen ions (active acidity) may be determined either electrometrically or colorometrically. The first is the most accurate but too laborious and time-consuming for the testing of such a large number of soils. Also it is questionable whether such extreme accuracy is essential in this work. The colorometric method was therefore selected and all samples during the season of 1925 were tested with the double wedge comparator of Stirlen and Wallace. This method is rapid and was considered sufficiently accurate for the field survey. All tests were made on fresh soils immediately when brought in. (It was found that if these soils were kept for several days and dried out before testing they gave a more acid reaction.) Tests were therefore made while the soil was fresh, after which it was dried and stored for different tests.

Hydrogen Ion Method of Measuring Soil Acidity.

The following non-technical explanation is offered for the benefit of those unacquainted with the hydrogen ion concentration method.

A soil that is exactly neutral (neither acid nor alkaline) is represented by the figure 7; alkaline soils by figures above 7, and acid soils by figures below 7. The further away from 7, the more acid or alkaline it is; thus 5 is more acid than 6, 4 more acid than 5, etc.

Although the figures of the hydrogen ion scale are from 1 to 14, only a small part of this scale is used in measuring soils. Up to the present we have not found a tobacco soil more acid than slightly below 4 or more alkaline than 7.3. Figure 6 may help to visualize the important points on the scale.

The method of preparing the solution for testing was as follows: Test tubes were filled with distilled water up to a mark indicating 10 cubic centimeters. The soil after thorough mixing was then added to the water until it rose to the mark on the tube indicating 12½ cubic centimeters (4 parts of water to 1 of soil). After shaking thoroughly, the suspension was either centrifuged until fairly clear or permitted to stand until the supernatant liquid was clear. In many samples the water does not become clear, but

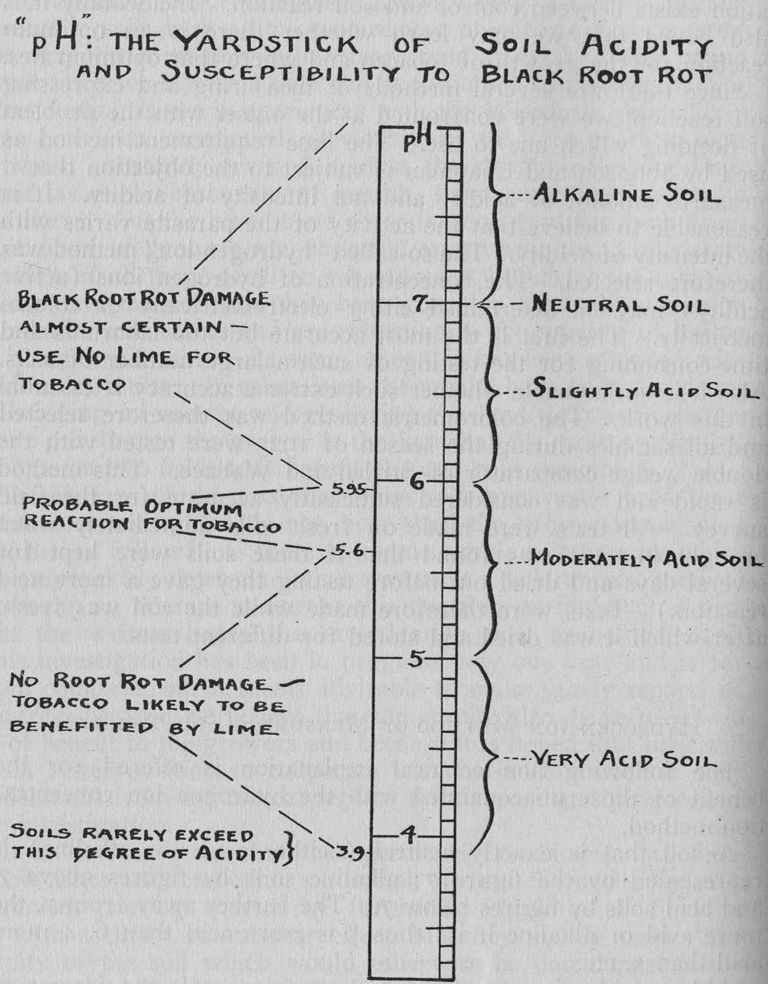


FIG. 6.—Black Rootrot in relation to Soil Reaction.

retains a murkiness which will not settle out for several days. This was particularly true of the less acid samples. The turbidity however, is compensated for by placing a tube of water without indicator in the comparator back of the double prism. Trials showed that the reaction was the same whether the solution was centrifuged at once, or permitted to settle until the next day. Two solutions were prepared from each sample—or more if the first two did not check closely. The indicators which were

found most suitable for this work were *brom thymol blue* at all ranges above 6.2, *brom cresol purple* from 6.2 down to 5.4, and *methyl red* below this. *Chlor phenol red* was used to some extent in the same range as *brom cresol purple*, but was not so satisfactory, especially in the upper half of the range. *Brom cresol green* gave results which were so clearly incorrect (possibly due to salt errors) that it was found to be worthless for this work and methyl red was substituted.*

STUDIES IN 1925.

Samples were taken and records of field history made as the writers had opportunity during the summer and fall of 1925. Conclusions can be drawn only from tests of old tobacco fields. New fields (1-4 years in tobacco) may have a high reaction and still not be seriously affected with rootrot. The same may also be said of old fields which were formerly very acid in reaction but have been limed heavily within the last year or two. Soil tests under such conditions might lead one to expect severe infection when really the crop is not appreciably injured. It is for this reason that one must know the past history of the field as regards lime and fertilizer treatment and use considerable judgment in selecting fields for data. Even when soil conditions are made favorable for rootrot, it seems to require from 1 to 3 years before serious infection is noticed. The first year after heavy liming is usually marked by increased growth and the injurious effects of an overdose become apparent only afterward. The black rootrot fungus (*Thielavia basicola*) is present to some extent in all tobacco fields. We have not yet seen a field where the roots were found entirely free from its lesions if enough plants were dug and the roots carefully washed and examined. The reason that more fields do not suffer severely from rootrot is that the soil conditions are not right for abundant propagation and infection. As soon as those conditions are made right (by liming, principally) propagation increases and becomes apparent in reduced yield after 1-3 years as mentioned above. In collecting the data, fields cannot be listed as "infected" and "not infected" because all are affected. They must be classified according to the degree of injury which is apparent on the parts above ground. This injury is measured by lack of growth and consequent reduced yield. For purposes of classification the degree of injury was designated as none, slight, moderate, heavy, and very heavy. In fields of the first class, no injury had been noticed by the grower. In fields of the last class the injury was so severe that the tobacco was not worth harvesting. If the field was uniform, only one composite sample was taken. If, however, there were some parts

* The method used is thus described in detail for the benefit of any who wish to compare results or to undertake similar work. Results can be compared only when the same method of procedure is used.

of the field which showed evidences of rootrot while other parts appeared normal, two or more samples were taken from the same field. A few samples were also taken from seed beds which were affected with rootrot. Data on uninfected beds are of little significance because most beds are sterilized and rootrot will not be found in them even when the soil reaction is apparently favorable for it. The 234 samples which were tested during 1925 were distributed among 17 towns of the Connecticut and Housatonic Valleys as follows: Amherst 26, Northampton 2, Hadley 7, Sunderland 15, Granville 7, Southwick 2, Suffield 4, Granby 11, Windsor 81, Bloomfield 20, Simsbury 6, Hazardville 15, Ellington 14, East Windsor 2, South Windsor 6, Manchester 1, New Milford and neighboring towns in Housatonic Valley 15.

A complete presentation of the data on these samples is too lengthy to include here. The data as regards rootrot and reaction are summarized in Table XXV.

Table XXV. Soil Reaction and Black Rootrot Injury. Summary of 234 Tests in 1925.

Reaction, pH	Number of Soils tested	Degree of damage from rootrot: None	Slight	Moderate	Heavy	Very heavy
Below 5.5	8	8	..	..	..	..
5.5 –5.6	11	11	..	..	..	..
5.6 –5.7	25	25	..	..	..	..
5.7 –5.8	56	56	..	..	..	..
5.8 –5.9	49	49	..	..	..	..
5.9 –5.95	23	23	..	..	..	..
5.95–6.0	5	1	4	..	..	..
6.0 –6.1	8	1	6	..	1	..
6.1 –6.2	7	1	2	4	..	..
6.2 –6.3	10	..	1	4	5	..
6.3 –6.4	7	..	..	1	6	..
6.4 –6.5	8	..	..	..	4	4
6.5 –6.6	3	..	..	..	2	1
6.6 –6.7	2	..	..	1	..	1
6.7 –6.8	2	..	..	1	..	1
6.8 –6.9	2	..	..	..	..	2
6.9 –7.0	3	1	..	..	..	2
7.0 –7.3	5	..	..	..	..	..
Total	234	176	13	11	18	16

An inspection of this table shows that:

1. The 68 samples taken from infested fields or beds all had a reaction of 5.95 or above.
2. The most severe infection was from 6.4 upward, i. e. those soils which are nearly neutral or slightly alkaline.
3. Of the 176 samples from fields which showed no injury, all but four were below 5.95. Lack of infection on these four may have been due to the fact that the reaction had been brought up to that point only within the last few years.

It is perhaps too early to draw definite conclusions because more extensive survey may reveal some fields which are not in agreement with those tested and because a different kind of season may shift the critical point upward or downward (since Johnson and Hartman show that soil temperature also plays an important role.) Results up to date indicate that the critical point between rootrot and safety is in the neighborhood of 5.95. We have yet to find a field suffering seriously from rootrot at a more acid reaction than this. Apparently the problem for the grower is to keep his soil below this point. How shall he do this? Fortunately, most soils in the tobacco sections are naturally more acid than this. In the Connecticut Valley the only cases of a more alkaline reaction we have observed were due either to heavy applications of lime or ashes or to location on heavy, low places in the field *into* which the alkaline elements leach from the other parts and *from* which the leaching seems to be very slow, thus resulting in an accumulation of alkaline substances. From the typical sandy tobacco soils the alkaline elements leach rather quickly, so that if applications of lime or wood ashes are avoided for a few years the soil naturally reverts to an acid condition. In the heavier soils where leaching is slower the case is not so simple. There is no fertilizer or other fairly inexpensive substance which can be applied to the soil to make it quickly acid comparable to lime for making soil alkaline. Large applications of sulfate of ammonia and sulfate of potash, however, will gradually produce an acid condition. The use of these salts in place of nitrate of soda or carbonate of potash is recommended in soils which are too nearly neutral, but rapid results should not be expected. It is perhaps best to avoid heavy, naturally neutral or nearly neutral soils for tobacco and on the lighter soils when the reaction is too high to avoid the application of alkaline substances.

However, it must be remembered that there is also a danger of getting the soil too acid. As previously mentioned, there is good evidence that lime, wood ashes and carbonate of potash are beneficial in tobacco culture. In fact it seems that the more nearly neutral a soil can be kept without incurring rootrot, the better the tobacco which is grown on it. In other words, the grower should attempt to keep it up as near 5.95 pH as possible without actually getting it above that point. Among the fields tested during 1925, there were many which had the reputation of producing the best tobacco in their respective neighborhoods and were selected for tests on that account. The larger part of these showed a reaction between 5.6 and 5.9 pH, the maximum number centering around 5.85. An occasional good field could be found as acid as 5.1 but on most of those below 5.5 the owners did not consider the growth satisfactory. Such fields would probably be benefited by applications of lime or wood ashes.

Soil conditions in the Housatonic Valley are somewhat different and need a few words of explanation. This part of the state is characterized by outcroppings of limestone and the soil is frequently called a limestone soil. One would naturally expect to find such a soil neutral or slightly alkaline, in which case it would not be possible to grow tobacco profitably on account of rootrot. Yet we know that good tobacco is grown in the Housatonic Valley. In order to see what the rootrot situation was there, the writers made a partial survey of the region about New Milford and tested the soil from 15 tobacco fields. The best tobacco fields were on the sandy terraces along the river and its larger tributaries, and the soil was no more alkaline than corresponding fields in the Connecticut Valley. Rootrot was causing no damage here. Other fields were located where there were outcroppings of limestone either in the fields or in such a position that there was direct wash from them into the fields. Such fields were suffering severely from rootrot and the reaction of the soil was found to be well above 6.0 pH. That more such fields were not found was probably due to past experience of the farmers which had taught them that tobacco could not be grown at a profit on these fields.

Many growers are interested in this problem and are anxious to know if lime may be safely used or if on the other hand an effort should be made to get their fields into a more acid condition. Soil samples may be brought or sent to the tobacco station for testing and while the number of pounds of lime to use can not be stated exactly, the test is sufficiently accurate to serve as a safe guide.

TOBACCO DISEASES OBSERVED IN 1925.

P. J. Anderson and G. P. Clinton.

The following paragraphs record only the observations the writers have made on the diseases prevalent in 1925. A more comprehensive bulletin treating of all the diseases will be published at a somewhat later date.

Brown Rootrot.

This is probably the least known of all the diseases of tobacco and yet there is no more important disease problem which confronts the Connecticut Valley tobacco grower. Scattered all over the valley are fields which once grew the best tobacco but which are now being rested or turned to other crops because tobacco will no longer grow there. The fields have become "tobacco sick" or

"run out." Many other good fields have patches of various sizes where the owner doesn't expect to make the crop pay. Some of these are cases of black rootrot, some are unexplainable, but the majority are brown rootrot cases.

The symptoms of brown rootrot as seen above ground in the field are the same as black rootrot, viz., slow growth, yellow narrow pinched leaves which wilt on hot days, premature topping

Fig. 7.—Brown rootrot "patch" in an otherwise good field of Havana seed. 1925.

out resulting in undersized plants and dead yellow tobacco when sorted. When the roots of such plants are washed and examined, many of the smaller ones, especially at the very base of the stem, are found to be dead and brown. There are no black segments of roots or enlarged rough black lesions such as one finds in the case of black rootrot. The stunted growth above ground is apparently caused by the destruction of so many of the roots with consequent starvation of the plant. Later in the season when the new roots are developed from the stalk, the dead lower roots are not so much in evidence.

The greatest gap in our knowledge of this disease is our ignorance as to the case of it. If we sufficiently understood the cause, it would probably not be so difficult to find some method of preventing it. In contrast to black rootrot, no one organism has been found associated with it. Yet there is some evidence that it is caused by an organism, although the responsible one has not been isolated. The fact that it can be prevented by sterilizing the soil with steam or formaldehyde lends support to this view since such treatment would be expected to kill the causal organism. Yet it is quite possible that such sterilization may have other effects on the soil. The fact that the disease can be prevented by spreading the soil out in a thin layer and aerating it for two weeks would be very unusual for a disease caused by the attack of an organism, since we are not acquainted with any pathogenic organisms which can be destroyed by such a mild measure. We know that certain preceding crops or cover crops have considerable influence on its prevalence. The writer has shown, in experiments in Massachusetts for instance, that timothy used as a cover crop favors brown rootrot. Hence there are those who see in brown rootrot only a crop effect. This might operate, but it could be only one of the operating factors at best since we have many fields where rootrot affects only small patches but the whole field has been cropped alike for many years. Up to the present, no practical remedy has been found. Cover crops should be avoided. Also nothing will be gained by "resting" the land to timothy for a few years, as has been tried by some. It will do better in continuous tobacco. The reaction of the soil seems to have no influence as we have observed during the soil tests of 1925. Growers have also learned from experience that application of additional fertilizer does not help it.

In view of the seriousness of the situation and the little progress that had been made in finding a way to combat it, a combined attack on the problem was planned in the spring of 1925 by representatives of the United States Department of Agriculture, the Botany Department of the Agricultural Experiment Station and the Tobacco Station. Field plots for this investigation were located on a badly affected lot in Poquonock. It was planned that these plots should be continued for at least three years. This is being supplemented by laboratory and greenhouse tests. The experiments have not progressed to a point which warrants a report at this time.

Other Diseases in 1925.

Wildfire. The first case of wildfire in the seedbeds seen by the writer was on May 1. No other case was found for two weeks and even as late as May 30 only ten cases had been reported in the Connecticut Valley, although hundreds of beds had been examined. In comparison with previous years, seed bed infection was thus rather light. More developed during the first two weeks of June. A few cases were found in the Housatonic

Valley during the second week of June. First cases in the field were found at about this same time. From this time on, more and more cases were found in the field until their number was surprisingly large in consideration of the light seed bed infection. It was a season of pretty heavy rainfall in most tobacco sections and it was feared that many of the crops would be ruined. Happily such was not the case. Not only were there no crops ruined—as the writer has frequently seen in recent years—but the amount of wildfire in the harvested crop has been almost negligible as far as we have been able to judge from visiting a considerable number of sorting shops and from many reports.

The unexpected behavior of wildfire during 1925 will be interpreted by some as an indication that this disease is losing its virulence. Such may be the case, but it would be dangerous on such an assumption to neglect any precaution against it in 1926. This year may witness a virulent epidemic.

