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Agricultural Experiment Station

STORRS, CONNECTICUT

For the Year Ending

June 30, 1930

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(as of June 30, 1930)

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LETTER OF TRANSMITTAL

To His Excellency, GOVERNOR WILBUR L. CROSS:

In accordance with the statutes relating thereto, I have the honor to transmit herewith the Forty-second Annual Report of the Storrs Agricultural Experiment Station for the year ending June 30, 1930.

ARTHUR F. GREENE,
Secretary of the Board of Trustees,
Connecticut Agricultural College.

PUBLICATION
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THE BOARD OF CONTROL

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BULLETIN 170 NOVEMBER 1930

STORRS

Agricultural Experiment Station

The Cost of Cooling Milk with Electricity

DEPARTMENT OF DAIRY INDUSTRY

CONNECTICUT AGRICULTURAL COLLEGE

STORRS, CONNECTICUT

The Cost of Cooling Milk with Electricity

E. O. Anderson*

When electric cooling units were first brought to the attention of dairy farmers as a quick and efficient means of cooling milk and thus producing a high quality product, one of the first questions asked was, "How much does it cost to operate them?" To answer this question in terms of local conditions, a study was made on a series of typical Connecticut dairy farms.

It should be kept in mind that while the results presented are based on certain actual farm conditions, and are therefore quite typical, the cost of electric power varies widely from farm to farm. The charge for power on this service line was probably higher than in other sections of the state. In order to make the data apply to any given case, it is only necessary to replace the cost per kilowatt hour of electric current by the rate charged in that service area, or to the farm in question.

Sources of Information and Methods

(1) Data for a period of one year reported herein were taken on seven cooling tanks located on seven farms in North Coventry, Connecticut.

(2) On all the farms except No. 1 and No. 2 the milk was canned warm and the cans were placed in the cooling tank until delivery. On Farm No. 1 most of the milk was bottled. The bottles were immersed in the cooling tank and remained there until delivery was made the following morning. On Farm No. 2 about 80 quarts of milk were bottled each day. The milk was bottled warm and cooled in the tank. The remainder of the milk was canned while warm and the cans placed in the cooling tank until delivered.

*The author is indebted to the several farmers on whose farms the data were obtained, to the Rockville-Willimantic Lighting Company for installing the meters, and to Mr. E. E. Tucker, County Agent of Tolland County, for his assistance and suggestions.

(3) The milk was cooled to a temperature between 38° and 45°F. The amount of milk cooled for home consumption was taken into consideration.

(4) The wet storage method of cooling milk was used in cooling the milk in all cases.

(5) Since it is not known how long a compressor will last, a theoretical depreciation of 10 percent per year was used.

(6) Depreciation on the cooling tanks was computed at 10 percent.

(7) Insurance and taxes were not taken into consideration because in the opinion of the writer it is a matter of conjecture just what part of the total cost of the insurance carried on farm equipment can be ascribed to the mechanical unit and cooling tank.

(8) Interest was figured at the rate of 5 percent on the average value for the year; that is, the average of the beginning and ending inventories.

(9) During the period reported, no repairs were necessary on any of the units.

(10) A meter was installed on each unit. Monthly readings and the quantity of milk cooled each month were recorded.

(11) The following method was used in calculating the *actual* cost of electric current for cooling milk:

The units studied were on the same service line. The method of charging was rather complex, consisting of several items:

(a) The *Line Charge*. In order to secure the service, the farmers were obliged to guarantee a minimum income to the company. Hence, a charge of $2.00 per month was made to each user.

(b) The *Flat Rate Charge*. On all of the farms except No. 5 electricity was used for lighting the house. The charge for lighting was 10 cents per month for each 100 square feet of floor area.

(c) The *Minimum Charge*. Each farm was metered and a base consumption, in kilowatt hours, was assigned by the company. For various reasons this base varied from farm to farm. All current up to this minimum was charged to the farmer at *seven* cents per kilowatt hour.

(d) The *Excess Rate*. Any current used in excess of his assigned minimum was sold to the farmer at *three* cents per kilowatt hour.

Thus the sum of all these items made the total cost to the farmer. The *actual* cost per kilowatt hour is obtained by dividing the metered consumption into this total cost. The details are shown for each farm in Tables 8 to 14.

(12) The following method was used in calculating the theoretical cost of current for cooling milk:

Assuming that the power used on the farm before a mechanical milk cooling unit was installed paid for the line and flat rate charges, plus the original current at seven cents per kilowatt hour, then the power used for cooling milk would be charged at three cents per kilowatt hour. The cost of cooling milk on these farms was therefore calculated at three cents per kilowatt hour.

Construction of Tanks

The construction of the cooling tanks and units used is given in Table 1. Two of the seven cooling tanks were made of concrete and permanently built in. The other five were of the "walk in" type. Of these five, two were reconstructed Cooley Creamers, two were home made wooden tanks, and one was made by a well known commercial house. Figure 1 shows one of the concrete cooling tanks. Figure 2 illustrates one of the home made wooden cooling tanks with meter connection for determining power used. All of the cooling tanks were insulated with three to four inches of cork on the sides and bottom. The lids were insulated with two inches of cork. The average cost of the mechanical units was $343.57, and of the cooling tanks, $125.41.

The Actual Cost of Cooling Milk

The data on the actual cost of cooling milk by electricity are shown in Tables 2 and 3. Complete data for each farm are given in Tables 8 to 14 inclusive, which appear at the end of this paper.

The average cost of cooling milk on these seven farms using the wet storage type of refrigeration was 15.07 cents for each 100 pounds of milk during 1929-1930. The average annual production of milk was 85,566 pounds, or 235 pounds of milk daily.