Some growers tried field spraying with Bordeaux mixture where the infection was serious and believed that they gained a measurable degree of control, but the data are not so convincing in view of the fact that it was not very serious even in the unsprayed fields when the tobacco was cut.

At this point it is well to repeat that every effort should be made to keep it out of the beds since this is the most vital point of attack. It has now been pretty well demonstrated that the wildfire germs do not winter in the soil, but that the principal source of spring infection is the tobacco shed where they winter in infected leaves or on the dry floors. From here it is carried to the beds on tools, feet of workmen, sash, boards, or may be blown. Every precaution should be taken to prevent such transfer of the germs. If the beds are very close to the sheds the grower should be careful to hang any wildfire tobacco he may have in the other sheds or move the beds so that they will be further away from the sheds. The most important measure in control of wildfire is the spraying or dusting of the beds. Some prefer the dust and some the liquid spray. Either will control the disease if it is regularly and thoroughly applied. After having had experience with both, and watching their operation in the hands of practical growers for four years, we are inclined to recommend spraying with home-made Bordeaux mixture as easiest, safest and cheapest. We know of few growers who, after trying both, have not come to the same conclusion. If the stock solutions are made up beforehand, it is not very much work to spray twice a week and keep the plants healthy all the time. There is no stunting of the plants, no dust-burn; other diseases are also controlled as well as flea beetles. Any growers who have not had experience with Bordeaux mixture and contemplate using it should send to the Tobacco Station for full directions for preparing it. A member of the staff will be glad to visit as many growers as desire in order to demonstrate methods of preparation and application.

Extreme care should also be taken not to set plants from a bed which has wildfire. A diseased plant has only about 1/3 as many chances of living when set, as a healthy plant has—not to mention the later effects of spreading the infection in the field.

Dust burn and Fertilizer burn. Dead spots on the leaves of plants in the beds resulting from the application of copper lime dust or of strong fertilizers such as nitrate of soda or fish were unusually common during the spring of 1925. The fertilizer burns may be prevented by care in washing the fertilizer off the leaves with water after application. The conditions which cause dust to burn in some cases and not in others are not so well understood. In some cases, at least, it is caused by putting the glass back on immediately after dusting wet plants and keeping the copper in solution for a long time.

Paris green burn. This injury was prevalent in many fields when the poison bait against cutworms was applied directly on the plants. It produces round dead spots of various sizes in the leaves. Frequently the grower confused it with the lesions of wildfire but the characteristic yellow halo of the latter spot was absent.

Angular leaf spot (Blackfire). This bacterial disease, which is considered more destructive than wildfire in the South, has not proved of serious import in New England. Anderson first reported it in Massachusetts in 1922 but it caused no serious damage at that time. It was also observed during the same year in Connecticut by Clinton but has been reported only once since until 1925 when several rather serious cases were observed. It produces numerous dead spots, commonly somewhat angular, on the leaves. Although there is some yellowing about the margins of the spots, it does not develop the broad definite halo of the wildfire spots. One of the worst cases seen was in the Station Broadleaf field. Many of the lower leaves were worthless when sorted. The effect on the cured leaf is just the same as that of wildfire. It is to be hoped that this disease is not destined to increase and become as destructive as it is in the Virginia and Kentucky districts. There is some basis for believing that the disease will not be serious here since attempts to inoculate plants have failed.

Hollow Stalk. This disease, also caused by bacteria, was found in a few fields but the damage in the aggregate has not been large. It appears first after topping and reduces the pith of the stalk to a wet black rotten mass which later shrivels and dries, leaving the stalk hollow. The lower leaves also become affected,

the midribs become black and they sometimes rot off at the stalk and drop away. The cases observed have not been sufficiently widespread to warrant special control measures.

Bed Rot. (Damping off) This disease is present every year and may affect the plants in any stage of growth in the beds. The worst cases observed during the past year were after the plants were well grown and almost ready to pull. Large patches in the beds were rotted completely off. These bad cases were invariably in beds which had been sowed too thick. When the plants get large the leaves are so tight together that there is no circulation of air, resulting in a constant state of high humidity around the bases of the stalks at the surface of the ground. Such conditions are ideal for the development and rapid spread and infection of the fungi which cause bed rot. No experiments have been undertaken on this disease during the year, but it has been found that beds which are kept thoroughly sprayed from the first are rarely affected with bed rot. The disease was checked in some bad cases by thoroughly ventilating and drying out the beds. Steam sterilization is advised and does much to prevent it from starting, but some of the bad cases of the year were in sterilized beds. We have never found bed rot in beds which were properly sterilized, ventilated, sprayed, planted not too thick and not overwatered. After the plants have developed to the stage when the stem is hardening there is little danger from bed rot.

Oversterilizing beds. Several cases came to our attention during the year where injury was apparently caused by too intensive or too long steaming. In one case a grower sterilized for about two hours at 120 lbs. pressure. He was unable to make tobacco plants grow at all on this soil. Another grower with an acre of beds sterilized some in the fall and the others in the spring. All were on the same kind of soil and all treated alike in every other way and seeded at the same time. The fall-sterilized beds were entirely satisfactory. In the spring-sterilized beds the seeds were said to have sprouted all right but they became thinner every day and probably 80% of them died before they were half grown. No evidence of disease could be found on those which died. Although the evidence all indicated that the damage was due to steaming, an experiment was begun during the last week of May by way of confirmation. One of the beds where the loss had been the heaviest was worked up again. One part of it was then steamed again, one was treated with formaldehyde and the third part was untreated. From another part of the bed the soil was removed and new soil put in. All were then reseeded with the same lot of seed as had been used before. The seed sprouted normally on all, but the plants became thinner day by day on the steamed part until soon there were hardly any left. The stand remained very thick on all the others. Since there was a good stand in the part which was not sterilized, it was apparent that the injurious influence of the early spring steaming had now passed away. The grower had waited at least ten days after sterilizing the first time before sowing, but apparently the injurious influence was of longer duration in this case.

Mosaic. "Brindle" was present in about the usual amount in all parts of the tobacco sections. Some unusually virulent cases occurred about Middletown in the extreme south end of the tobacco country. In some of these fields fully 95% of the plants were diseased. The effect on the plants was also unusual. The leaves were not merely mottled with areas of darker and alternating lighter green as in the ordinary case. The younger leaves especially were distorted and wrinkled and the dark green areas stood out like huge blisters from the surface. The leaves looked like peach leaves affected with the parasitic leaf curl. The growers stated that they had not noticed the disease in the beds. One attributed its virulence to a heavy application of nitrate of soda made shortly before the disease became so prominent. Just why it should be so exceptionally virulent in the fields in that particular neighborhood this year is difficult to explain.

Frenching. This disease, characterized by narrow but heavy strap-like chlorotic leaves, was formerly confused with mosaic and the leaves do frequently have a mosaic character. The number of leaves is also usually increased, especially in the upper part of the plant. Very little of this disease was noticed during the summer in the Connecticut Valley, but a few fields in the Housatonic were found to be rather seriously affected.

Lightning Injury. On account of the frequent electric storms during the early growing season, in the field a number of cases of lightning injury occurred. Some of these which were observed by the writer were three or four rods in diameter. Usually all the plants in the center were quite dead and around this a zone of stunted and deformed plants, the degree of injury gradually diminishing with the increasing distance from the center. When the dead plants were examined a slender cavity was found in each corresponding to the pith. When the marginal plants were allowed to grow they made a one-sided deformed growth.

Injury from tarvia fumes. One grower was very much puzzled at a peculiar injury to his plants along the side of a macadam road. When first examined the leaves had a glistening, varnished appearance. After a few days, parts of the leaves died, the dead places being either marginal strips or irregular areas between the veins. A thorough investigation of the case showed that it had been induced by fumes blowing on to the plants from tarvia which was being spread in a hot condition on the road with a tarvia "sprinkler." Although there were tobacco fields on both sides

of the road, no injury occurred on the side from which the wind was blowing when the "sprinkler" came along.

Curly dwarf. This rare and peculiar disease was again found in fields around Windsor Locks where it had been found in previous years by Mr. Slagg. The plants are very much stunted in growth, the leaves are distorted and wrinkled, and set very close together. The whole aspect of the plant reminds one more of a cabbage or cauliflower. The plants are worthless. Fortunately the disease is confined to a very small locality and a very small percentage of the plants in a field are affected. The cause is entirely unknown.

Yellowing from fertilizer leaching. Shortly before harvesting, it became apparent to anyone who travelled the tobacco section very extensively that something was wrong in a great many of the fields. The growth was not all that it promised to be early in the season. More particularly it was noticeable that the leaves on the lower part of the plant were "yellowing." There was also more than the usual amount of spotting, particularly in the broadleaf. After the tobacco was cured this same condition resulted in a high percentage of dead, yellow and double color tobacco which was very largely responsible for the disappointing quality of the 1925 crop. Most of the tobacco sections had very heavy rains during the middle of the growing season and, without having absolute proof for our conviction, we are inclined to believe that these rains were responsible for the later yellowing by causing loss of the nitrogen through leaching. If these rains had been followed immediately by rather heavy applications of quickly available ammoniates such as fish and nitrate of soda, it is probable that a great deal of this injury could have been prevented. When, however, the grower waited until the symptoms of nitrogen shortage were visible, it was so near harvest that he feared to stimulate growth by application of extra fertilizer at that time.

Physiological Spotting of Broadleaf. Soon after the heavy rains of midseason, large brown dead spots began to develop in the broadleaf to an extent which caused alarm to many of the growers. Since no organisms were found associated with these spots, it seems likely that they were of physiological origin. The most characteristic kind of spot was the "star and crescent" spot, characterized by a small round dead area encircled incompletely by a slender curved dead line. The whole "star and crescent" varies in size, from a quarter of an inch to two inches across. Various other irregular shaped spots occur among them. These spots are quite different and distinct from the little round white spot characteristic of the John Williams type of broadleaf. The writer has noticed in previous years that these spots frequently come soon after heavy rains but the connection between the two is not plain. No method of preventing these spots is known.

TOBACCO INSECTS OBSERVED IN CONNECTICUT IN 1925.

W. E. Britton and P. J. Anderson.

The following pages include our observations of insect injuries to the tobacco crop during the season of 1925. Some of the chief features were the unusually severe outbreak of wireworms, which caused great injury, the prevalence of cutworms, flea-beetles, seed-corn maggots, and a new form of injury caused by the larvae of a crane fly. Most of the field observations of the past season were made by the junior author, but these have been supplemented by records, identifications and illustrations from the Department of Entomology of the Station in New Haven, and this paper is the joint effort of both authors.

Wireworms.

The first reports of wireworm trouble came to the Tobacco Sub-station on May 25. During the next two weeks, numerous reports were received and the junior author visited a number of infested fields, some of which were near the Tobacco Sub-station so there was abundant opportunity to keep in daily touch with the situation. On June 2, the epidemic was at its height, but the extremely hot weather of that week caused the wireworms to go deeper into the ground, so by June 15 it was hard to find one except by digging down deep under the rows. No reports after that date came to our attention. The most severe cases observed were on plantations of shade-grown tobacco, though many cases were also reported in outdoor tobacco fields.

One grower of shade tobacco had 84 acres under cloth, and 40 acres of newly-set plants were ruined. All of it was reset once, much of it twice, and some of it three times. At the second resetting, the wireworms appeared to be just as thick as at the time of the first resetting. On some of his fields, 95 per cent of the plants were dead when the junior author first saw them. The stalks were completely riddled with tunnels, as shown in Figure 8. Usually one or more wireworms still remained in the stalk, and from three to six others could be found in the soil close around each plant, but in some cases the numbers ran up to 18 and even 24 wireworms per plant. Apparently, all had been attracted to the plants and were gathered immediately around them, and only rarely could one be found in the soil between the rows.

The writers visited this field on June 2, in company with Dr. Philip Garman, Assistant Entomologist of the Station, and some of the wireworms were collected and taken to the laboratory in New Haven. Many adult click beetles were observed resting upon the cloth, both inside and outside the tent. They were not known to be connected with the wireworms but it was suspected that they might be the adult stage, and some of these also were collected.

The writers together visited the field again on June 5, when it was found that most of the wireworms had disappeared by going deeper into the soil. Some wireworms could be found by digging for them, but very few were seen around the plants or near the surface. Adults on the cloth were also less numerous than on June 2. When one of the fields was plowed late in the fall, wireworms were observed near the bottoms of the furrows.

Fig. 8.—Injury to young plants by wireworms, natural size.

Identity of the Species: Mr. B. H. Walden, Assistant Entomologist of the Station, examined the wireworms and identified the species as *Limonius agonus* Say, by comparison with some named material in the collection and this identification was afterward confirmed, and the adult beetles pronounced the same species, by Mr. J. A. Hyslop of the Bureau of Entomology, at Washington, D. C. The general appearance of both wireworms and adult beetles is shown in Figure 9. Mr. Hyslop visited East Windsor Hill in 1917 and found this species, which he calls the eastern field wireworm, causing considerable damage to newly-set tobacco, though the attack was much less severe than this 1925 outbreak.

We also have material from Hockanum, July 1, 1920. Little is known about the life history of the eastern field species or the length of the wireworm stage. With other kinds according to species, this stage may require from two to six years.

Though perhaps *Limonius agonus* is the most common wireworm attacking tobacco in Connecticut, we have other material in the Station collection identified by Mr. Hyslop and bearing the

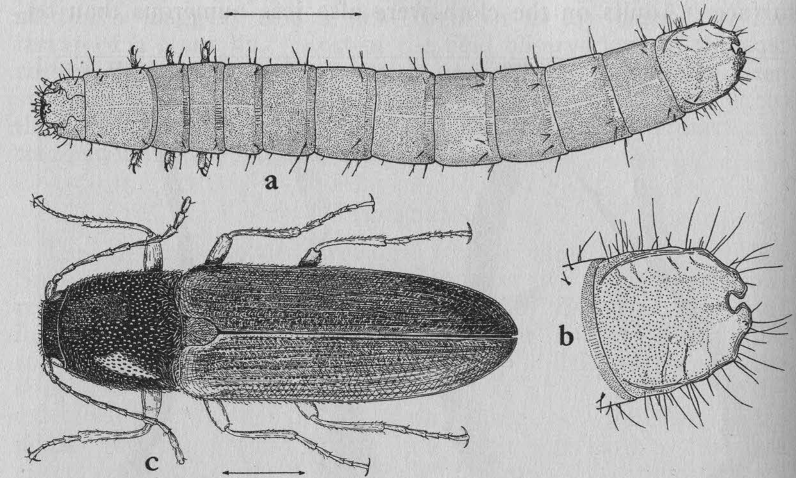


Fig. 9.—The Eastern Field Wireworm, *Limonius agonus*, a. larva; b. posterior segment of larva; c. adult beetle. All enlarged. Natural length of larva and adult indicated by the lines.

following records: *Asaphes* sp., Portland, June 12, 1906, B. H. Walden; *Melanotus* sp., Poquonock, May 28, Windsor, May 29, 1921, E. H. Jenkins.

All wireworms are the grubs or larvae of click beetles, which form the family Elateridae, of which there are nearly 100 different species occurring in Connecticut.

CONTROL OF WIREWORMS.

Probably no group of insects has so baffled the tobaccco grower as has the wireworms. For most of the tobacco insect pests and diseases some partial or complete remedy has been found, but before the wireworms the farmer has been helpless. No remedy was known. When the wireworms came, he had his choice of abandoning the field, or part of the field, for that year, or restocking every few days until the worms were driven down by hot weather. Since frequent restocking results in objectionable differences in maturity at harvest and considerable financial loss, many

prefer to harrow the whole field and reset with the setter. In cases of bad infestation, however, it is frequently necessary to repeat this operation several times before an even "stand" is secured. Wireworm infestation is not equally severe every year. Some years they cause little or no damage; the next year may see an epidemic. Growers have noticed, however, that there is a tendency for them to appear in cycles. If they are injurious on a certain field or part of a field, it is probable that they may occur in the same place the following one or two years. Only rarely is a field equally infested throughout. More often the damage occurs in spots which may cover several acres or may be no more than a rod across. When the wireworms are numerous in the soil, the plants die within a few days after setting; in fact they frequently never recover from the initial wilt after setting. If, however, wireworms are few, the plants may not die at once but remain stunted and sickly. Some recover entirely and make a normal but usually belated growth.