The cost varied from 13.64 cents to 20.12 cents for each 100 pounds of milk cooled.

The power charge was 7.01 cents or 46 percent of the total cost. Depreciation of the unit was 4.01, of the tank 1.47, and the interest on investment was 2.58 cents for each 100 pounds of milk cooled.

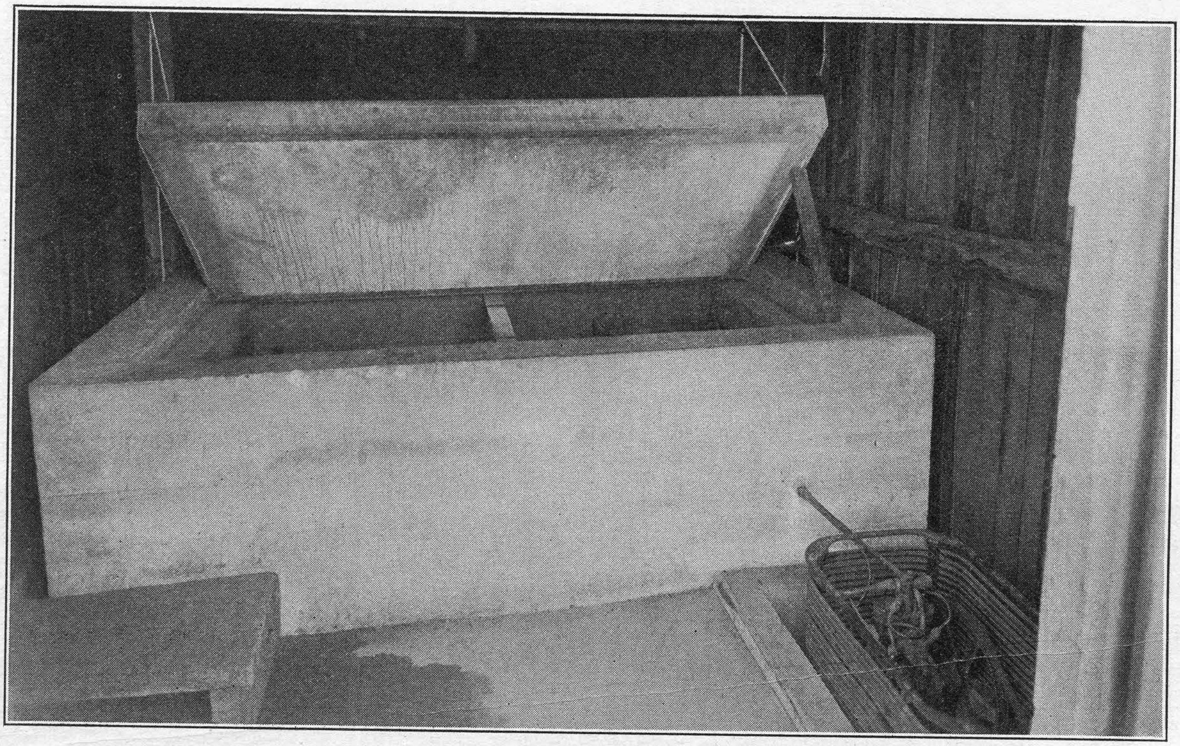

Fig. 1. Insulated Concrete Tank and Cooling Unit on Farm No. 4.

Table 1. *Construction and Cost of Cooling Tanks and Units*

Farm	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Cost of Tank	$200	$93	$140	$210	$30	$140	$65
Cost of Unit	479	318	325	390	310	273	310
Material	Concrete	Wood	Wood	Concrete	Reconstructed Cooley Creamer	Wood & Metal	Reconstructed Cooley Creamer
Inner Lining	Concrete 8″	Zinc	Gal. Iron	Concrete 4″	Zinc	Gal. Iron	Gal. Iron
Cork Insulation							
Sides, Inches	4	4	4	3	4	3	4
Bottom, Inches	4	4	4	3	4	3	4
Lid, Inches	2	2	2	2	2	2	2
Outside Lining	Concrete 8″	Plank 2″	Plank 1¼″	Concrete 4″	Wood ½″	Galvanized Iron	Wood 1″
Tank Dimensions							
Length, Inches	149½	83	59	72	57	48	57
Width, Inches	39	31½	31	40	25¾	40	26¾
Height to overflow, Inches	25½	25	21	25¼	25	25½	25
Cooling Units	Two	One	One	One	One	One	One
Motor Horsepower	¾	⅓	½	⅓	¼	⅓	⅓
Auxiliary Cooling	Winter Air	Spring Water	None	Winter Air	None	None	Winter Air
Method of Cooling Compressor	Air	Air	Air	Air	Air	Air	Air
Method of Operation	M & A	M & A	A	M & A	A	A	M & A

M=Manual. A=Automatic.

While a comparison of different thicknesses of insulation for cooling tanks has not been undertaken in this study, the fact that the power charges were approximately 50 percent of the total cost of cooling milk with electricity emphasizes the necessity of provision for insulation when installing cooling systems.