Various remedies have been tried in the past, but without signal success. Fall plowing is frequently recommended but growers who have made careful tests of this method report that it has given no relief. One prominent grower, who considers the wireworm problem as the most serious with which the tobacco farmer has to contend, informed the writers that one of the most serious infestations he ever had was on a lot which he had plowed in the fall. The use of camphor dissolved in wood alcohol and mixed with the water in the setter barrel has also had its advocates, and a few claim to have had success, but others who have spent hundreds of dollars for camphor and alcohol state that the total result has been the repelling of wireworms for a few days with subsequent return and destruction of the crop. Many other substances such as turpentine, various soaps, etc., have been used in the setter barrel and still have their advocates but none of them stand the test when the infestation is serious. Others have tried soaking potatoes or corn in mercuric chloride, formaldehyde, Paris green and other poisons. Wireworms are attracted by these baits which are soon riddled with their tunnels, but they are apparently not killed. Failure may be due either to the extreme resistance of wireworms to such poisons or to the fact that the poisons do not penetrate the baits. At any rate, this method has not been generally successful. Growers sometimes think that the methods they employ are successful because the worms disappear very soon after some remedy has been tried. It is very easy to be misled, however, because of the peculiar habits the wireworms have of disappearing as suddenly as they came. When the soil warms up sufficiently they dig deeper into it and leave the plants on which they have been feeding. If this migration into the deeper soil happens to coincide with the time the grower applied some remedy, he is prone to believe that the remedy has been successful, although it may have had no effect whatever. This habit of the wireworms also probably explains why during some years there is no wireworm injury, since the soil warms up earlier some seasons than others.

EXPERIMENTS AT THE TOBACCO SUB-STATION.

Carbon disulfide; On June 2, Dr. Garman and the writers made a carbon disulfide soap emulsion in the setter barrel and applied it to rows which were being reset. Two rates of application were used; first, one part of carbon disulfide to 360 parts of water, and, on other rows, one part to 720 of water. Three days later it was found that the stronger mixture had killed all the plants, and the weaker mixture had failed to kill the wireworms.

Calcium cyanide: Another remedy suggested by the entomologists was calcium cyanide compound, or "Cyanogas," a poison which had been used in other parts of the country against wireworms in beans and other vegetables. The method used by the bean growers in California is to sow a bait crop of split beans, or other inexpensive seeds, in the field before it is time to plant the main crop. The wireworms from all sides congregate in these seeds and plants. The Cyanogas is then drilled into the soil along the row of infested plants and the fumes kill the wireworms. At our request the American Cyanamid Company of New York, manufacturers of Cyanogas, sent one of their experts to Windsor to investigate the situation and to aid in testing the toxicity of Cyanogas against the tobacco wireworm and in working out a practicable method of using it. Unfortunately at the time Mr. Rice, their expert, arrived, on June 11, the epidemic was subsiding and extensive field experiments were out of the question. Some experiments on a small scale, however, were made to test the toxicity of Cyanogas on the wireworms and the effect it had on the plants. Such experiments seemed essential as preliminary to field experiments, which it is hoped will be tried in the season of 1926. Some of these may be briefly described.

Toxicity to wireworms: When a wireworm is placed in direct contact with Cyanogas, it dies within a minute or two, but in the soil it is seldom that many come into direct contact with the poison. In order to see how the fumes would pass through the soil, 24 wireworms were distributed in the soil of a box one foot square. A small teaspoonful of the cyanide was then buried at the center of the box about three inches below the surface. Eighteen hours later the soil was sifted and 21 of the worms were dead, while three of them were barely able to move.

With the idea that the enclosing walls of the box might have some effect, the next test was carried out in the open field. Eighty

wireworms were distributed in the soil of a row of plants, eight feet long. A thin line of cyanide was then drilled in the row two inches deep. Two days later the row was dug up but only 60 of the wireworms could be found. All but three were lifeless and these three were very sluggish. This soil was not screened and it is not always easy to find them in the open field without screening. Undoubtedly more of them could have been accounted for by more careful search, but some may have been far enough away to escape the fumes and have crawled away.

In a third test, Mr. Rice distributed 140 wireworms in a narrow box ten feet long and a foot deep and wide, and then set a row of plants in the center. After a few days, when the wireworms were working well in the plants, a thin line of cyanide at a rate calculated to equal 100 pounds per acre, was drilled two or three inches deep along the row. Then after a few days the soil was sifted, but only 60 of the wireworms could be found, all of which were dead. The box was thought to be tight enough to prevent escape of any wireworms, but the soil and water had warped it so that there were cracks large enough for them to escape, which they probably did before the application of cyanide was made. Not a live wireworm was found in the box.

Effect of Cyanogas on tobacco plants: When the cyanide is placed directly in contact or even very near a tobacco plant, it wilts and dies within a few hours. It is therefore not possible to use it directly on plants which one wishes to save, but of course when the plant is affected with wireworms, one does not wish to save it. The important question is: how soon after applying the cyanide to a soil will it be safe to set the plants? In order to test this, a row of cyanide was drilled in at the rate of 100 pounds per acre. After four days a part of the row was set with plants, directly over cyanide. An additional part was set each following day until the row was all set at the end of ten days. All were watched carefully for any signs of wilting, stunting, or other injury, but all grew alike into strong healthy plants. Apparently four days was ample time in this test for the toxic effects tc pass out. It should be mentioned, however, that in this test there was a *heavy rain* during those four days which may have had some effect in dispelling the toxic substances. Experts of the American Cyanamid Company recommend seven days before setting.

Another important question to be answered is: will the cyanide have any effect on the quality of the cured leaf? In order tc test this, four rows of Havana seed tobacco were set where cyanide at the above mentioned rate had been applied six days before. Four alternating rows were set at the same time, but where no cyanide had been drilled. Throughout the season the tobacco was watched for any differences in growth but none were apparent. The rows were kept separate at time of harvesting and sorted separately. No difference in quality could be seen at time of sorting. Neither were there any differences when burn tests were made.

From these preliminary tests we may conclude that:

1. Calcium cyanide is highly toxic to the wireworms not only when in contact but is able to kill them through several inches of soil.
2. Most of the wireworms during the danger season congregate in or very close to the plants, leaving the more distant soil almost uninfested.
3. Although Cyanogas kills tobacco plants when first put near them in the soil, its toxic effects disappear within a few days and it is safe to set plants there at least within a week or possibly sooner.
4. Cyanogas seems to have no injurious effect on the quality of the cured leaf.

Suggested Method of Application: Pending more extensive field trials we are not yet ready to give unqualified recommendation to the cyanide method, but it is by far the most promising method which has been tried. We make the following suggestions for those who are troubled with wireworms and are willing to try something, even though success has not been fully demonstrated, rather than to do nothing and see their fields ruined. The average grower will not do anything until he finds his plants already infested. When this stage is reached it is hopeless to try to save any of the plants in the infested area. It is best then to drill the Cyanogas into the row as deeply as can be conveniently done with the least disturbance of the soil. For this purpose the writer has found a Planet Junior hand seed drill very convenient. Other drills of similar construction and on which the outflow can be regulated may be used. For more extensive work a larger drill operated by horses such as a corn drill or a fertilizer attachment on a tobacco setter could be used. Cyanogas is a fine powder which does not lump and flows freely from the drill. All the plants which remain in the row will be killed along with the wireworms. A week later the plants may be set in the same row. This method has the disadvantage of delaying the final setting of the plants. Another method is to bait and kill the wireworms before the field is set in the first place. This may be done by drilling corn or other seeds in the field ten days before ready to set and then killing the wireworms which gather in the row by the method mentioned above. If the grower is uncertain as to whether his soil is infested with wireworms, he may find out by planting a few rows of corn across the suspected places and see whether or not wireworms attack it. It is not necessary to wait until the corn comes up, since it will be attacked within a few days if the wireworms are there. If it has an abundance of tobacco plants, the grower may find it best to set these as the bait crop. It has also been suggested that the bait rows be located somewhat to the side or between where the final rows will be set. In this way the cyanide may be applied and the final setting made immediately afterward without a week of delay. Yet another method may be used on fields where infestation is not severe enough to warrant replacement of the entire stand. If there is only an occasional plant affected, the grower may make a hole beside each affected plant with a dibble or a stick, insert a half teaspoonful of Cyanogas and close with dirt. After a few days the field may be restocked with safety.

The Tobacco Sub-station will be glad to coöperate with any growers who wish to try these methods and to learn of results obtained by the use of Cyanogas.

Cutworms.

Cutworms cause more or less injury each year in tobacco fields and were unusually troublesome in 1925. They are the larvae or caterpillars of certain species of Noctuid moths, a dozen or more different species having been recorded as causing injury. Though the different kinds have varying habits and life histories, with most of them there is one annual generation, the eggs are laid on grass, weeds or other plants in late summer, and the larvae hatching from them feed upon the smaller weeds, grass and other vegeta-

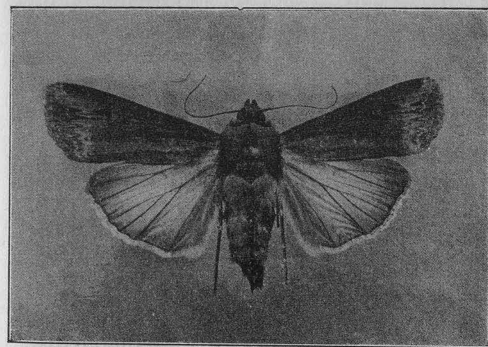


Fig. 10.—Moth of the black cutworm. Natural size.

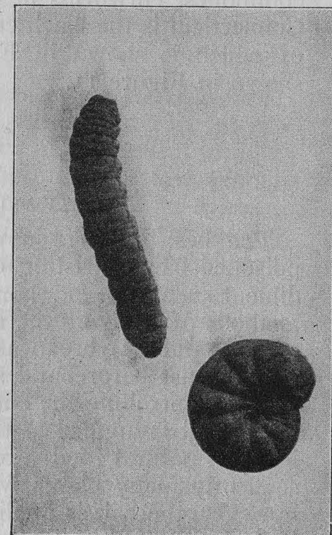


Fig. 11.—The variegated cutworm. Natural size.

tion of the field, becoming about half-grown on the approach of cold weather, going into the ground or under rubbish to gain protection during the winter. When warm weather arrives in spring and vegetation begins to grow, they emerge from their winter quarters and resume feeding. When the land is plowed, the weed growth is turned under and the cutworms have difficulty in finding food and accumulate great appetites. Consequently they are all ready and waiting for a full meal, and proceed to take it as soon as the plants have been set. Their attacks necessitate a great deal of resetting followed by a lack of uniform maturity at harvest time.

Cutworms do their feeding at night and hide during the day, usually curled up just beneath the surface of the soil, where they may be found by hunting for them around the base of injured plants. The adult moths are mostly grayish or brownish to black in color and also fly and lay their eggs at night and rest during the day in protected places on barns, fences, trees, etc. One of the commonest cutworms in tobacco fields and vegetable gardens in Connecticut is the black cutworm, *Agrotis ypsilon* Rott., the adult of which is shown in Figure 10. The variegated cutworm is shown in Figure 11.

CONTROL OF CUTWORMS.

The best growers now control cutworms by the use of a poisoned bait consisting of a mixture of Paris green with some diluent such as brand, hominy feed, or middlings. There are two methods of applying the mixture: (1) on the row at the time of setting, and (2) broadcasted before setting. Those who applied it broadcast beforehand seem to have been more successful this year in controlling the cutworms. This is to be expected because if the bait is applied at time of setting, the cutworm will hardly leave its natural food, a tender plant, and seek the dry bait. Consequently many plants will be eaten and must be replaced. If, however, the bait is applied beforehand to the bare ground there is nothing else for the cutworm to eat, and it will naturally be attracted to the bait, and should be killed before the crop is set. In order to test the two methods side by side, alternating plots were treated by each method and the number of plants destroyed by cutworms was recorded. Unfortunately, this field proved to be one of the few in the Connecticut Valley which was not seriously infested with cutworms even where no bait was used. The final results were all in favor of the application before setting, but since the infestation was very slight on the untreated plots, the results were not very convincing. The mixture used in these tests was made as follows:

Bran (1 bag)	100 lbs.
Paris green	5 lbs.
Oranges or lemons	½ doz.
Cheap molasses	4 qts.
Water ....about	15 gals.

The amount of water to be used must be determined by the condition of the mixture. Enough must be added to make the bran stick together in small lumps so that it can be broadcasted by hand, but not enough to "puddle" it. The bran and Paris green were first mixed dry by shoveling over, as one mixes fertilizer on a platform. The oranges were cut into very small pieces and mixed with the water and molasses. After thoroughly stirring, the sweetened water was sprinkled over the bran in order, while shoveling, to mix thoroughly. The mixture was broadcasted on the field just before night, several days before the tobacco was set. The oranges and molasses are said to attract the worms to the poisoned bran.

FLEA-BEETLES.

The cucumber or potato flea-beetle, *Epitrix cucumeris* Harris, often causes injury to newly-set tobacco plants, and even afterwards the large leaves are frequently eaten. Flea-beetles usually attack the under surface of the leaves, where they eat away portions of the tissue, giving a spotted appearance. The injured spots become dry and drop away, leaving holes through the leaves as shown in Figure 12. Sometimes the beetles feed upon the upper surface with similar results.

In most tobacco growing regions, particularly southward, such injury is caused by the tobacco flea-beetle, *Epitrix parvula* Fabr., but in all the collections made from tobacco plants in Connecticut only *E. cucumeris* was obtained and so far as we know, *E. parvula* has not been recorded from Connecticut.

The cucumber or potato flea-beetle is about one-sixteenth of an inch in length, black in color, with rear legs enlarged and fitted for jumping. It also has wings and can fly. It is shown in Figure 13.

The junior author in 1925 made an interesting observation on the ability of the beetles to distinguish between the different kinds of tobacco. In the shade tent at the Tobacco Sub-station, there were under experiment a large number of selections and hybrids of Cuban tobacco. During the summer it was noticed that the beetles gathered on one particular row, a hybrid near the center of the field. After the tobacco was cured and this hybrid came to the sorting bench, it was found to be so riddled with small holes that it was not worth sorting. This was the only row on the whole field which was severely injured, and rows on either side of it showed hardly a trace of flea-beetle injury. Apparently there was some factor in the make up of this hybrid strain which was attractive to them, or perhaps it lacked some principle which in the other strains was repellent to them. We have not seen any references in tobacco literature to this selective taste of flea-beetles

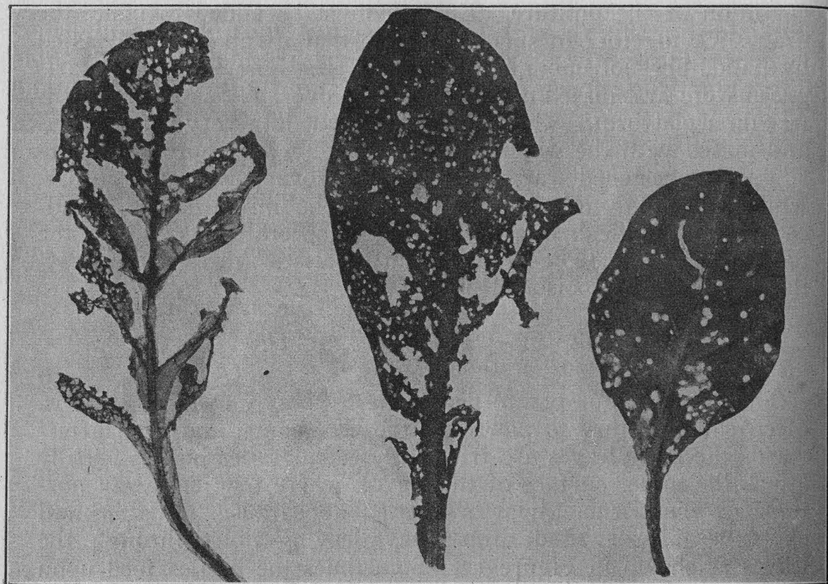


FIG. 12.—Lower tobacco leaves injured by flea-beetles.

for different kinds of tobacco. One grower of long experience states, however, that he has previously noticed this peculiarity. The worst cases of flea-beetle injury on the grown leaves which we have seen this year were on the edges of fields immediately adjacent to potato fields. After the potato tops died the beetles swarmed upon the tobacco and ruined the outside rows.

There is some question about the best method of controlling flea-beetles. In potato fields, they are kept in check by heavily spraying both upper and under sides of the leaves with Bordeaux mixture and lead arsenate. In the Station experiments many years ago, it was found that tobacco plants as well as tomato and cabbage plants could be dipped, root and leaf, before setting, into a mixture of lead arsenate, one pound in 10 gallons of water. This caused no injury to the plant and flea-beetles did not injure the leaves which were dipped. In the senior author's garden in 1925, one day when using a nicotine spray, it was noticed that

some tomato plants were being injured by flea-beetles. The plants were sprayed with nicotine (Black Leaf 40, 2 teaspoonfuls in a gallon of water with an inch cube of laundry soap dissolved

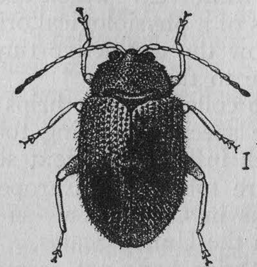


FIG. 13.—The cucumber flea beetle *Epitrix cucumeris*. (After Chittenden, Bureau of Entomology, U. S. Department of Agriculture.)

and added) and there was no further trouble. It is probable that all of the treatments mentioned act chiefly to repel the beetles instead of killing them.

THRIPS.

Thrips have never been considered among the serious insect pests of tobacco in Connecticut, but are said to cause severe injury in tobacco sections of the south. However, a number of cases were seen in Connecticut during the year, and there is an impression among the growers that they are becoming more prevalent each year in certain sections of the valley. Most, but not all, of the cases which came to our attention were in shade fields. It has also been observed in Florida that shade tobacco is more seriously affected than the sun-grown crop. This may be due to the fact that heavy rains do not beat them off under the shade cloth, as may be the case outside. It is said that they are worse during dry seasons and are partially kept in check by heavy rains. At the Tobacco Sub-station, the most serious infestation was on Havana seed, adjacent to the tent tobacco. The symptoms appear on the lowest leaves, and then slowly on the successively higher leaves. In this case, none were observed as high as the middle of the plants, and damage was confined to the first few leaves. In the field the veins of the affected leaves have a silvery appearance which makes them stand out from the remaining green tissue of the leaf. The insects work along the main veins on the upper leaf surface. Close examination shows the silver lines peppered over with tiny black specks. The insects themselves are not so often seen as are their effects. They are slender, brown, very small (about one twenty-fifth of an inch long) and when disturbed jump and disappear like fleas. Badly affected leaves turn yellow and may die prematurely. In the cured leaf, the veins are still more conspicuous, and the average sorter calls it "white vein" without recognizing the difference between this and the ordinary "white vein" which usually occurs on leaves higher up, and which is of a physiological origin. Close examination, however, will show the distinctive tiny black specks and a rather irregular outline to the veins.

As we have made no collections of thrips from tobacco plants, we cannot identify the species attacking tobacco in Connecticut, but hope to obtain such information next season. *Thrips tabaci* Linde. is said to injure tobacco in Europe, but though it is a common pest of onions in Connecticut, so far as we can learn is not a tobacco pest in the United States.

Up to the present, thrips have not seemed to be of sufficient importance to warrant special control efforts. Attention is called to them at this time in order that growers will be on their guard and may know them if they should become serious. We have no reason to believe that they will become more prevalent.

The Garden Springtail.

Tobacco plants, as well as the young seedlings of many vegetable plants, are often attacked and injured in the seed beds by the garden springtail, *Sminthurus hortensis* Fitch. The individuals are extremely abundant near the surface of the soil when

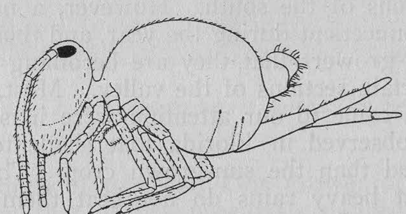


Fig. 14.—The garden springtail. Outline profile. This insect is purple with pale yellow irregular spots. Enlarged about 40 times.

the plants are coming up and eat very small holes in the leaves and enlarge the wounds made by flea-beetles and other insects. In fact, large areas of young seedlings are destroyed by the springtails, each year before their presence is noticed by the owner. They are scarcely more than a millimeter in length and it takes twenty of them end to end to reach an inch. They are dark purple, spotted with yellow, and jump like fleas so that it is almost impossible to catch them. Each has a globular shaped body with a rather large head and narrow neck. From beneath the body extends a forked tail-like appendage by means of which

the insect is able to throw itself. See Figure 14. Seed beds in Silver Lane, East Hartford, were infested in 1925. There were four beds each about 100 feet long and covered with cloth, and containing broadleaf plants from one-fourth to one-half inch high when attacked. All the beds were invaded and some had hardly any plants left. The junior author visited this plantation and also saw another less severe case in Simsbury. This insect caused much injury to vegetable seedlings in Pine Orchard in 1922 and 1923. The garden springtail can doubtless be controlled by dusting or spraying the seed beds with nicotine.

The Seed Corn Maggot.

Tobacco plants are occasionally injured by small white maggots which enter the stems just below the surface of the ground. Sometimes only a pin hole is visible, but often a larger injury is apparent. On cutting into the stem, one or more white mag-

Fig. 15.—Stems of newly-set tobacco plants, showing injury by seed corn maggot. Twice enlarged.

gots may be found and sometimes the entire stem has been hollowed out by their feeding. Injured plants are shown in Figure 15. The insect responsible is a small two-winged fly, *Hylemyia cilicrura* Rond., shown in Figure 16, with its brown cocoons or puparia in Figure 17. Serious injury to tobacco caused by this insect occurred in Windsor in 1921, particularly on a portion of the field where clover had been plowed under in the spring, and some 40 acres under cloth had to be harrowed and reset. This insect is liable to be abundant following heavy applications of stable manure.

During the first week in June, 1925, Mr. C. A. Huntington, a shade grower of Windsor, brought to the Tobacco Sub-station a handful of young plants, the stalks of which were riddled with

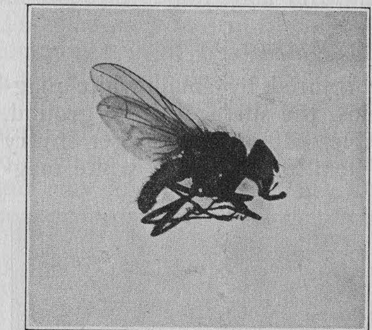


FIG. 16.—Adult of seed corn maggot. Four times enlarged.

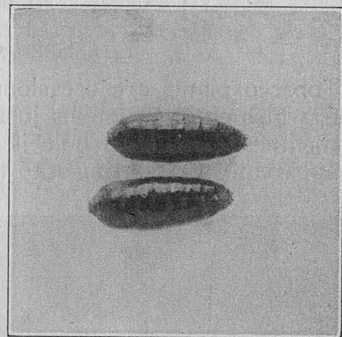


FIG. 17.—Pupae of seed corn maggot. Four times enlarged.

tunnels, somewhat resembling those made by wireworms, but when the stalks were cut open, small white maggots were found in the tunnels. These maggots attacked the plants soon after they were set in the field and killed many of them, necessitating considerable work in restocking. A week later they had disappeared completely, but in a visit to the field on June 5 we found a few puparia and were able to identify the invaders as seed corn maggots. No other report of damage from this source came to the Tobacco Sub-station this year. Apparently it is of unusual occurrence and does not cause widespread injury.

TOBACCO PLANTS INJURED BY CRANE FLY MAGGOTS.

The authors visited the shade field of Mr. Huntington of Windsor on June 5, and while hunting for seed corn maggots, found many "leather jackets" or crane fly larvae near the surface with an occasional pupa case protruding from the soil. Many plants were also observed with notches eaten in the stems, causing them to break off, that did not seem to be the characteristic injury of the seed corn maggot. The crane fly maggots

were often found near the plants, but were also present half way between the rows; in fact they were distributed quite uniformly over a portion of the field. On account of their abundance in that particular section of the field where the injured plants were found, we began to wonder if there might not be some connection. Mr. Huntington believed these maggots to be the cause of the trouble, and stated that so many plants were killed that it was

FIG. 18.—Injury to plants by crane fly larvae. Natural size.

necessary to harrow and reset certain parts of the field. Here the soil contained considerable undecomposed organic matter which may have served to attract these insects. A few adult crane flies were also collected from the cloth on the tent and from a tobacco barn close by. Before leaving the field, we collected about 30 of the larvae, which were taken to New Haven and placed in soil in a cage sunk in the ground. In this cage were set some uninjured tobacco plants. Three days later two of the plants had holes eaten in the sides of the stems like those observed in the tobacco field, and shown in Figure 18. On September 9, adult flies emerged and have been identified as *Nephrotoma ferruginea* Fabr., by Professor Charles P. Alexander of the Massachusetts Agricultural College, Amherst, Mass. These crane flies proved to be identical with those collected from the cloth of the tent and from the tobacco barn, and belong to the family Tipulidae. The maggots are tough and leathery in texture, gray in color, about an inch in length with four curious protuberances at the head. There is probably a generation each

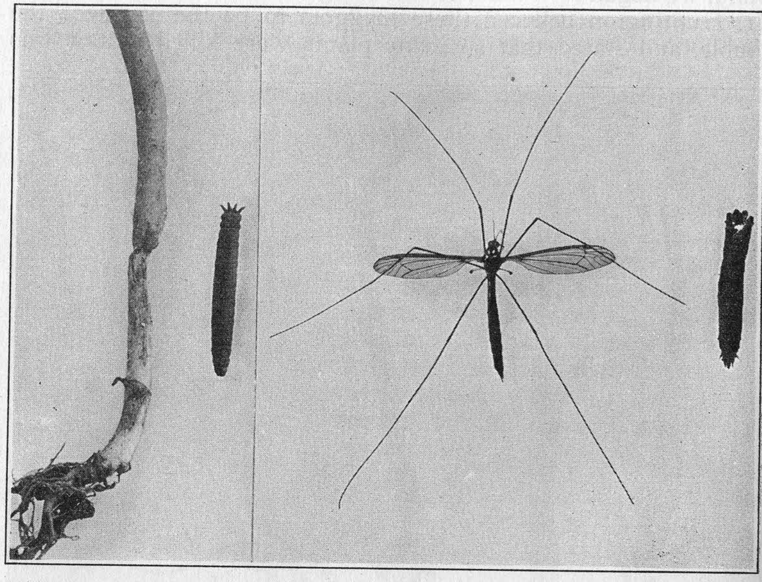


FIG. 19.—Adult crane fly, larva and pupa skin. Natural size.

year, and Figure 19 shows the maggot, pupa case, adult and injured plant.

According to the Insect Pest Survey Bulletin for July, similar injury to tobacco by crane fly maggots was observed in Hadley, Mass., by Dr. H. T. Fernald late in June of the past season. So far as we are aware, these are the first records of damage to tobacco by crane fly maggots, at least in this country. No control measures can be recommended at this time.

TOBACCO WORMS OR HORN WORMS.

Horn worms are the larvae or caterpillars of sphinx moths, also called hawk moths or hummingbird moths, which are found feeding on tobacco and tomato leaves during July, August and September. They are called horn worms on account of the single horn, which is only a fleshy protuberance on the back near the

tail. When fully grown, they may be nearly as large as one's finger, between three and four inches in length, and have the appearance shown in Figure 20. They then enter the ground and transform into curious "jug-handle" pupae shown in Figure

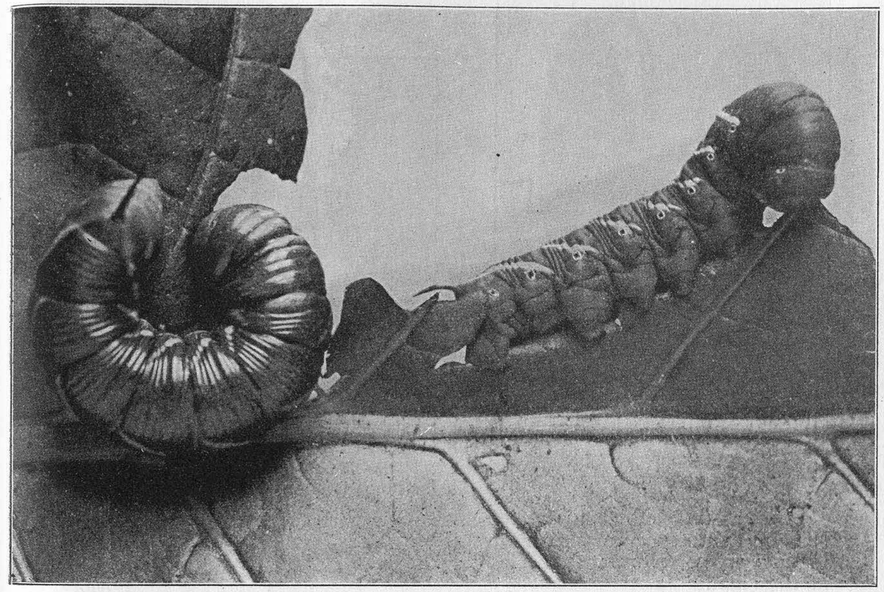


FIG. 20.—Tobacco worms. Natural size.

21. There are two species in Connecticut, the northern tobacco or tomato worm, *Phlegethontius quinquemaculata* Haworth, and the southern tobacco or tomato worm, *Phlegethontius sexta* Johansen. The pupa of the northern species has the longer "jug-handle," and both are shown in Figure 21. The northern species is the more common in the tobacco fields north of Hartford, though the southern species is more common in the vicinity of New Haven. Horn worms are highly parasitized by small four-winged wasp-like insects and it is not unusual to find them covered with white cocoons as shown in Figure 22. In such cases the horn worm dies without transforming, but never before the crop of parasites has been brought through to maturity. It is uncertain whether more than one generation occurs in Connecticut, but if so, the second is not distinct from the first, and larvae of all sizes are often found in the field at the same time late in the

season. The adult moths have large heavy bodies with long narrow wings which expand between four and five inches as shown in Figure 23. They fly just at dusk, lay eggs singly on the tobacco plants and sip nectar from deep throated flowers by means

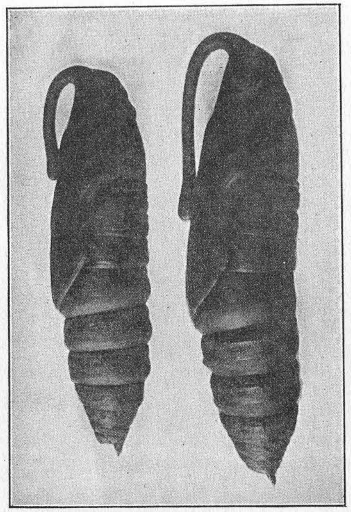


FIG. 21.—Pupae of both species showing difference in length of tongue cases. Northern species at the right.

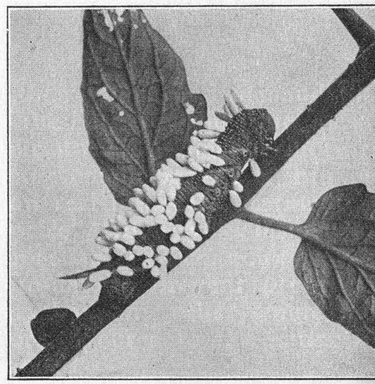


FIG. 22.—Young tobacco worm bearing cocoons of parasite.

of the long tongue which is coiled up like a watch spring under the head.

Hand picking is the common remedy in Connecticut, but in southern tobacco fields spraying and dusting with lead arsenate is commonly practiced.

GRASSHOPPERS.

Grasshoppers caused some damage to tobacco in 1925 by eating large holes in the leaves. They were especially prevalent along the margins of the fields which were adjacent to grass or other vegetation, upon which they feed. They were not of sufficient importance to warrant special control measures.

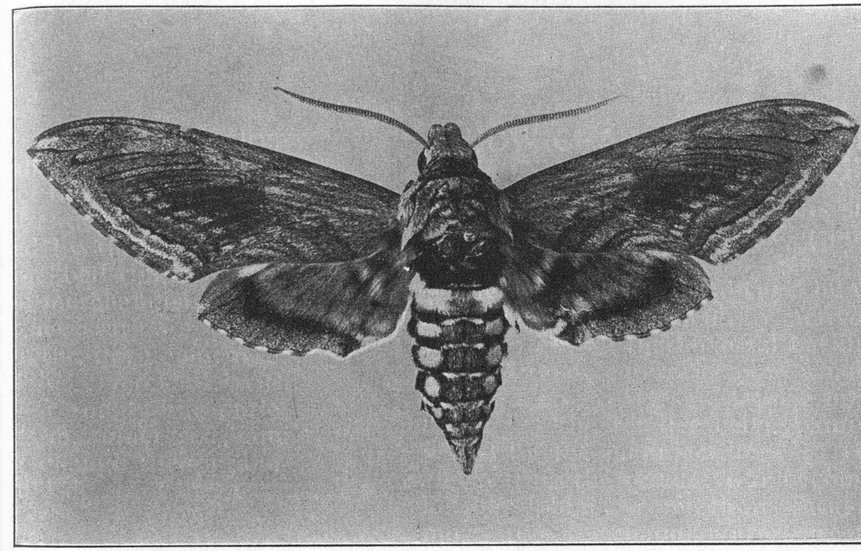


FIG. 23.—Moth of Northern tobacco worm *Phlegethontius quinquemaculata* Haw.

Bulletins

OF

Immediate Information

Numbers 51 to 54

Bulletin of Immediate Information No. 51 | October 1, 1925

Connecticut Agricultural Experiment Station

New Haven, Connecticut

REGULATIONS CONCERNING THE TRANSPORTATION OF NURSERY STOCK IN THE UNITED STATES AND CANADA

Compiled by W. E. Britton, State Entomologist.

At the present time nearly every State in the Union has laws or regulations in regard to the inspection, certification and transportation of nursery stock. These all have one object in view, namely, the control of plant pests. But conditions are not uniform throughout the United States, and each State has established such requirements as seem to give it the best protection, with the result that there are many different regulations.