TABLE 2. *Actual Cost of Cooling Milk*

(1929-1930)

Farm No.	Annual Production Lbs.	Power $	Depreciation Unit $	Depreciation Tank $	Interest $	Repairs $	Total $	For each 100 lbs. milk $
1	139,696	90.34	47.90	20.00	32.35	0.00	190.49	0.1364
2	102,272	47.68	31.80	9.30	19.49	0.00	108.27	0.1059
3	84,348	66.63	32.50	14.00	20.92	0.00	134.05	0.1589
4	80,620	41.59	39.00	21.00	28.50	0.00	130.09	0.1614
5	65,343	81.30	31.00	3.00	16.15	0.00	131.45	0.2012
6	64,796	35.61	27.30	14.00	19.36	0.00	96.27	0.1486
7	61,883	57.00	31.00	6.50	17.81	0.00	112.31	0.1815
Average	85,566	60.02	34.34	12.54	22.07	0.00	128.99	
Ave. per 100 lbs. milk		.0701	.0401	.0147	.0258	0.00	.1507	.1507

Estimate of Cost with Three Cent Rate

When a base of three cents per kilowatt hour is used, the average cost of cooling milk is 10.78 cents per 100 pounds. This is shown in Table 4. Compared with the actual cost as shown in Table 2, it is 4.29 cents cheaper per 100 pounds of milk. At a lower charge per kilowatt hour, the cost would be proportionably less.

When the charge for power is calculated at three cents per kilowatt hour, this item becomes 2.72 cents per 100 pounds of milk, or 25 percent of the total cost. (See Table 5). This is a decrease of 21 percent from the actual cost of power. The depreciation of the unit is 4.01 cents and that of the tank 1.47 cents. This depreciation is 51 percent, or over half, of the cooling costs. Interest on investment increases from 17 to 24 percent.

The power cost per 100 pounds of milk at actual charges was 7.01 cents, and at 3 cents per kilowatt hour, 2.72 cents. This difference is to be expected, but even at the higher rate the cooperating farmers believe that cooling milk with electricity is much cheaper than with ice.

Manual Versus Automatic Control

It has been assumed by many farmers that if they would operate the compressors manually less power would be necessary to cool the milk. Four of the seven units studied were operated on a combined manual and automatic control. Of these four, three were not operated during December, January, February and March, with the exception of one which was operated for a short time in February. The three remaining units were operated on a strictly automatic basis. Hence, it was possible to make a comparison of the two methods of control. The data on current consumption per month for both groups are given in Table 6.

Manual control of the units does not decrease the amount of power necessary to cool 100 pounds of milk. Under manual control 1.106 kilowatt hours of power were needed to cool 100 pounds of milk as compared to 1.096 kilowatt hours when the compressor was automatically operated. Instead of reducing the power consumed under manual control of the compressor, there was a slight increase per 100 pounds of milk cooled. Obviously, there is no return for the extra trouble of turning the unit off and on. It is safe to assume that the milk will be cooled to a more uniformly low temperature when the unit is automatically controlled.

The monthly cost of electricty per 100 pounds of milk for the units which were operated automatically was usually less than the average for all units. This is shown in Table 7.

TABLE 3. *Distribution of Actual Costs in Cooling Milk*

(1929-1930)

Cost Item	Average Annual Costs	Average Costs for each 100 lbs. Milk produced	Percent of Total
Power	$60.02	$.0701	46
Depreciation, Unit	34.34	.0401	27
Depreciation, Tank	12.54	.0147	10
Interest	22.07	.0258	17
Repairs	00.00	.0000	00
Total	$128.97	$.1507	100

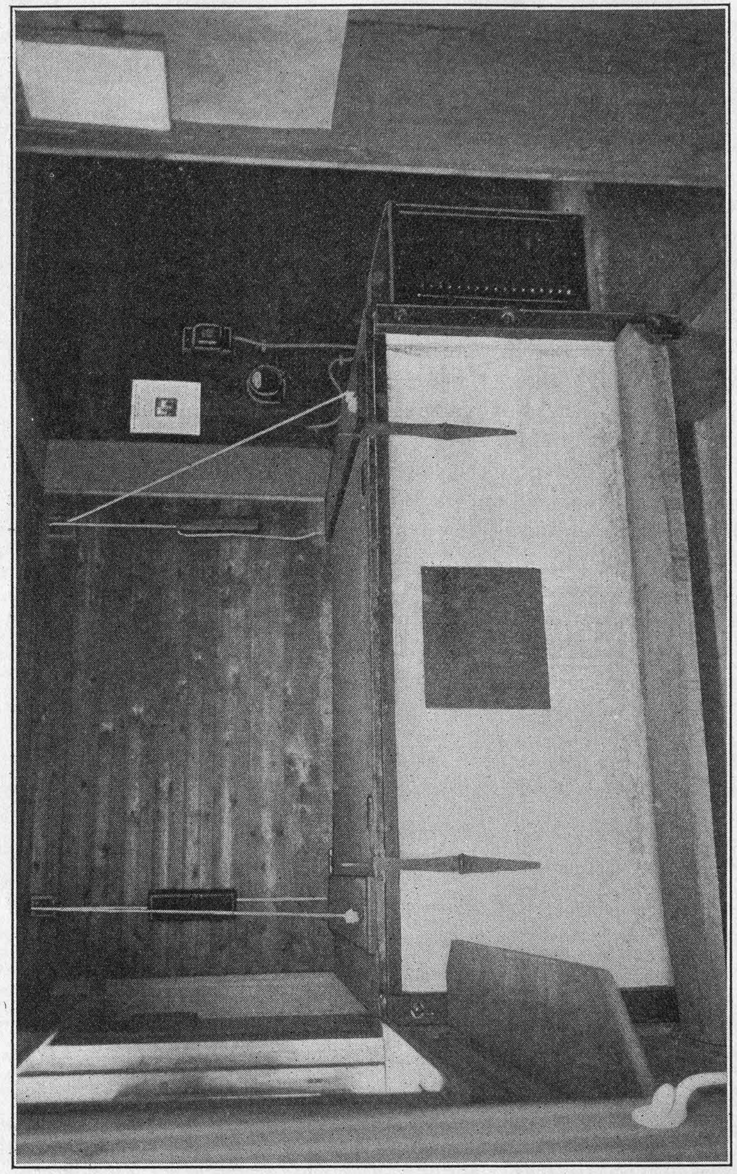

Fig. 2. Cooling Equipment on Farm No. 3. Meter is shown just above the right end of cooling tank.