This situation assumes a serious aspect to the nurseryman who may wish to fill orders received from eighteen or twenty or more different States. In order to tabulate and bring together these varying regulations in convenient form for the use of Connecticut nurserymen, this bulletin has been prepared. It should be understood that it presents only a brief digest in each case, and if any points are not clear, the nurseryman should write to the officer in charge of inspection in that State, for more information.

In addition to the various State laws and regulations, there are several Federal quarantines regulating the shipment of nursery stock. A digest of these has been included in this bulletin, together with the regulations of the District of Columbia and of the Dominion of Canada.

Federal Quarantines

The following Federal Quarantines concern the shipment of nursery stock:

White Pine Blister Rust: Quarantine No. 26, as amended, prohibits the interstate movement of all five-leaved pines, currant and gooseberry plants from all States east of and including Minnesota, Iowa, Missouri, Arkansas and Louisiana, to points west of this area; also prohibits the interstate shipment of five-leaved pines and black currant plants from the New England States and New York to points outside this area; further prohibits the shipment of five-leaved pines and black currant plants from the New England States into New York. Quarantine No. 54 as amended prohibits the movement of five-leaved pines, currant and gooseberry plants, from the State of Washington.

Black Stem Rust of Grains: Quarantine No. 38, as amended, prohibits the interstate movement of the common species of barberry and their horticultural varieties, except the Japanese barberry; also *Mahonia* from about three-fourths of the States.

European Corn Borer: Quarantine No. 43 (third revision, as amended) provides that the stalks of common host plants of the European corn borer (which include some herbaceous perennials) cannot be shipped interstate outside of the infested areas unless inspected and provided with a Federal certificate.

Gipsy Moth and Brown-Tail Moth: Quarantine No. 45, as amended, regulates the interstate shipment of all nursery stock, forest products, stone and quarry products from the infested area in the New England States, and from the generally infested to the lightly infested areas within those States. Nursery stock must be inspected and certified by Federal inspectors.

Japanese Beetle: Quarantine No. 48, as revised, regulates the interstate shipment of all nursery stock out of the infested area which includes certain portions of the States of New Jersey, Pennsylvania and Delaware. Such stock can be shipped only after it has been examined and certified by Federal inspectors.

Satin Moth: Quarantine No. 53, as amended, prohibits the interstate shipment from the infested areas in Massachusetts and New Hampshire of all species and varieties of willow and poplar.

For further information regarding Federal quarantines and regulations address: Federal Horticultural Board, U. S. Department of Agriculture, Washington, D. C.

District of Columbia

Each package of nursery stock entering the District must bear a valid certificate of inspection, must be marked "plants," with name and address of both consignor and consignee. No package shall be delivered to the consignee until authorized by the inspector of the Federal Horticultural Board.

Federal quarantines prohibit the entry of all five-leaved pines and *Ribes* grown in the New England States, and the States of New York and Washington.

Federal Horticultural Board, Washington, D. C.

Dominion of Canada

Nursery stock from the United States can enter Canada only after a permit has been secured from the Secretary, Destructive Insect and Pest Act Advisory Board, Ottawa, Can. Applications must specify kind, quantity, value, source and destination of stock, with name and address of consignee and the customs port. All shipments must bear certificates of inspection, and where required, similar certificates of fumigation. Unless these certificates are attached, the shipments will not be released by the Collector of Customs. Plants exempt from fumigation requirements include greenhouse plants, roses grown under glass (up to three inches), herbaceous plants, strawberry plants, blackberry plants, grape vines, conifers, bulbs and corms, if accompanied by the consignor's certificate regarding contents of shipment. Fruit and nut scions are exempt only when forwarded under official labels requiring their reinspection at Montreal or Vancouver.

Quarantines prohibit the entrance of conifers and decorative plants (such as holly and laurel), and Christmas greens from New England: all five-leaved pines, chestnuts and chinquapin, all species of currants and gooseberries, European buckthorn and all varieties of *Berberis vulgaris*, all varieties of *Corylus* in British Columbia, all peach stock and fresh peaches from the States of Wisconsin, Illinois, Missouri, Arkansas, Mississippi and eastward to the Atlantic Ocean.

Arthur Gibson, Chairman; L. S. McLaine, Secretary, Destructive Insect and Pest Act Advisory Board, Department of Agriculture, Ottawa, Canada.

Postal Regulations Regarding Nursery Stock Shipped by Parcel Post

The U. S. Postal Laws and Regulations, Section 467, paragraph 2, governing the mailing of plants and plant products, reads as follows:

"Nursery stock, including all field-grown florists' stock, trees, shrubs, vines, cuttings, grafts, scions, buds, fruit pits and other seeds of fruit and ornamental trees or shrubs, and other plants and plant products for propagation, except field, vegetable and flower seeds, bedding plants and other herbaceous plants, bulbs and roots, may be admitted to the mails only when accompanied with a certificate from a State or Government inspector to the effect that the nursery or premises from which such nursery stock is shipped has been inspected within a year and found free from injurious insects, and plant diseases, and the parcel containing such nursery stock is plainly marked to show the nature of the contents and the name and address of the sender."

State Regulations

FILING OF CERTIFICATES IN OTHER STATES

In order to ship nursery stock into the following States, it is necessary to file duplicate inspection certificates:

Alabama	Michigan	Oklahoma
Arkansas	Minnesota	Oregon
Connecticut	Mississippi	Pennsylvania
Florida	Missouri	South Carolina
Georgia	Montana	South Dakota
Illinois	New York	Tennessee
Indiana	New Mexico	Texas
Iowa	North Carolina	Utah
Louisiana	North Dakota	Virginia
Maryland	Ohio	Wisconsin
Massachusetts		Wyoming

Though not absolutely required by law, certificates may be filed in the following States:

Kansas	Kentucky	Nebraska

FILING OF BONDS

Bonds are required in the following States:

Arkansas	$1,000.00	Montana	$1,000.00	Oregon	$1,000.00
Georgia	1,000.00	North Dakota	500.00	Utah	500.00
Idaho	5,000.00	Ohio	1,000.00	Washington	1,000.00
Michigan	1,000.00	Oklahoma	1,000.00	Wyoming	500.00

Tennessee requires a bond of $5,000.00 where trees are planted by outside nurserymen under contract to prune and spray for a period of years.

PAYMENT OF FEES

The payment of fees is required for registration in certain States, as follows:

State	Registration Fee	Agent's Fee	State	Registration Fee	Agent's Fee
Alabama	$10.00	$1.00	Oklahoma	$5.00	
	(Dealer's)—10.00		Oregon	10.00	$1.00
Arkansas	5.00	1.00	South Dakota	1.00	1.00
Georgia	5.00	1.00	Tennessee (Dealer's)		5.00
Idaho	10.00	1.00			1.00
Indiana	1.00	1.00	Texas	5.00	
Maine	5.00		Virginia	5.00	1.00
Michigan	5.00		Washington	5.00	1.00
Montana	25.00*		West Virginia	20.00	
North Dakota	10.00		Wyoming	15.00	
Ohio	5.00	1.00			

* Covering all Montana agents. Agents for unlicensed nurseries must pay annual fee of $10.00 and file bond of $1,000.00. Inspection fees $10.00 per car lot, smaller lots in proportion. Unlicensed nurseries, 10 per cent. of invoice price, with minimum of 50 cents per package.

FUMIGATION

All deciduous nursery stock subject to the attack of San José scale must be fumigated with hydrocyanic acid gas and labeled with a certificate or affidavit stating that this has been done before it will be allowed to enter the following States:

Colorado	Michigan	North Carolina
Delaware	Mississippi	Tennessee
Florida		Utah

STATE TAGS

State tags are required and will be furnished at the shipper's expense, by the following States:

Alabama	Louisiana	Virginia
Arkansas	Mississippi	West Virginia
Florida	North Carolina	Wyoming
	South Carolina	

Requirements of Various States.

Alabama: Nurserymen in other States wishing to ship stock into Alabama must obtain an Alabama license by filing a signed copy of inspection certificate, with fee of $10.00. Each package of nursery stock entering the State must bear an Alabama tag which is furnished at cost. Dealers must register, file list of all nurseries from which they purchase stock, pay fee of $10.00, and obtain a dealer's certificate. An agent's certificate (cost $1.00) must be obtained through the principal for each agent selling nursery stock in Alabama. Nursery stock infested with San José scale, new peach scale, woolly aphis, brown-tail moth, gipsy moth, crown gall, black knot, citrus canker, peach yellows, pear blight, apple blotch, root nematode, peach borer, grape phylloxera or nut grass, must not be sold in Alabama.

B. P. Livingston, Chief, Division of Plant Industry, Montgomery, Ala.

Arizona: All nursery stock and plant products entering Arizona through the U. S. mails or transported in any manner shall be prominently labeled, showing (a) name and address of consignor; (b) name and address of consignee; (c) certificate of inspection; (d) locality where grown, and (e) contents of shipment. Common carriers shall not deliver to consignee any shipment of nursery stock or plant products until inspected by the State Entomologist or his agent and a certificate of release issued in each case to the common carrier and to the consignee. Postmasters are required to forward all parcels of nursery stock or plant products to the nearest Post Office Inspection Station, and cannot forward from these stations to point of destination any parcel of nursery stock or plant products unless accompanied by an inspected plant shipment tag.

Quarantines: Olive nursery stock and olive root cuttings from all other States and foreign countries are prohibited. Peach, nectarine or apricot trees or cuttings, grafts, scions, buds or pits, or trees budded or grafted upon peach stock from Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, Ohio, Indiana, Michigan, Illinois, West Virginia, Tennessee, North Carolina, Arkansas, Nevada, Florida, and Ontario, Can., and any other section in which peach yellows or rosette are known to exist are also prohibited.

O. C. Bartlett, State Entomologist, Box 348, Phoenix, Ariz.

Arkansas: In order to ship nursery stock into Arkansas, it is necessary (1) to file a nursery inspection certificate, pay a fee of $1.00 and secure a permit-certificate, and (2) every shipment into the State must bear a copy of the permit-certificate with chief inspector's facsimile signature, and tags must be purchased of the chief inspector.

Out-of-state nurserymen having agents or representatives soliciting orders, or doing other nursery business in Arkansas must (1) file a bond of $1,000.00, (2) pay $5.00 for a license to do business in the State, and (3) pay $1.00 for a license for each agent in the State.

Quarantines prohibit entrance of chestnut trees from all States east of the Mississippi River.

George G. Becker, Chief Inspector, Little Rock, Ark.

California: All shipments of nursery stock, plants, seeds, etc., into California, must be conspicuously marked with name and address of both consignor and consignee and declaration of contents and origin. All stock entering the State held until inspected.

Peach, nectarine or apricot trees or cuttings, grafts, scions, buds or pits of such trees, or any trees budded or grafted upon peach stock or roots from districts where contagious peach rosette is known to exist are refused entry and will be destroyed or returned to point of shipment at option of consignor and at his expense. The States known to be infected with this disease are as follows: Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Pennsylvania, West Virginia, Virginia, North Carolina, Tennessee, Kentucky, Mississippi, Ohio, Michigan, Indiana, Illinois, Arkansas, Nevada, Florida, and the Province of Ontario, Canada.

Quarantine order No. 36 prohibits entry of all five-leaved pines, currant and gooseberry plants from all States and districts east of and including Minnesota, Iowa, Missouri, Arkansas and Louisiana, and from the State of Washington. Quarantine order No. 38 prohibits entry of all trees, plants, grafts, cuttings or scions of all species and varieties of the cultivated filbert or hazelnut and American wild hazel (*Corylus americana*) from all States and districts east of and including Wyoming, Colorado and New Mexico. Quarantine order No. 43 prohibits entry of citrus trees and citrus fruits. Quarantine order No. 44 prohibits all chestnut and chinquapin (Castanea sp. and Castanopsis sp.) trees from all states east of east line of Idaho, Utah and Arizona. Pecan trees, hickory and Japanese walnut trees are prohibited from all states.

A. C. Fleury, Supervising Quarantine Officer, Sacramento, California.

Colorado: Each package of nursery stock entering the State must bear a certificate of inspection signed by a duly authorized inspector in the State from which it was shipped, and a certificate of fumigation signed either by an inspector or by the shipper of the nursery stock. On arrival, shipments are turned over to the County Inspector who in turn, if they pass inspection, releases them to the consignee.

Quarantines prohibit the entrance of the common barberry, white pines, currants and gooseberries, the potato tuber moth and alfalfa weevil.

C. P. Gillette, State Entomologist, Fort Collins, Colo.

Connecticut: Nurseries are inspected annually and nurserymen and dealers must register: nurserymen receive registration and inspection certificates and dealers receive permits. Out-of-state nurserymen must make application and file signed copies of their valid inspection certificates and receive permits before shipping stock into the State. All stock entering the State must be accompanied by both certificate and permit, and all stock transported within the States must be accompanied by either a certificate or by a permit, and transportation companies are subject to prosecution for accepting shipments without valid certificates or permits. Nursery stock imported from foreign countries must be held unopened until inspector arrives. Have authority to inspect any stock at destination.

Quarantine prohibits the shipment of all nursery stock and forest products, unless inspected and certified, from the gipsy moth infested area to the area uninfested.

W. E. Britton, State Entomologist, New Haven, Conn.

Delaware: Shipments of nursery stock entering the State must each bear a certificate of inspection and also a certificate stating that the stock has been properly fumigated. All shipments not provided with proper certificates will be held by the transportation companies until inspected.

Quarantines exclude all five-leaved pines and all species of *Ribes* from Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, Minnesota, Wisconsin, Ohio and Michigan.

Ralph C. Wilson, Secretary, State Board of Agriculture, Dover, Delaware.

Florida: In order to ship nursery stock into Florida, duplicate inspection certificates must be filed in Florida and permit-certificate tags obtained which, together with valid inspection certificates issued in the States where the stock was grown, must accompany each box, bundle or package. All host plants of San José scale must be fumigated with hydrocyanic acid gas of standard strength, immediately before shipment to a Florida point. Shipments of plants infected with nematode root knot, crown gall, hairy root or any insect pest or disease or markings thereof are excluded. Club orders entering Florida must have a Florida permit-tag attached to each individual order. When using a Florida permit-tag, the nurseryman must at once mail to the nursery inspector (Gainesville, Fla.) a duplicate invoice showing name and address of both consignor and consignee, itemized list of plants in shipment and serial number of Florida permit-tag used on it. All certificates on expiration and all mutilated, spoiled or unused permit-tags must be returned to the nursery inspector.

Shipments of stock liable to carry European corn borer, Japanese beetle, gipsy moth and brown-tail moth from areas under Federal quarantine for these pests will be admitted in Florida when accompanied by Federal inspection certificates, but are also subject to inspection by Florida authorities.

J. C. Goodwin, Nursery Inspector, State Plant Board, Gainesville, Fla.

Georgia: Each nurseryman, dealer, agent, salesman or solicitor must apply to the State Board of Entomology, giving (1) the name and location of the nursery, and (2) the approximate acreage and kinds of stock grown, and receive from the Board a license: annual fee for nurserymen and dealers $5.00: annual fee for each agent, salesman or solicitor $1.00. Where a sale amounts to $100.00 or over, a duplicate of the complete invoice (without price) must be filed with the State Board of Entomology, within thirty days of shipment, with the name and address of the salesman and of the purchaser, and name and quality of all nursery stock sold in the State or for delivery in the State.

All nurserymen, corporations, firms or individuals selling or offering to sell nursery stock in Georgia must file with the Board of Entomology, and maintain for three years, a bond of $1,000.00 made out to the Secretary of the Georgia State Board of Entomology.

Quarantines prohibit shipment into the State of all five-leaved pines, currants and gooseberries; all varieties of chestnut and chinquapin nursery stock, grafts, scions or nuts for propagation from infested States; and from all States infested with the Oriental peach moth, all trees, nursery stock, fruit, twigs, cuttings, scions and other parts of peach, apple, plum, quince, cherry and all other host plants of this insect, except apple fruit; all nursery stock from sections of states where Japanese camphor scale is present. Shipments of plants from areas infested by the Japanese beetle, European corn borer, gipsy moth and brown-tail moth admitted only in strict accordance with the requirements of the Federal quarantine.

Ira W. Williams, State Entomologist, State Board of Entomology, Atlanta, Ga.

Idaho: No person, firm or corporation shall import or sell nursery stock by agents within the State without first applying to the Department of Agriculture, filing a bond for $5,000.00 and obtaining an annual license by paying a fee of $10.00. All shipments into the State must show name of shipper, locality where grown, variety of nursery stock and an official certificate of fumigation from the State where the stock was grown. Imported trees are fumigated before distribution, and all nursery stock shipped into the State must be inspected upon arrival at the expense of the consignee. Each nursery firm doing business in the State must annually pay an additional $1.00 for each agent. Duplicate certificates should be filed.

State quarantines exclude the entrance of all five-leaved pines, currants, gooseberries, peach, nectarine, prune, almond or other trees worked on peach stock and all pits, cuttings, buds or scions grown in a district where peach yellows or other detrimental diseases exist. There are special quarantines against the potato tuber moth and the alfalfa weevil.

M. L. Dean, Director, Bureau of Plant Industry, Boise, Idaho.

Illinois: Before shipping nursery stock into Illinois, a signed duplicate copy of the certificate of inspection must be filed with the Division of Plant Industry. Nurseries and dealers employing salesmen must file in the office of the Chief Inspector a complete list of such salesman representing them within the State, and apply, after July 1, for an agent's permit for each salesman employed in the State. All nursery stock entering the State must bear a valid certificate of inspection, names and addresses of consignor and consignee, nature of stock and place where grown. If stock arrives without such certificate it must be reported immediately to the Division of Plant Industry, and held until released.

Quarantine orders exclude from the New England States all five-leaved pines, all species and varieties of currants and gooseberries; common barberry (*Berberis vulgaris*) and all its horticultural varieties, and all species of *Castanea*. Stock shipped into Illinois in violation of quarantines is destroyed or returned to the consignor at the discretion of the owner.

P. A. Glenn, Chief Inspector, Division of Plant Industry, Urbana, Illinois.

Indiana: Nursery stock entering or shipped within the State must bear an official inspection certificate, and give the names of both the consignor and the consignee. All out-of-state nurseries must file with the State Entomologist a copy of their valid inspection certificate, pay $1.00, and obtain a license good for one year from date of issue, before shipping stock into the State. Each dealer and agent selling or soliciting sales of nursery stock in Indiana must pay $1.00, and obtain a license from the State Entomologist. All foreign grown stock must be inspected at destination.

Frank N. Wallace, State Entomologist, Department of Conservation, Indianapolis, Ind.

Iowa: Copy of inspection certificate must be filed with and approved by the State Entomologist, and must accompany each shipment into the State.

Quarantine against European corn borer prohibits all the usual host plants entering the State from the infested areas in Massachusetts, New Hampshire, New York, Pennsylvania, Ohio and Michigan.

Carl J. Drake, State Entomologist, Ames, Iowa.

Kansas: Nurseries are inspected annually and all certificates and dealer's permits lapse on June 1, following date of issue. Nursery stock may be shipped into the State when accompanied by a recognized certificate of inspection. Duplicate certificates may be filed.

Quarantine prohibits the entrance of five-leaved pines, currants and gooseberries from certain middle and eastern States.

O. F. Whitney, Secretary, Entomological Commission, Topeka, Kans.

Kentucky: Nurseries are inspected annually and each package of nursery stock entering the State must bear a certificate of inspection, list of contents, name of both consignor and consignee. Duplicate certificates may be filed with the State Entomologist.

H. Garman, State Entomologist, Lexington, Ky.

Louisiana: Before shipping nursery stock into Louisiana, application must be made to the Entomologist for permit by filing copy of valid certificate, and order for certificate tags accompanied by money to pay for them (price on application). The Louisiana tag and the inspection certificate of the State where the stock was grown must both accompany each shipment. A duplicate invoice must be filed with the Entomologist once a week, showing the permit number, and the number and varieties of plants shipped.

W. E. Anderson, State Entomologist, Department of Agriculture, Baton Rouge, La.

Maine: All individuals or firms selling or soliciting sales of nursery stock which they have not grown shall annually obtain a license from the State Horticulturist by paying a fee of $5.00. All stock entering the State shall bear on each box or package a valid inspection certificate; such stock may be inspected at destination and if found infested with dangerous pests may be destroyed or returned to the consignor.

Quarantine prohibits entrance of currant or gooseberry plants. Five-leaved pines cannot enter without a permit from the Forest Commissioner.

George A. Yeaton, State Horticulturist, Augusta, Me.

Maryland: Nurseries are inspected twice each year. Nursery stock subject to attack of San José scale must be fumigated before shipment. Shipments entering the State must bear certificates of inspection besides names of consignor and consignee. Duplicate certificate should be filed with State Entomologist.

Quarantines prohibit the shipment of five-leaved pines, currants and gooseberries from New York, the New England States, Pennsylvania, New Jersey, Michigan, Wisconsin, Minnesota and Washington; also into the non-infested counties of Maryland, of any nursery stock of peach or sweet cherry from areas infested with the Oriental peach moth.

Ernest N. Cory, State Entomologist, College Park, Md.

Massachusetts: All growers and agents who sell nursery stock for delivery within the State must have a grower's certificate or an agent's license, and a copy of such certificate or license must accompany each car, box or package of stock shipped or delivered. Agents must apply to Director, Division of Plant Pest Control, Boston, Mass., and file list of nursery firms from which they purchase stock before receiving agent's license. Authority is granted to inspect at destination all stock entering the State, and if found infested may be destroyed, treated, or returned to the consignor at his expense.

Quarantines prohibit *Ribes* from entering the State except under permit.

R. H. Allen, Director, Division of Plant Pest Control, Boston, Mass.

Michigan: Shipments of nursery stock entering the State must bear on each package a valid certificate of inspection, together with statement of contents and names of consignor and consignee; also if stock consists of species subject to attack of San José scale, it must have been fumigated with hydrocyanic gas and bear a certificate to that effect. Nurserymen of other States who employ agents to sell nursery stock in Michigan, must first file a bond of $1,000, pay a fee of $5.00, and obtain a license. Duplicate certificates must be filed before any stock can be shipped into the State.

Quarantines prohibit raspberry plants from entering the State unless they have had two inspections, one prior to July 31, and the other in August or September at least thirty days later; also five-leaved pines and black currants from New York and the New England States, though red and white currants and gooseberries may be shipped from the vicinity of Rochester, Geneva, Fredonia and Newark, New York, provided the white pine blister rust has not been found in the vicinity within two years. Neither barberry in any of its upright forms, nor sweet chestnuts grown east of Ohio, can be shipped into Michigan, and a quarantine against the European corn borer prohibits the entrance from infested localities of the common hosts of that pest, including hardy perennials with stems.

L. R. Taft, Chief Horticulturist, Department of Agriculture, Lansing, Mich.

Minnesota: All nursery stock entering the State must bear valid certificates of inspection and any transportation companies accepting stock not so tagged are liable to prosecution. Outside nurserymen and dealers must file certificates with the State Entomologist before shipping stock into the State.

Quarantines prohibit the entry of all five-leaved pines and black currants from the New England States, New York, New Jersey, Pennsylvania, Ohio, Michigan and Wisconsin; other species of *Ribes* from these States are allowed to enter if stripped of leaves: all barberry except Japanese (*Berberis thunbergii*): the usual host plants of European corn borer.

A. G. Ruggles, State Entomologist, University Farm, St. Paul, Minn.

Mississippi: Outside nurserymen and shippers must file valid inspection certificates and obtain (at cost) permit tags, which together with inspection certificate of State where stock was grown, names and addresses of consignor and consignee, nature and quantity of contents, and locality where grown must be attached to each package. State certificate must also affirm that the nursery is properly equipped for fumigating plants with hydrocyanic acid gas, and the proprietor or manager of the nursery must file an affidavit that all host plants of San José scale will be fumigated immediately before being delivered for shipment into Mississippi.

Agents or salesmen must register with and obtain certificates from the Nursery Inspector before selling, delivering or taking orders for nursery stock in the State.

Plants infected with root knot (caused by nematodes), crown gall, or showing any other evidence of pest infestation, must not be shipped into Mississippi.

All plants capable of defoliation must be defoliated. Soft ornamental plants are classed as nursery stock in Mississippi.

Quarantines provide that nursery stock classed as host plants of the European corn borer and Japanese beetle can be shipped to this State from infested districts only when the shipments are made in conformity with the United States Department of Agriculture regulations and in addition are accompanied by permit tags of the State Plant Board of Mississippi.

Geo. F. Arnold, Nursery Inspector, A. and M. College, Mississippi.

Missouri: Outside nurseries must file necessary papers including certificate and apply for a permit certificate which will be issued with fee. All agents or salesmen must apply for agent's certificate. Each package of nursery stock entering the State must bear the names of both consignor and consignee, statement of contents, and a certificate showing that the stock therein contained has been inspected where grown by a duly authorized inspector and found to be apparently free from dangerously injurious insect pests and plant diseases. Transportation companies are not permitted to deliver nursery stock unless so labeled.

Leonard Haseman, State Entomologist and Chief Inspector, State Plant Board, Columbia, Mo.

Montana: All nursery stock entering the State must be unpacked and inspected at one of the following designated quarantine stations: Billings, Butte, Miles City, Missoula, Sanders or Fairview. All shipments entering the State are subject to inspection with fees as follows: licensed nurseries, car lots $10.00, smaller lots proportionate; unlicensed nurseries, ten per cent of invoice price of shipment with minimum of 50 cents per package. Notice of shipment including list of stock and names of transportation company, consignor and consignee must be sent to the Chief, Division of Horticulture, Missoula, Montana, five days prior to shipment.

Nurserymen are required to pay an annual fee of $25.00 and file a bond of $1,000.00 in favor of the State of Montana; this includes licenses for all Montana agents. Agents for unlicensed nurseries must pay an annual fee of $10.00 and file bonds of $1,000.00.

Quarantines prohibit the entrance of the common barberry from all States, and of all five-leaved pines, currant and gooseberry plants from the States east of and including Minnesota, Iowa, Missouri, Arkansas and Louisiana and all of the State of Washington.

Edward Dickey, Chief, Division of Horticulture, Missoula, Mont.

Nebraska: All nursery stock entering the State shall bear the names of consignor and consignee and an inspection certificate issued since the preceding July 1. It is desired that duplicate certificates be filed.

Quarantine prohibits the entrance of five-leaved pines.

Myron H. Swenk, State Entomologist, University of Nebraska, Lincoln, Neb.

Nevada: All nursery stock entering the State must bear on each car, bale, or package a copy of a valid official inspection certificate, and names of consignor and consignee. Transportation companies shall not deliver nursery stock lacking such certificate.

Quarantine prohibits entry of any pine trees, currant or gooseberry plants or cuttings from east of the Mississippi River or from foreign countries.

Edward Records, State Quarantine Officer, University of Nevada, Reno, Nev.

New Hampshire: All nursery stock entering the State must bear on each container a copy of a valid inspection certificate, or an affidavit showing that susceptible plants have been fumigated.

Quarantines prohibit the entrance of all five-leaved pines, currant and gooseberry plants, except that such pines may be admitted if certified that no pine blister rust is known to occur in the nursery and that all *Ribes* had been removed from within 300 yards of the nursery; also that plants susceptible to attack of the European corn borer, gipsy moth and satin moth from infested regions cannot enter uninfested territory without inspection certificates.

W. C. O'Kane, Deputy Commissioner of Agriculture, Durham, N. H.

New Jersey: Each car or parcel of nursery stock entering the State must bear a copy of a valid inspection certificate, with a statement from the shipper that the contents are a part of the stock inspected and whether or not it had been fumigated with hydrocyanic gas. Transportation companies shall refuse for transportation within the State all nursery stock not accompanied by a certificate of inspection. All such stock entering the State may be inspected wherever found and if infested with dangerous pests, will be destroyed.

Common carriers and New Jersey nurserymen who bring nursery stock into the State shall send notice of each shipment with full data prior to, or within twenty-four hours after, its arrival.

Quarantines prohibit the entrance of five-leaved pines from all States where the pine blister rust occurs.

Harry B. Weiss, Chief, Bureau of Statistics and Inspection, State Department of Agriculture, Trenton, N. J.

New Mexico: Before shipping nursery stock into New Mexico, a duplicate copy of a valid certificate of inspection must be filed and a permit obtained.

Quarantine prohibits the entrance of *Ribes*.

H. L. Kent, President, Agricultural College, State College, N. Mex.

New York: Nursery stock cannot enter the State or be moved within the State unless a valid certificate is attached issued by the New York State Department of Farms and Markets or by the State in which the shipment originated. Transportation companies and all persons bringing nursery stock into the State must send notice to the Department of Farms and Markets. Blanks will be furnished for such notices. An exact copy of the certificate must be attached to each package sent by mail. Stock received from abroad or from other States must not be unpacked or distributed until after inspection and release by Department of Farms and Markets.

Quarantines prohibit the entrance of five-leaved pine trees from New England, New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin and Minnesota; also of Christmas trees and woody greens from New England, except from those areas lightly or not infested by gipsy moth and then only under certificates of inspection; of raspberry plants unless apparently free from mosaic diseases and are so certified after two inspections and the removal of all diseased plants, as is practiced in New York State; other regulations concern the European corn borer, and the usual host plants can be transported from within to without the infested areas only after being inspected and certified; currants and gooseberries cannot be grown in certain pine-growing areas of the State.

George G. Atwood, Director, Bureau of Plant Industry, Department of Farms and Markets, Albany, N. Y.

North Carolina: Nursery stock can enter the State only when shipments bear North Carolina official permit tags, which will be supplied at cost on request, and the filing of a duplicate inspection certificate accompanied by an affidavit that all fruit stock will be fumigated.

Quarantines prohibit the entrance of five-leaved pines and *Ribes* from Canada, the New England States, New York, New Jersey, Pennsylvania, Ohio, Wisconsin, Minnesota and Washington.

W. V. Reed, Inspector, State Department of Agriculture, Raleigh, N. C.

North Dakota: Nursery stock entering the State must bear inspection certificates. Every person employing agents or salesmen or who solicits for the sale of nursery stock, must obtain a license by paying a fee of $10.00, filing a duplicate inspection certificate, and a $500.00 bond. License is good for one year.

Director, North Dakota Experiment Station, Agricultural College, N. D.

Ohio: Out-of-state nurserymen must file copies of their inspection certificates and obtain an Ohio certificate permitting them to solicit orders for nursery stock. Each dealer within or without the State shall obtain annually a dealer's certificate, by furnishing an affidavit that he will buy and sell only inspected stock and will maintain with the Secretary of Agriculture a list of all sources from which he obtains nursery stock. Each affidavit shall be accompanied by a fee of $5.00. All agents soliciting orders for nursery stock shall file annually a statement that he will sell only inspected stock, and pay a fee of $1.00. He shall carry an agents' certificate and a copy of the certificate held by his principal.

Each shipment entering the State shall be accompanied by a tag or poster giving an exact copy of the valid certificate. Altered certificates are prohibited.

Quarantines prohibit the entrance or shipment within the State of the common barberry and its horticultural varieties, and the common host plants of the European corn borer.

Richard Faxon, Chief, Division of Plant Industry, Department of Agriculture, Columbus, Ohio.

Oklahoma: Nursery stock entering the State must bear on each package of each shipment an inspection certificate. Nurserymen must each file a duplicate copy of his valid inspection certificate, and furnish a surety bond of $1,000.00 in favor of the State Board of Agriculture. A permit will be issued on payment of the fee of $5.00, and a copy of this permit must be attached to all shipments entering the State of Oklahoma.

All dealers within or outside the State must attach to each package of each shipment a copy of the dealer's certificate issued to them by the Board of Agriculture.

Thomas B. Gordon, State Nursery Inspector, Oklahoma City, Okla.

Oregon: The unlicensed sale or distribution of nursery stock is unlawful. The applicant must pay a fee and furnish a bond. The fee for a nurseryman, dealer or importer is $10.00, and for any agent, solicitor or salesman, $1.00. The bond shall be for $1,000.00 and shall be conditional that all stock delivered shall be true to name.

Quarantines prohibit the entry of all five-leaved pines and all species and varieties of currants and gooseberries from States east of the Mississippi River and from the State of Washington; of all hazel and filbert nursery stock from all territory east of the Province of Alberta, Canada, and the States of Idaho, Utah and Arizona; grape vines and cuttings from most of the eastern States and portions of California; cranberry nursery stock from the New England States, New York, New Jersey and Pennsylvania.

Chas. A. Cole, Secretary, State Board of Horticulture, Portland, Ore.

Pennsylvania: Nurserymen from outside the State must file duplicate copies of their valid inspection certificates, each certified by the State official in charge, and each non-resident nurseryman must supply a statement giving the exact acreage which he is growing in nursery stock and the acreage which is being grown for him under contract. Then a Pennsylvania certificate must be obtained before shipping stock into the State. Dealers are granted certificates on application and receipt of a statement from each that he will buy stock only from nurseries holding valid certificates of inspection. Agents soliciting for the sale of nursery stock in the State must obtain and carry agents' duplicate certificates. All shipments of nursery stock entering the State will be rejected unless accompanied by certificates of inspection.

Quarantines prohibit the entrance of chestnut trees, black currants, five-leaved pines, all barberry plants except Japanese barberry, and shipments of Christmas trees or woody greenery from the gipsy moth district of New England.

C. H. Hadley, Director, Bureau of Plant Industry, Harrisburg, Pa.

Rhode Island: All stock entering the State must bear a valid official certificate of inspection, but is subject to further inspection and may be destroyed or returned to the consignor if found infested. Agents must obtain agent's licenses, on stating where they expect to purchase their stock.