The month of the highest average cost for electricity for each 100 pounds of milk cooled was July, when the cost was 12.92 cents as compared to 2.76 cents during January. The same relationship is true for the units operated automatically.

It cost the four all year around consumers of electricity 3.21, 2.59, 3.09 and 3.61 cents respectively for power to cool each 100 pounds of milk during December, January, February and March. During this interval the manually operated units were not consuming very much power for cooling. However, as pointed out, in the long run the manually controlled units required more power to cool each 100 pounds of milk than did the automatically operated units.

Table 4. *Computed Cost of Cooling When Power Is Charged at Three Cents per Kilowatt Hour*

Farm	Annual Production	Power	Depreciation Unit	Depreciation Tank	Interest	Repairs	Total	Average per 100 lbs. milk
No.	Lbs.	$	$	$	$	$	$	$
1	139,696	46.11	47.90	20.00	32.25	0.00	146.26	.1047
2	102,272	22.80	31.80	9.30	19.49	0.00	83.39	.0815
3	84,348	22.20	32.50	14.00	20.92	0.00	89.62	.1062
4	80,620	17.97	39.00	21.00	28.50	0.00	106.47	.1321
5	65,343	16.50	31.00	3.00	16.15	0.00	66.65	.1020
6	64,796	19.95	27.30	14.00	19.36	0.00	80.61	.1244
7	61,883	17.40	31.00	6.50	17.81	0.00	72.71	.1175
Average	85,566	23.29	34.34	12.54	22.07	0.00	92.33	
Ave. per 100 lbs. milk		.0272	.0401	.0147	.0258	0.00	.1078	.1078

Summary

1. The average total actual cost of cooling 100 pounds of milk with electricity in the wet storage type of cooling tanks on seven farms was 15.07 cents. When power is rated at three cents per kilowatt hour, the cost of cooling 100 pounds of milk was 10.78 cents.

2. The average investment in the cooling unit and wet tank was $343.57 and $125.41 respectively.

3. Manual control of the cooling unit does not decrease the amount of power necessary to cool each 100 pounds of milk. Under manual

control 1.106 kilowatt hours of power were needed to cool 100 pounds of milk as compared to 1.096 kilowatt hours of power when the compressor was automatically operated.

4. The average number of kilowatt hours of power needed to cool 100 pounds of milk was 1.103.

Discussion

The farmers whose electrical refrigeration units were under observation would not return to the old method of cooling milk with ice. This was true even in the case of Farm No. 5 where the actual cost of cooling 100 pounds of milk was 20.12 cents. The figures on ice cooling on this same farm were 24 cents for each 100 pounds of milk. The high cost of cooling on this farm was due to the fact that all the power used was utilized in cooling milk.

TABLE 5. *Distribution of Costs When Power Is Charged at Three Cents per Kilowatt Hour*

Cost Item	Average Annual Costs	Average cost for each 100 lbs. Milk produced	Percent of Total
Power	$23.29	$.0272	25
Depreciation, Unit	34.34	.0401	37
Depreciation, Tank	12.54	.0147	14
Interest	22.07	.0258	24
Repairs	00.00	.0000	00
Total	$92.33	$.1078	100

The convenience of cooling milk by electricity is difficult to estimate in dollars. After having experienced the benefits of its convenience and its prompt and constant cooling to a low temperature, the farmers have stated that they would not return to the ice method even though the electrical system had cost more to operate. Cooling of the milk to a uniformly low temperature with little or no attention is not only a convenience but insures a high quality product.

TABLE 6. *Current Consumption per Month for Automatic Versus Manual and Automatic Control*

	Jan. KWH	Feb. KWH	March KWH	April KWH	May KWH	June KWH	July KWH	Aug. KWH	Sept. KWH	Oct. KWH	Nov. KWH	Dec. KWH	Total KWH
Average of all	13.86	14.14	18.71	55.71	89.28	118.28	149.14	110.14	83.14	69.57	41.85	13.14	5432
Average number of kilowatts per 100 lbs. milk, 1.103													
Average of Manual-Automatic	5.50	4.00	8.00	53.75	98.50	134.50	184.25	140.00	102.50	85.50	48.25	4.25	3476
Average number of kilowatts per 100 lbs. milk, 1.106													
Average of Automatic	25.00	27.66	33.00	58.33	77.00	96.66	102.33	70.33	55.00	48.33	33.33	25.00	1956
Average number of kilowatts per 100 lbs. milk, 1.096													

The data indicate that automatically operated units require about the same amount or less of power to cool a given quantity of milk than manually controlled units. Hence, it seems to the writer, that an expenditure of 2.59 to 3.61 cents for each 100 pounds of milk during the winter months is cheap insurance for the delivery of a good quality of milk. When producing milk, we should always have the consumer in mind because in the last analysis the consumer is the judge as to how much milk he will consume. It is an accepted fact that consumers will drink more high quality milk than poor quality milk.

No mention has been made of the relative costs of ice and mechanical devices. Is the cost of cooling milk with electricity less than with ice? We are making a comparative study of the two methods which will be published later. However, judging from the results secured by workers in other states, the indications are that it is cheaper to cool milk with electricity.

From Corbett's (1) survey in Rhode Island made in 1929, the average cost of cooling 100 pounds of milk with ice was 10 cents. When cooling milk with electricity using wet boxes the cost was 12 2/3 cents for each 100 pounds of milk, and with dry boxes the cost was 14 1/4 cents for each 100 pounds of milk.

Bucknam (2) in New York found that if electricity could be purchased at four cents per kilowatt hour, the total cost of cooling milk was 11.4 cents per 40 quart can or 13.2 cents per 100 pounds of milk. On the other hand, when milk was cooled by means of ice, Bucknam reports that the cost varied from 7 to 39 cents, with an average of 13.7 cents for each 40 quart can of milk. For each 100 pounds of milk this would be 15.9 cents. The study in New York showed that it was cheaper by 2.7 cents to cool 100 pounds of milk with electricity.

Ellenberger (3) in Vermont found that it cost 22.1 cents per 100 pounds of milk to cool milk with ice as compared to 16.7 cents to cool with electricity. The ice was valued at $3 to $4 per ton.

Ackerman (4) in New Hampshire found that the average cost of cooling 100 quarts of milk was 30 cents when ice was used and 15 cents when cooled by electricity. For each 100 pounds of milk this would be 13.9 cents when ice was used, as compared to 6.9 cents when electricity was used. The equipment used on the farms studied by Ackerman was of the dry room type, consisting of an insulated room large enough to admit a person and chilled through the medium of cold dry air.

TABLE 7. *Monthly Average Cost of Electricity per 100 Pounds of Milk Cooled*

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	$	$	$	$	$	$	$	$	$	$	$	$
Average of all	.0276	.0360	.0289	.0698	.1139	.0983	.1292	.0977	.1016	.0911	.0597	.0300
Average of Farms Nos. 1, 3, and 6*	.0259	.0309	.0361	.0722	.0863	.0853	.1125	.0985	.0982	.0852	.0452	.0321

*Note—These farms used electricity for cooling milk the year around.

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2. Bucknam, R. F., Farm Economics, Cornell University, No. 66, June 1930, p. 1311, 1312.

3. Ellenberger, H. B., Bulletin 300, July 1929. Vermont Agricultural Experiment Station.

4. Ackerman, W. T., Bulletin 233, March 1928, New Hampshire Agricultural Experiment Station.

The complete data for each farm are appended as Tables 8 to 14 inclusive.

Table 8. *Details of Charges and Costs on Farm No. 1*

Month	Total Power Used	Charge for Current*	Flat Rate	Line Charge	Total	Actual cost per KWH	Power for cooling milk	Total Cost	Milk Produced	Cost of cooling 100 lbs. milk Actual	Cost of cooling 100 lbs. milk At 3c per KWH
	KWH	$	$	$	$	$	KWH	$	Pounds	$	$
1929											
April	185	10.35	1.80	2.00	14.15	.0765	140	10.7100	12900.00	.0830	.032
May	211	11.13	1.80	2.00	14.93	.0708	200	14.1600	13222.50	.1079	.046
June	348	12.24	1.80	2.00	16.04	.0461	267	12.3087	12631.25	.0974	.063
July	310	14.10	1.80	2.00	17.90	.0577	259	14.9443	9675.00	.1544	.080
Aug.	330	14.70	1.80	2.00	18.50	.0560	223	12.4880	9782.50	.1276	.068
Sept.	369	15.87	1.80	2.00	19.67	.0533	167	8.9011	9567.50	.0941	.052
Oct.	287	13.41	1.80	2.00	17.21	.0600	135	8.1000	10320.00	.0785	.039
Nov.	317	14.31	1.80	2.00	18.11	.0571	69	3.9399	10642.50	.0370	.019
Dec.	233	11.79	1.80	2.00	15.59	.0669	17	1.1373	10750.00	.0106	.005
1930											
Jan.	281	13.23	1.80	2.00	17.03	.0606	22	1.3332	11717.50	.0114	.005
Feb.	301	13.83	1.80	2.00	17.63	.0585	6	.3510	13975.00	.0025	.001
March	275	13.05	1.80	2.00	16.85	.0613	32	1.9616	14512.50	.0135	.006

*Minimum, 120 kilowatt hours, @ 7c; excess @ 3c.

TABLE 9. *Details of Charges and Costs on Farm No. 2*

Month	Total Power Used	Charge for Current*	Flat Rate	Line Charge	Total	Actual cost per KWH	Power for cooling milk	Total Cost	Milk Produced	Cost of cooling 100 lbs. milk Actual	Cost of cooling 100 lbs. milk At 3c per KWH
1929	KWH	$	$	$	$	$	KWH	$	Pounds	$	$
March	55	3.85	1.28	2.00	7.13	.1296	...	......	7740	....	...
April	39	2.73	1.28	2.00	6.17	.1582	...	......	8546	....	...
May	59	4.13	1.28	2.00	7.41	.1256	49	6.1534	9137	.0673	.016
June	141	7.11	1.28	2.00	10.39	.0736	99	7.2864	8976	.0812	.033
July	234	9.90	1.28	2.00	13.18	.1563	199	11.2037	8707	.1287	.068
Aug.	287	11.49	1.28	2.00	14.27	.0497	157	7.8029	8514	.0916	.055
Sept.	230	9.78	1.28	2.00	13.06	.0567	106	6.0102	8256	.0728	.038
Oct.	181	8.31	1.28	2.00	11.59	.0640	86	5.5040	7699	.0715	.033
Nov.	219	9.45	1.28	2.00	12.73	.0581	64	3.7184	8707	.0427	.022
Dec.	118	6.42	1.28	2.00	9.70	.0822	...	......	9072	....	...
1930											
Jan.	134	6.90	1.28	2.00	10.18	.0760	...	......	9075	....	...
Feb.	133	6.87	1.28	2.00	10.15	.0763	...	......	7841	....	...