Five-leaved pines and *Ribes* can be shipped into the State or planted in certain parts of the State only on permission.

A. E. Stene, State Entomologist, State House, Providence, R. I.

South Carolina: Each package of nursery stock entering the State must bear a permit tag of the South Carolina State Crop Pest Commission, which may be obtained at cost by filing a duplicate certification of inspection and fumigation.

Quarantines prohibit the entrance of chestnut plants or cuttings, five-leaved pines, currants, gooseberries and all host plants of the European corn borer.

South Carolina State Crop Pest Commission, Clemson College, S. C.

South Dakota: Out-of-state dealers may obtain certificates permitting them to solicit and fill orders in the State, by filing with the Secretary of Agriculture a certified copy of their official inspection certificates and by paying a fee of $1.00 each. All agents shall likewise obtain and carry agents' certificates bearing copies of the certificates held by their principals, and paying fees of $1.00 each.

Quarantines prohibit the entrance of all five-leaved pines and *Ribes;* of all poplars and willows from areas infested by the satin moth; all host plants of the European corn borer.

B. F. Myers, Secretary of Agriculture, Pierre, S. D.

Tennessee: Out-of-state nurseries must file duplicate inspection certificates and the following agreement regarding fumigation:

> "We, the undersigned, agree to fumigate with hydrocyanic acid gas, according to the required strength, all nursery stock subject to attack from San José scale and other dangerous insect pests. We also agree to attach a fumigation tag to each and every shipment going into the State of Tennessee."

Every shipment must bear a valid inspection certificate and a fumigation tag, and failure to comply with these requirements subjects the stock to confiscation.

Nursery agents and dealers must file sworn statements on official Tennessee blanks which will be supplied. Each agent operating in Tennessee must pay a license fee of $1.00 and each dealer or jobber must pay $5.00.

Nurserymen selling trees under contract to prune and spray the same for a period of years are required to take out a bond of $5,000.00 before selling trees under such special contract.

State quarantines prohibit the entrance of all five-leaved pines, currants and gooseberries; all varieties of barberry except Japanese barberry; all varieties of chestnut and chinquapin from all States where chestnut blight occurs. Other restrictions apply to Japanese beetle, European corn borer, gipsy moth, sweet potato weevil and pink bollworm of cotton. Peach and pecan seedlings are allowed entrance only by special permit for experimental purposes.

G. M. Bentley, State Entomologist and Plant Pathologist, Knoxville, Tenn.

Texas: Nurserymen, florists and other shippers of nursery stock desiring to do business in Texas, must file with the Texas State Department of Agriculture a certified copy of certificate of inspection from the State Inspector of the State in which the shipment originates, and also in addition to this, a fee of $5.00 is required which must be remitted in post-office money order, cashier's check, or bank draft. This permit is good for one year, expiring on August 31 of each year.

All shipments of nursery and floral stock originating outside of the State must bear shipping tags showing the exact copy of certificate of inspection from the State Inspector of the State in which the shipment originated, and in addition thereto must have a tag showing the exact copy of permit from Texas. These tags the shipper must have printed.

Texas freight and express companies are prohibited from receiving or delivering all shipments which do not bear proper tags, showing copies of necessary permits.

Nurserymen and florists of all States who ship nursery and floral stock into Texas, are requested to file with the Department of Agriculture a copy of invoice or memorandum of each and every shipment of stock made into the State, giving the date, consignor, consignee and a list of stock shipped. The price need not be given.

Those intending to ship orange and citrus seed of all kinds into Texas must furnish the Texas Department with a certified statement from their State Plant Board, that the seed was gathered from citrus-canker-free territory, and also an affidavit that the seeds to be shipped were treated in a corrosive sublimate solution of a strength of 1-1000.

Agents or dealers operating in Texas for nurserymen and florists outside of the State must procure proper credentials as agents from the nurserymen they represent. The form for this credential approved by the Commission of Agriculture is furnished free of charge. Each agent or dealer must be prepared to present such credential at all times.

Dealers are classed as nurserymen and are required to take out a permit. Greenhouses and greenhouse plants are included for inspection by the Texas laws and all State Inspectors should advise their nurserymen, florists or owners of greenhouses that they must have a Texas certificate before they can make shipments into the State of Texas.

G. J. Scholl, Chief Nursery Inspector, Department of Agriculture, Austin, Texas.

Utah: Out-of-state nurserymen must file with Board of Agriculture a valid official inspection certificate, and names of their agents in Utah, and obtain (without fee) an annual license; file a bond for $500.00 that they will comply with the law and to cover cost of inspection, fumigation, or destruction of stock shipped into the State or sold by their agents. Agents and salesmen representing out-of-state firms must carry proper credentials.

All nursery stock entering the State must bear a valid official inspection certificate and an official certificate that the shipment has been given a cyanide fumigation for 45 minutes at the rate of one ounce to each 100 cubic feet of enclosed space. Also a notice of each shipment giving duplicate invoice, list of contents, date, and names of both consignor and consignee must be mailed

to the State Agricultural Inspector. Any out-of-state shipment not bearing the proper license and certificate tags will be placed in quarantine and inspected and disinfected at the owner's expense.

H. J. Webb, State Agricultural Inspector, State Board of Agriculture, Salt Lake City, Utah.

Vermont: All nursery stock entering the State must bear valid official inspection certificates and the names and post office addresses of both consignor and consignee.

Quarantines restrict the free movement of raspberry plants on account of mosaic, leaf roll and rosette, hosts of the European corn borer, and all uninspected and non-nursery grown trees and forest products on account of the gipsy and brown-tail moths.

M. B. Cummings, State Nursery Inspector, Burlington, Vt.

Virginia: All nurseries must file valid inspection certificates, pay fee of $10.00 (checks must be certified and made payable to the Treasurer of Virginia) and obtain a certificate of registration; duplicates for agents' use $1.00 each. State tags will be furnished at cost and one must accompany each package of stock entering the State or sold within the State.

W. J. Schoene, State Entomologist, Blacksburg, Va.

Washington: No person shall sell, solicit sales, or distribute nursery stock, except berry plants, without first obtaining a license ($5.00 for nurserymen and tree dealers, $1.00 for agents). Nurserymen and dealers must file a bond of $1,000.00 for compliance with the law that the stock be true to name. All licenses expire July 1st. The State is divided into eleven horticultural districts, with an inspector-at-large in charge of each district. Notice of nursery stock entering Washington must be sent to the inspector-at-large into whose district the shipment is made, and a duplicate notice sent to the Department of Agriculture, Olympia, Wash.

J. I. Griner, Supervisor of Horticulture, Olympia, Washington.

West Virginia: All nursery stock entering the State must bear a valid certificate of inspection and a West Virginia permit tag. No nursery stock shall be sold, offered for sale or delivered, without first obtaining from the Commissioner of Agriculture, a certificate of registration, annual fee $20.00.

Quarantines prohibit the entrance of all five-leaved pines, and all species and varieties of gooseberries.

W. E. Rumsey, State Entomologist, Morgantown, W. Va.

Wisconsin: Each out-of-state nurseryman must file valid certificate of inspection and obtain State license before shipping stock into the State. Each car, or package, must bear certificate tags. Each agent selling nursery stock in the State must carry an agent's duplicate certificate bearing the same number and date as that of his principal. No fees are charged.

Quarantines prohibit entrance of all five-leaved pines and all barberry bushes (except Japanese barberry) and host plants of European corn borer from infested areas; also nursery stock from gipsy moth infested areas except under Federal Certificate.

S. B. Fracker, State Entomologist, Madison, Wis.

Wyoming: Each out-of-state nurseryman must file valid certificate of inspection and deposit fee of $15.00 and receive license good until the following July 1st. Authorized shipping tags are furnished at cost, and carriers are forbidden to deliver unless each shipment bears such a tag.

Quarantines prohibit entrance of all five-leaved pines, currants and gooseberries.

C. L. Corkins, State Entomologist, Laramie, Wyoming.

OFFICERS IN CHARGE OF INSPECTION AND QUARANTINE SERVICE

Alabama ....B. P. Livingston, Chief, Division of Plant Industry, Auburn, Ala.
Arizona ....O. C. Bartlett, State Entomologist, Phoenix, Ariz.
Arkansas ....Geo. G. Becker, Chief Inspector, Little Rock, Ark.
California ....A. C. Fleury, Supervising Quarantine Officer, Sacramento, Cal.
Colorado ....C. P. Gillette, State Entomologist, Fort Collins, Colo.
Connecticut .....W. E. Britton, State Entomologist, New Haven, Conn.
Delaware ....Ralph C. Wilson, Secretary, State Board of Agriculture, Dover, Del.
Florida ....J. C. Goodwin, Nursery Inspector, State Plant Board, Gainesville, Fla.
Georgia ....Ira W. Williams, State Entomologist; Jeff Chaffin, Chief Inspector, State Board of Entomology, Atlanta, Ga.
Idaho ....M. L. Dean, Director, Bureau of Plant Industry, Boise, Idaho.
Illinois ....P. A. Glenn, Chief Inspector, Division of Plant Industry, Urbana, Ill.
Indiana ....Frank N. Wallace, State Entomologist, Indianapolis, Ind.
Iowa ....Carl J. Drake, State Entomologist, Ames, Iowa.
Kansas ....O. F. Whitney, Secretary, Entomological Commission, Topeka, Kans.
Kentucky ....H. Garman, State Entomologist, Lexington, Ky.
Louisiana ....W. E. Anderson, State Entomologist, Baton Rouge, La.
Maine ....Geo. A. Yeaton, State Horticulturist, Augusta, Me.
Maryland ....E. N. Cory, State Entomologist, College Park, Md.
Massachusetts ...R. H. Allen, State Nursery Inspector, State House, Boston, Mass.
Michigan ....L. R. Taft, Chief Horticulturist, Department of Agriculture, Lansing, Mich.
Minnesota ....A. G. Ruggles, State Entomologist, University Farm, St. Paul, Minn.
Mississippi ......Geo. F. Arnold, Nursery Inspector, Agricultural College, Miss.
Missouri ....Leonard Haseman, State Entomologist and Chief Inspector, State Plant Board, Columbia, Mo.
Montana ....Edward Dickey, Chief, Division of Horticulture, Missoula, Mont.
Nebraska ....Myron H. Swenk, State Entomologist, Lincoln, Neb.
Nevada ....Edward Records, State Quarantine Officer, University of Nevada, Reno, Nev.
New Hampshire..W. C. O'Kane, Deputy Commissioner of Agriculture, Durham, N. H.
New Jersey ......Harry B. Weiss, Chief, Bureau of Statistics and Inspection, State Department of Agriculture, Trenton, N. J.
New Mexico .....H. L. Kent, President, Agricultural College, State College, N. Mex.

New York ....Geo. G. Atwood, Director, Bureau of Plant Industry, Department of Farms and Markets, Albany, N. Y.
North Carolina ..W. V. Reed, Inspector, State Department of Agriculture, Raleigh, N. C.
North Dakota ...Director, Experiment Station, Agricultural College, N. D.
Ohio ....Richard Faxon, Chief, Division of Plant Industry, Department of Agriculture, Columbus, O.
Oklahoma ....Thomas B. Gordon, State Nursery Inspector, Oklahoma City, Okla.
Oregon ....Chas. A. Cole, Secretary, State Board of Horticulture, Portland, Ore.
Pennsylvania ....C. H. Hadley, Director, Bureau of Plant Industry, Harrisburg, Pa.
Rhode Island ....A. E. Stene, State Entomologist, State House, Providence, R. I.
South Carolina ..South Carolina State Crop Pest Commission, Clemson College, S. C.
South Dakota ....B. F. Myers, Secretary of Agriculture, Pierre, S. D.
Tennessee ....G. M. Bentley, State Entomologist and Plant Pathologist, Knoxville, Tenn.
Texas ....G. J. Scholl, Chief Nursery Inspector, Department of Agriculture, Austin, Tex.
Utah ....H. J. Webb, State Agricultural Inspector, State Board of Agriculture, Salt Lake City, Utah.
Vermont ....M. B. Cummings, State Nursery Inspector, Burlington, Vt.
Virginia ....W. J. Schoene, State Entomologist, Blacksburg, Va.
Washington .....J. I. Griner, Supervisor of Horticulture, Olympia, Wash.
West Virginia ...W. E. Rumsey, State Entomologist, Morgantown, W. Va.
Wisconsin ....S. B. Fracker, State Entomologist, Madison, Wis.
Wyoming ....C. L. Corkins, State Entomologist, Laramie, Wyo.

Federal Quarantines and District of Columbia ....Federal Horticultural Board, U. S. Department of Agriculture, Washington, D. C.

Dominion of Canada ....L. S. McLaine, Secretary, Destructive Insect and Pest Act Advisory Board, Department of Agriculture, Ottawa, Can.

BULLETIN OF IMMEDIATE INFORMATION NO. 52 DECEMBER 15, 1925

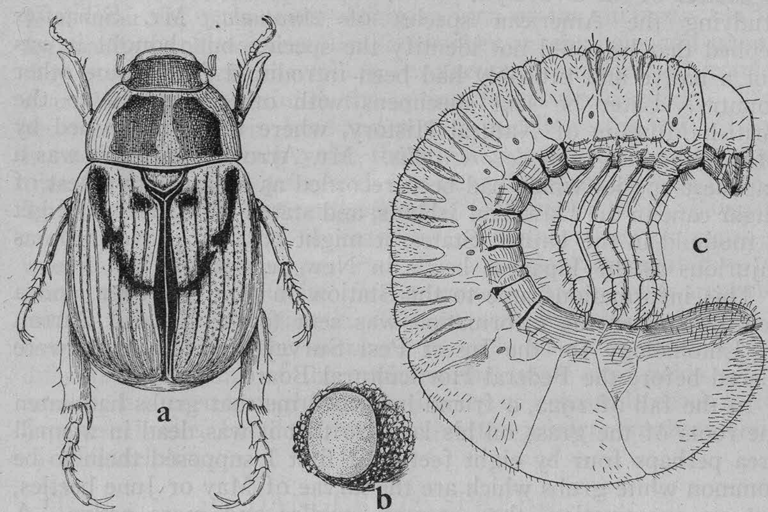
Connecticut Agricultural Experiment Station

New Haven, Connecticut

A New Pest of Lawns

W. E. BRITTON, *State Entomologist.*

For the past three seasons, lawns in a portion of the Westville section of New Haven have been injured by grubs eating the grass roots causing dead and brown patches—sometimes small and again 15, 20 or more feet in diameter. This damage was



The Asiatic beetle, *Anomala orientalis*. a. adult beetle. b. egg. c. grub or larva. All enlarged about five times.

much more conspicuous the past fall than it has been before, and many complaints and inquiries have been received at the Station concerning the matter.

The insect responsible for the injury is a small brown beetle of the family Scarabaeidae, known to science as *Anomala orientalis* Waterhouse. We have called it the Asiatic beetle to distinguish it from the green Japanese beetle, *Popillia japonica* Newm., which is now established in southern New Jersey and eastern Pennsylvania. As near as can be determined, it was brought to New Haven in balls of earth on nursery stock from Japan, prior to 1917, when the Federal Horticultural Board prohibited all further importations of plants unless the soil had been removed from the roots.

DISCOVERY OF THE PEST.

A few of the beetles were taken by Messrs. Zappe and Walden, Assistant Entomologists of this Station, on July 16 and 21, 1920, in the nursery just south of Edgewood Avenue. They were pinned up and put away with other material. On July 26, 1921, a few more beetles were collected in the same locality. They were immediately recognized as belonging to the genus *Anomala,* but were different from any species in the Station collection or that we had ever seen. Specimens were then sent to Mr. Charles Schaeffer of the Brooklyn, N. Y., Museum, who at that time was studying the American species of *Anomala.* Mr. Schaeffer replied that he could not identify the species, but thought it was not a native and probably had been introduced from some other country. Later he sent specimens with other material to the British Museum of Natural History, where it was identified by Mr. Arrow as *Anomala orientalis.* Mr. Arrow reported it was a Japanese species which had been recorded as a destructive pest of sugar cane in the Hawaiian Islands, and stated that if it should get a foothold in the United States, it might possibly prove to be as injurious as the Japanese beetle in New Jersey.

This information came to the Station on May 17, 1922, and a few days later the information was sent to the Federal Bureau of Entomology for the Insect Pest Survey, and the facts were placed before the Federal Horticultural Board.

In the fall of 1922, a friend informed me that grubs had eaten the roots of the grass on his lawn so that it was dead in a small area perhaps four by eight feet. At first I supposed them to be common white grubs which are the larvae of May or June beetles, but on examination, they seemed smaller and more active. A number were gathered, placed in a small tin box with a little soil and taken to the laboratory. They nipped each other with their jaws and all died. The following spring more material was obtained; only a few were placed in each box with plenty of soil so that they could not injure each other. On July 24, 1923, the adults were obtained and proved to be identical with the specimens collected in that vicinity two and three years before.