*Minimum, 72 kilowatt hours, @ 7c; excess @ 3c.

TABLE 10. *Details of Charges and Costs on Farm No. 3*

Month	Total Power Used	Charge for Current*	Flat Rate	Line Charge	Total	Actual cost per KWH	Power for cooling milk	Total Cost	Milk Produced	Cost of cooling 100 lbs. milk Actual	Cost of cooling 100 lbs. milk At 3c per KWH
1929	KWH	$	$	$	$	$	KWH	$	Pounds	$	$
March	65	4.35	.90	2.00	7.25	.1115	48	5.3520	7226	.0741	.019
April	71	4.53	.90	2.00	7.43	.1046	66	6.9036	7307	.0945	.027
May	81	4.83	.90	2.00	7.73	.0954	75	7.1550	8167	.0876	.027
June	119	5.97	.90	2.00	8.87	.0745	94	7.0030	7716	.0907	.036
July	110	5.70	.90	2.00	8.60	.0782	99	7.7418	7445	.1039	.039
Aug.	115	5.85	.90	2.00	8.75	.0760	71	5.3960	5845	.0923	.036
Sept.	85	4.95	.90	2.00	7.85	.0923	57	5.2611	4919	.1069	.035
Oct.	76	4.68	.90	2.00	7.58	.0997	59	5.8823	5639	.1043	.031
Nov.	105	5.55	.90	2.00	8.45	.0805	45	3.6225	7052	.0513	.019
Dec.	70	4.50	.90	2.00	7.40	.1057	39	4.1223	7574	.0544	.015
1930											
Jan.	86	4.98	.90	2.00	7.88	.0916	44	4.0304	8238	.0489	.016
Feb.	82	4.86	.90	2.00	7.76	.0946	44	4.1624	7215	.0577	.018

*Minimum, 60 kilowatt hours, @ 7c; excess @ 3c.

TABLE 11. *Details of Charges and Costs on Farm No. 4*

Month	Total Power Used	Charge for Current*	Flat Rate	Line Charge	Total	Actual cost per KWH	Power for cooling milk	Total Cost	Milk Produced	Cost of cooling 100 lbs. milk Actual	Cost of cooling 100 lbs. milk At 3c per KWH
1929	KWH	$	$	$	$	$	KWH	$	Pounds	$	$
March	53	3.71	1.20	2.00	6.91	.1304	...	......	5998	....	...
April	58	4.06	1.20	2.00	7.26	.1252	30	3.7560	5934	.0633	.015
May	34	2.38	1.20	2.00	6.17	.1815	63	11.4345	5923	.1930	.032
June	166	8.18	1.20	2.00	11.38	.0686	83	5.6938	6172	.0922	.040
July	335	13.25	1.20	2.00	16.45	.0491	176	8.6416	6723	.1285	.078
Aug.	406	15.38	1.20	2.00	18.58	.0457	94	4.1958	9647	.0435	.029
Sept.	304	12.32	1.20	2.00	15.52	.0510	68	3.4680	6514	.0532	.031
Oct.	283	11.69	1.20	2.00	14.89	.0526	60	3.1560	6806	.0462	.026
Nov.	325	12.95	1.20	2.00	16.15	.0497	25	1.2425	7159	.0173	.010
Dec.	116	6.68	1.20	2.00	9.88	.0851	...	......	5998	....	...
1930											
Jan.	139	7.37	1.20	2.00	10.57	.0760	...	......	7426	....	...
Feb.	136	7.28	1.20	2.00	10.48	.0771	...	......	6316	....	...

*Minimum, 80 kilowatt hours, @ 7c; excess @ 3c.

TABLE 12. *Details of Charges and Costs on Farm No. 5*

Month	Total Power Used	Charge for Current*	Flat Rate	Line Charge	Total	Actual cost per KWH	Power for cooling milk	Total Cost	Milk Produced	Cost of cooling 100 lbs. milk Actual	Cost of cooling 100 lbs. milk At 3c per KWH
1928	KWH	$	$	$	$	$	KWH	$	Pounds	$	$
April	65	4.55	...	2.00	6.55	.1007	65	6.55	6234	.1051	.0313
May	73	5.11	...	2.00	7.11	.0974	73	7.11	6301	.1128	.0348
June	97	6.79	...	2.00	8.79	.0906	97	8.79	6387	.1376	.0456
July	107	7.49	...	2.00	9.49	.0887	107	9.49	5742	.1652	.0590
Aug.	59	4.17	...	2.00	6.17	.1046	59	6.17	4788	.1289	.0370
Sept.	31	4.17	...	2.00	6.17	.1990	31	6.17	3831	.1610	.0242
Oct.	29	4.17	...	2.00	6.17	.2127	29	6.17	4732	.1304	.0184
Nov.	23	4.17	...	2.00	6.17	.2682	23	6.17	4942	.1248	.0139
Dec.	18	4.17	...	2.00	6.17	.3417	18	6.17	5398	.1143	.0100
1929											
Jan.	15	4.17	...	2.00	6.17	.4113	15	6.17	5323	.1159	.0085
Feb.	9	4.17	...	2.00	6.17	.6955	9	6.17	5110	.1207	.0053
March	24	4.17	...	2.00	6.17	.2571	24	6.17	6551	.0942	.0099

*7c straight per kilowatt hour.

TABLE 13. *Details of Charges and Costs on Farm No. 6*

Month	Total Power Used	Charge for Current*	Flat Rate	Line Charge	Total	Actual cost per KWH	Power for cooling milk	Total Cost	Milk Produced	Cost of cooling 100 lbs. milk Actual	At 3c per KWH
1929	KWH	$	$	$	$	$	KWH	$	Pounds	$	$
April	260	11.48	1.38	2.00	14.86	.0572	44	2.5168	6413	.0392	.021
May	280	12.08	1.38	2.00	15.46	.0552	83	4.5816	7202	.0636	.034
June	416	16.16	1.38	2.00	19.54	.0470	99	4.6530	6856	.0678	.043
July	369	14.75	1.38	2.00	18.13	.0491	101	4.9591	4689	.0794	.064
Aug.	442	16.94	1.38	2.00	20.32	.0460	81	3.7260	4927	.0756	.049
Sept.	321	13.31	1.38	2.00	16.69	.0519	77	3.9963	4269	.0936	.054
Oct.	190	9.38	1.38	2.00	12.76	.0671	57	3.8247	5246	.0729	.032
Nov.	198	9.62	1.38	2.00	13.00	.0656	32	2.0992	4429	.0474	.021
Dec.	139	7.85	1.38	2.00	11.23	.0808	18	1.4544	4637	.0313	.011
1930											
Jan.	241	10.91	1.38	2.00	14.29	.0593	16	.9488	5411	.0175	.009
Feb.	269	11.75	1.38	2.00	15.13	.0562	30	1.6860	5157	.0327	.017
March	532	19.64	1.38	2.00	23.02	.0432	27	1.1664	5555	.0209	.015

*Minimum, 92 kilowatt hours, @ 7c; excess @ 3c.

TABLE 14. *Details of Charges and Costs on Farm No. 7*

Month	Total Power Used	Charge for Current*	Flat Rate	Line Charge	Total	Actual cost per KWH	Power for cooling milk	Total Cost	Milk Produced	Cost of cooling 100 lbs. milk Actual	At 3c per KWH
1929	KWH	$	$	$	$	$	KWH	$	Pounds	$	$
March	45	3.15	1.14	2.00	6.29	.1398	...	......	5835	....	...
April	69	4.83	1.14	2.00	7.97	.1155	45	5.1975	5020	.1035	.027
May	79	5.47	1.14	2.00	8.61	.1090	82	8.9380	5415	.1654	.045
June	117	6.55	1.14	2.00	9.69	.0828	89	7.3692	6073	.1213	.044
July	103	6.13	1.14	2.00	9.27	.0900	103	9.2700	6424	.1443	.048
Aug.	108	6.28	1.14	2.00	9.42	.0872	86	7.4992	6000	.1249	.043
Sept.	90	5.74	1.14	2.00	8.88	.0987	69	6.8103	5239	.1301	.039
Oct.	78	5.38	1.14	2.00	8.52	.1092	61	6.6612	4962	.1342	.038
Nov.	80	5.44	1.14	2.00	8.58	.1072	35	3.7520	3863	.0971	.027
Dec.	32	2.24	1.14	2.00	6.17	.1928	...	......	3861	....	...
1930											
Jan.	33	2.31	1.14	2.00	6.17	.1870	...	......	5310	....	...
Feb.	41	2.87	1.14	2.00	6.17	.1505	10	1.5050	3876	.0388	.007

*Minimum, 76 kilowatt hours, @ 7c; excess @ 3c.

BULLETIN 171 MARCH, 1931

STORRS
Agricultural Experiment Station

Report of the Director
for the
YEAR ENDING JUNE 30,
1930

CONNECTICUT AGRICULTURAL COLLEGE
STORRS, CONNECTICUT

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(as of June 30, 1930)

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Report of the Director

For the Year Ending June 30, 1930.

To President Charles C. McCracken:

In the usual manner, I submit herewith a brief account of the activities of the Storrs Experiment Station. The Report of Progress does not include a statement on all projects, but only those in which results of special interest have developed. A complete list of all projects will be found on page 29. Following this are the changes in staff, the publications issued during the year, and the financial statement.

Of special importance was the completion and dedication of the Atwater Laboratory. It is difficult to express the great satisfaction we are finding in the facilities this new building provides. For years our staffs in Animal Diseases and in Genetics have been handicapped by inadequate space and equipment and while we will outgrow these quarters, they afford ample space for the present. The dedication exercises, held on June 12, were attended by about 100 guests from other stations and colleges. The papers presented have been published as a bulletin of the Station under the title, "Dedication of Atwater Laboratory."

The need of broadening the animal disease program by the appointment of a pathologist has been recognized for the past seven years, but heretofore means have been lacking. Through the active interest of Dr. Works certain funds were reallocated and the appointment made, thus strengthening the work in this field.

Needs of the Station

The College campus is gradually encroaching on the land set aside for experimental purposes and very soon we will be forced to abandon these plots. A suitable tract should be acquired at once.

A greenhouse for soil and plant research is needed to strengthen our program in pasture and forage crop investigations. The lack of this equipment has greatly handicapped our work for many years. The expense is not great, $8000 being ample for our purposes.

A moderate increase in the maintenance appropriation will be necessary if we are to meet the increasing demands for help in the state's marketing problems. Some of these are local but many involve thorough studies of the entire industry, as in the case of vegetables and fruit.

REVIEW OF THE YEAR

The program of the Station is organized under 49 formal projects or subprojects distributed among the several departments. Obviously it is impossible to make the titles completely descriptive and further many minor researches are always involved as necessary contributing or preliminary steps. Research is a process of exploration which inevitably involves pauses and side trips on the route to the final objective.