DISTRIBUTION.

The insect is not known to occur anywhere else in the United States except in Westville, New Haven, where it seems to be restricted to the area bounded by Chapel Street on the south, West Elm Street on the north, and from Yale Avenue to Forest Street. Of course it may develop that the pest has been carried out of this area on the roots of plants or in transporting soil, but no such separate infestations have been discovered.

In the Orient, this species is present in Japan and Hawaii, but apparently it is a native of the Philippine Islands, whence it has been carried to Japan and Hawaii.

LIFE HISTORY AND HABITS.

The adult beetles emerge during July and the females lay eggs in the soil. These eggs hatch in a few days and the young grubs feed upon the grass roots within an inch of the surface. On the approach of cold weather, late in October, when about half-grown, they go deeper into the soil for protection from the cold, coming near the surface again in the spring to resume feeding. They become full-grown in June and pupate in cells in the soil. There is one generation each year, though a few of the larvae fail to transform the first year and run over into the second season. The adult beetles apparently fly and feed very little and usually are found in the turf or crawling upon the stems of grass or weeds. In Hawaii this pest caused much injury to sugar cane ten years ago, and a parasite, *Scolia manilae* Ashm., was imported with a view to controlling it. The parasite was successful and in two years reduced the numbers to such an extent that it was difficult to find any of the grubs in the sugar cane fields. This parasite has been brought to this country as a possible check to the Japanese beetle, but does not survive the winters in the vicinity of Philadelphia.

DANGER OF SPREAD.

The natural spread of this insect is not as rapid as might be the case were it a strong and active flyer. However, there is great danger of starting new colonies whenever rose bushes or other plants are carried with earth about the roots, or in carting away rubbish from the garden or surplus soil from grading, especially when carried to a point outside the infested area. Property owners and tenants are therefore cautioned against allowing any soil to be carried away from their premises. If allowed to spread southward, *Anomala orientalis* might become a serious pest of various crops.

CONTROL MEASURES.

The most promising control measures are treating the soil with something that will kill the grubs. Calcium cyanide and sodium cyanide, both dangerous poisons, have been used for this purpose. Either used at the rate of four ounces per square yard, and the ground well watered, will kill the grubs, but the vegetation will be injured. Carbon disulphide can now be made in the form of an emulsion which when applied to the soil will kill the grubs without injuring the grass and other vegetation.

ERADICATION RECOMMENDED.

At our request, specialists were sent from the Federal Bureau of Entomology to review the situation, and on October 29, 1925, Mr. Loren B. Smith in charge of Japanese beetle investigations, with Messrs. B. R. Leach and J. P. Johnson, all of Riverton, N. J., visited New Haven and inspected the infested territory. Soon afterwards, Mr. Smith submitted a report recommending that a co-operative attempt be made to eradicate the insect from this section. To do so is estimated to cost at least $25,000.00. Federal authorities expect that $10,000.00 will be raised in Connecticut. Probably a part of this amount will be available from State funds, and the City of New Haven may be asked to make an appropriation. The Edgewood Civic Association, through a special committee, asks property owners and residents to contribute towards this sum; they can afford to do so if there is a prospect of becoming rid of the pest altogether, and many have already expended modest sums on their own premises which will avail them little unless eradication measures are carried out over the whole area. The plans include treating the entire area with carbon disulphide emulsion under Federal and State direction and after the most approved methods.

In case the efforts are not immediately successful in eradicating this pest, they will surely reduce its numbers to such an extent that little damage will be done, and the danger of spread will be small in comparison with present conditions. We believe, however, that the chances for success are excellent. If prompt measures for extermination, in the light of our present knowledge, could have been carried out with such pests as the gipsy moth and the Japanese beetle, many millions of dollars might have been saved by the American people.

BULLETIN OF IMMEDIATE INFORMATION NO. 53 — APRIL 10, 1926

Connecticut Agricultural Experiment Station
New Haven, Connecticut

The Asiatic Beetle Quarantine

W. E. BRITTON, *State Entomologist.*

A new pest has appeared in the western or Westville section of New Haven in the form of a beetle, the grubs of which feed upon the roots of grass and probably other plants. This beetle is known to science as *Anomala orientalis* Waterhouse. We have called it the Asiatic Beetle to distinguish it from the Green Japanese Beetle, *Popillia japonica,* which now is present over some 6,000 square miles of territory in New Jersey, Pennsylvania and Delaware. *Anomala orientalis* is said to be a native of the Philippine Islands, but in some way it was introduced into Japan and also into Hawaii, where it has caused severe injury to the sugar cane crop. Many lawns have already been ruined in the Westville section of New Haven. As it is not known to occur elsewhere in the United States, and as it may prove a very serious pest here, especially if it should spread southward, every reasonable measure should be taken to eradicate it and prevent its further dissemination.

Following a hearing at the Station April 5, of which due notice was given, quarantine restrictions have been established by the following order:

STATE OF CONNECTICUT
AGRICULTURAL EXPERIMENT STATION
NEW HAVEN, CONN.

QUARANTINE ORDER NO. 8

CONCERNING ASIATIC BEETLE

Effective April 15, 1926.

It has been brought to my attention that a destructive insect pest known as the Asiatic beetle, *Anomala orientalis* Waterhouse, has been introduced into the western portion of the City of New Haven, and there is grave danger that this insect may be further spread or disseminated by transporting soil, turf, plants with soil about the roots, lawn clippings, rubbish, etc., from infested yards.

Therefore pursuant to the provisions of Chapter 107, Public Acts of 1925, I do hereby declare and order that the area bounded by Yale Avenue, Willard Street, Forest Road, Cleveland Road, Central Avenue and Chapel Street, shall be a restricted area out from which, until further notice, the following materials will not be allowed to be moved except where treatment or inspection is practicable and permits issued by some person or persons authorized by me to issue such permits:

1. Soil or loam.
2. Plants with soil about the roots; plants in pots which have been set on or in the ground out of doors between June 1 and September 30, inclusive.
3. Turf or sod trimmings.
4. Lawn clippings.
5. Ground litter, weeds, manure or compost which has lain upon the ground.

This order does not affect such materials originating outside of and passing through the restricted area.

This order shall take effect April 15, 1926.

W. L. SLATE, JR.,
Director, Connecticut Agricultural Experiment Station.

Approved:
JOHN H. TRUMBULL,
Governor.

On and after April 15, inspectors will be on duty in the infested area, to supervise the movement of such materials as are named in the quarantine order, scout around the infestations and later to treat the infested lawns.

The foregoing regulations do not constitute an embargo, and the movement of these materials will be prohibited only where there is great danger of carrying the pest into uninfested territory and where inspection or treatment is considered impracticable. Permits may be issued for the movement of such materials which are not in danger of carrying the insects or which may be rendered safe by inspection or treatment.

Headquarters will soon be established on West Elm Street, just east of Alden Avenue, where Mr. J. P. Johnson will be in charge of enforcing this quarantine and will supervise the treatment of all infested material. Applications for permits and information about the insect may be obtained at headquarters.

BULLETIN OF IMMEDIATE INFORMATION NO. 54

OCTOBER 1, 1926

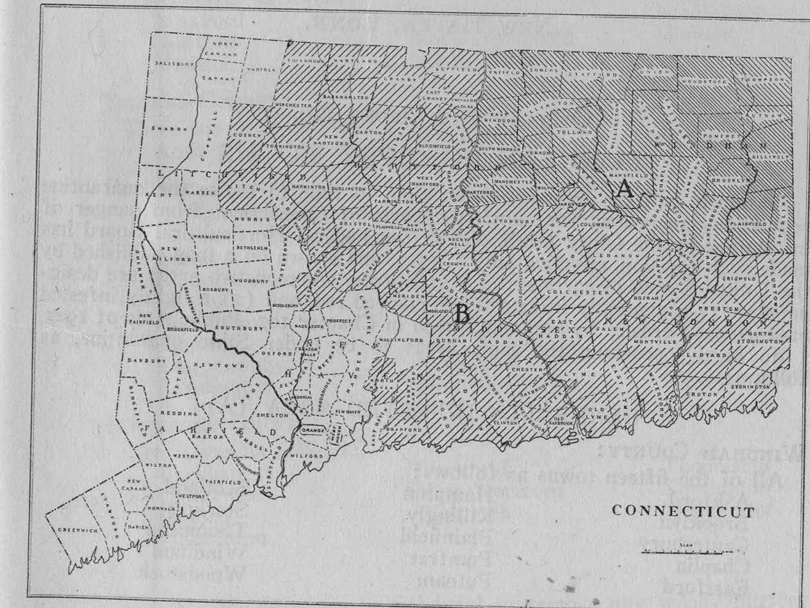
Connecticut Agricultural Experiment Station
New Haven, Connecticut

The Gipsy Moth Quarantine

(Revision Effective September 20, 1926)

W. E. BRITTON, *State Entomologist*

From time to time it is necessary to revise the gipsy moth quarantine to meet changing conditions and to bring it into harmony with the Federal quarantine. The Federal Horticul-



Map of Connecticut; shaded area quarantined on account of the gipsy moth; (A) Generally infested; (B) Lightly infested.

tural Board of the United States Department of Agriculture has recently revised the Federal quarantine relating to the gipsy and brown-tail moths (effective July 1, 1926). The authority for establishing quarantines in Connecticut (Section 2106 of the General Statutes) was amended by the last General Assembly, Chapter 107, Public Acts of 1925, so that stone, quarry products, and other materials liable to carry dangerous pests may now be included instead of plant products only.

After due notice, a public hearing was held in Hartford on September 9, 1926, and the subject discussed. There was no opposition expressed. The preceding quarantine order relating to the gipsy moth became effective July 20, 1924. Seven towns then placed under quarantine are now released by the present order, namely: Salisbury, Canaan, North Canaan, Norfolk, Cornwall, Cheshire and Wallingford. The two areas (A) and (B) are shown on the accompanying map, and the quarantine order follows:

STATE OF CONNECTICUT
AGRICULTURAL EXPERIMENT STATION
NEW HAVEN, CONN.

QUARANTINE ORDER NO. 9
CONCERNING GIPSY MOTHS

Inasmuch as it is necessary from time to time to revise the quarantine regulations, to protect the uninfested parts of Connecticut from danger of infestation by the Gipsy Moth, and as the Federal Horticultural Board has made such revision, effective July 1, 1926, and shown on a map published by the United States Department of Agriculture, whereon two areas are designated: (1) a generally infested area, colored red, and (2) a lightly infested area, colored green; by authority given in Chapter 107, Public Acts of 1925, I do hereby proclaim the same areas to be under State quarantine, as follows:

GENERALLY INFESTED AREA (A)

WINDHAM COUNTY:

All of the fifteen towns as follows:

Ashford	Hampton	Scotland
Brooklyn	Killingly	Sterling
Canterbury	Plainfield	Thompson
Chaplin	Pomfret	Windham
Eastford	Putnam	Woodstock

TOLLAND COUNTY:

The ten northernmost towns as follows:

Bolton	Somers	Union
Coventry	Stafford	Vernon
Ellington	Tolland	Willington
Mansfield		

HARTFORD COUNTY:

Five towns east of the Connecticut River as follows:

East Hartford	Enfield	South Windsor
East Windsor	Manchester	

LIGHTLY INFESTED AREA (B)

NEW LONDON COUNTY:

All of the twenty-one towns as follows:

Bozrah	Ledyard	Old Lyme
Colchester	Lisbon	Preston
East Lyme	Lyme	Salem
Franklin	Montville	Sprague
Griswold	New London	Stonington
Groton	North Stonington	Voluntown
Lebanon	Norwich	Waterford

MIDDLESEX COUNTY:

All of the fifteen towns as follows:

Chester	East Hampton	Middletown
Clinton	Essex	Old Saybrook
Cromwell	Haddam	Portland
Durham	Killingworth	Saybrook
East Haddam	Middlefield	Westbrook

NEW HAVEN COUNTY:

Seven towns as follows:

Branford	Meriden	Waterbury
Guilford	North Branford	Wolcott
Madison	North Haven	

TOLLAND COUNTY:

Three towns as follows:

Andover	Hebron	Columbia

HARTFORD COUNTY:

Twenty-four towns as follows:

Avon	Glastonbury	Rocky Hill
Berlin	Granby	Simsbury
Bloomfield	Hartford	Southington
Bristol	Hartland	Suffield
Burlington	Marlborough	West Hartford
Canton	New Britain	Wethersfield
East Granby	Newington	Windsor
Farmington	Plainville	Windsor Locks

LITCHFIELD COUNTY:

Ten towns as follows:

Barkhamsted	Litchfield	Thomaston
Colebrook	New Hartford	Torrington
Goshen	Plymouth	Winchester
Harwinton		

1. It shall therefore be unlawful to remove any woody nursery stock, trees, shrubs, lumber, cordwood, telegraph or telephone poles, railroad ties, Christmas trees, "Christmas greens," tree branches for decoration, or other forest plant products, or stone or quarry products, or any material likely to carry the gipsy moth, from the generally infested to the lightly infested area, or from either infested area to the non-infested area of the State, except under certificates or permits issued by authorized State or Federal inspectors.

2. In view of possible future changes in the lines between the generally infested, lightly infested, and non-infested areas of the State, the areas quarantined by the State shall conform to those quarantined by the Federal Horticultural Board of the United States Department of Agriculture; fur-

thermore, the Federal regulations covering interstate shipments of materials cited in Section 1 are hereby adopted for the regulation of shipments within the State of Connecticut.

3. This order shall take effect from its date.

Dated September 20, 1926.

W. L. SLATE, JR., *Director,*
Connecticut Agricultural Experiment Station.

Approved:
JOHN H. TRUMBULL,
Governor.

It will be seen that the present quarantine involves fewer towns than the preceding quarantine (Quarantine Order No. 6) and that it follows the Federal quarantine in dividing Connecticut territory into two parts (A), generally infested, and (B), lightly infested, these areas being colored red and green respectively on the Federal map. It also differs from Quarantine Order No. 6 in that it includes stone, quarry products, and any other materials liable to carry the gipsy moth.

MATERIALS AND PRODUCTS REQUIRING INSPECTION

The materials requiring inspection under both Federal and State quarantines may be roughly divided into four classes as follows:

1. **Christmas Greens and Decorations:**—Coniferous trees, such as spruce, hemlock, fir, pine, juniper or red cedar, arbor vitae or white cedar, or foliage thereof, and decorative plants such as holly and laurel or parts thereof known and described as Christmas greens or greenery.

Movement of materials in this class originating in the generally infested area (A) may be moved within the area without inspection, but will not be allowed to points outside of the area. If originating in the lightly infested area (B), they may be moved to other points in the same area or to points in the generally infested area (A) without inspection, but cannot be shipped outside the quarantined area without a Federal certificate or permit.

2. **Nursery Stock:**—Trees, shrubs, vines, cuttings, and florists' stock if woody and field-grown, but not including florists' greenhouse-grown stock or herbaceous plants.

Nursery stock grown within the generally infested area (A) may be moved within the area without inspection, but in order to move it to points within the area lightly infested (B) or to points outside the quarantine limits it must be accompanied by a certificate of inspection or permit issued by the United States Department of Agriculture. From points in the lightly infested area

(B) plants may be moved to other points in the same area or to points in the generally infested area (A) without inspection; to points outside the quarantined area a Federal certificate or permit is necessary. Regular nurseries must hold State inspection certificates or this Federal inspection may be refused.

3. **Forest Products:**—Logs, poles, posts, ties, car stakes, cordwood, lumber, tanbark, etc., but not including square-edged lumber direct from the saw, or lumber direct from the mills and finished on all faces, boxes, shooks, staves, etc., which have not been exposed to infestation by piling or storing out of doors.

Forest products may be moved between points within the generally infested area (A) and from points in the lightly infested area (B) to points within both areas without inspection; but must bear Federal certificates or permits if moved from within the generally infested area (A) into the lightly infested area (B) or from either area to points outside the quarantine limits.

4. **Stone and Quarry Products:**—Field stone, paving, building or monumental stone, etc., brick, tile, drain or sewer pipe.

Such materials may move between points in the same area or from points in the lightly infested area (B) to points in the generally infested area (A) without inspection; but from the generally infested area (A) to points in the lightly infested area (B) or from points in both areas to points outside the quarantine limits, they must be accompanied by Federal certificates or permits.

It is understood that most of these inspections will be made by Federal inspectors, but State inspectors are also qualified to make inspections and issue certificates. Each frequent shipper should procure a Federal map showing these areas in colors, and learn the name, address, and telephone number of the Federal inspector detailed to cover his locality. The Federal inspection service is in charge of

D. M. ROGERS, 408 Atlantic Avenue, Boston, Mass.

to whom applications for maps and inspections should be made.

The State inspection service is in charge of

W. E. BRITTON, Agricultural Experiment Station, New Haven, Conn.