In the following pages no attempt has been made to review the present status of all of the work under way, but there are presented the more definite and more useful results obtained during the past year.

Agronomy

Factors that may affect the vigor of seed potatoes. This investigation dates back to 1915 when it was begun as an attempt to learn why potatoes "run out" in a climate such as is found in Connecticut. Very shortly thereafter the virus diseases were recognized in this country. The opinion is now widely held that they are the cause of all running out or degeneration irrespective of climate. However this may be, these diseases so masked any results obtained in our investigations that it became necessary to learn first how to grow potatoes free from the virus diseases. These efforts were quite successful and the problem of

FIGURE 1. Sweet clover seeded in April furnished abundant grazing on July 16.

determining the effects of climatic or other environmental factors was again taken up. The factors studied are *maturity, plane of nutrition,* and the *effect of individual nutrient elements.*

(a) *Maturity of seed.* Up to the present the only indication is that early dug (immature) seed produces a larger yield when planted the following spring than seed dug later. It is quite probable that any increase in vigor is due to the removal of the crop from the field before infection has proceeded very far. Therefore we are again dealing with the problem of disease rather than the direct physiological effect of climate.

(b) *The effect of plane of nutrition and nutrients.* Again the virus diseases have interfered and masked any possible results although the plots have been severely rogued every year. Perhaps this problem can only be handled by growing the crop in cages.

Fertilizing alfalfa. Both phosphoric acid and potash seem to be essential for success. These studies have now been under way for many years and even where chemical determination shows considerable phosphoric acid, further additions are beneficial. The effect of potash is particularly noticeable on new seedings in that it improves the stand.

Pasture Improvement.

A. *The effects of fertilizer treatments on the soil, the flora, and the production as measured by grazing:*

1929 was the first year of the second five-year period on this project under fertilization. In March and April, after a lapse of five years since the initial fertilization of the experimental pastures, the limestone, superphosphate and potash treatments were, with few exceptions, repeated. As usual, nitrogenous fertilizers were applied in April, with the exception that one plot received one-half (28 pounds per acre) of its nitrogen in July.

Where a ton of limestone per acre was applied in both 1924 and 1929, the average pH reading for six plots in April, 1930, was 0.4 higher in the surface 2 inches of soil than in the 2-4 inch, and 0.6 higher than the 4-6 inch horizons. There were practically no differences in pH acidity in the corresponding horizons from five *unlimed* plots. The results indicate that the topdressed limestone is now affecting the reaction of the 2-4 inch, but not the 4-6 inch horizon.

Determinations of available phosphorus on samples of soils from eight plots that have received 1000 pounds of 16% superphosphate, show there is two and one-half times as much of this important element available in the 0-2 inch as in the 2-4 inch horizon, and nearly four times as much as in the 4-6 inch level. Evidently a little of the top-dressed superphosphate has penetrated below the upper 2 inches of soil.

Although the 1929 season, being one of the driest in forty years, was very unfavorable to the growth of pasture vegetation, several of the plots actually produced more feed than in the preceding wet years of 1927 and 1928. This result was chiefly due to the second 500 pound application of superphosphate in April, 1929. Omitting the second ton of limestone did not reduce the 1929 production, while omitting the second 500 pounds of superphosphate resulted in a 28 percent reduction in that season. However, the plot that received limestone and superphosphate in 1924 and no phosphorous since, afforded better pasturage in 1929 than the plot that was treated with superphosphate *only* in *both* 1924 and 1929. This suggests that lime is very important in any long time pasture improvement project on our acid soils.

FIGURE 2. The effect of date of cutting gray birches. From left to right: (1) April; (2) May; (3) June; (4) July; (5) August; (6) September.

Applying one-half of the nitrogen (total 56 pounds per acre) in July rather than all in April, resulted in less total pasturage for the season without affecting the distribution of the grazing appreciably. The four nitrogen plots averaged to produce 82 percent of the total feed for the season before July 1, while the corresponding figure for the four limestone-superphosphate plots was 62. The respective percentages for July were 8 and 27.

The relative productions of pasturage for 1929 are given below:

No treatment	100
Superphosphate	228
Superphosphate and limestone	315
Superphosphate, limestone and potash	325
Superphosphate, limestone, potash and nitrogen	342
Superphosphate, potash and nitrogen	298
Limestone and potash	138

B. *Effect of time of cutting on bushes and weeds:*

After mowing the ungrazed, unfertilized brush land in different months for four years, marked differences in the number and size of bushes were evident in 1929. July and August were the months in which cutting was the most effective in subduing such species as gray birch, alder, blueberry, and soft maple as well as weeds like golden rod, ferns and asters. Cutting during the dormant season was particularly ineffective. See Figure 2.

C. *Response of pasture species to plant nutrients:*

By growing white clover, Kentucky Blue grass and redtop in jars of variously fertilized pasture soil, it was found that the clover and blue grass responded most to applications of lime and phosphorus. The growth of redtop was practically the same regardless of treatment and this fact suggests why its close relative, Rhode Island Bent, is so abundant in the run-down permanent pastures of northeastern United States.

Biennial sweet clover for pastures. Recent work indicates that it will be good management to use sweet clover as supplemental feed where ample permanent pasture is available for the first half of the season. Seeded in April on well limed, fertile soil, an acre of this crop may be expected to furnish approximately 120 "cow days" of grazing between July 15 and the end of the growing season. Thus, 10 acres of spring seeded sweet clover should provide grazing for a 20 cow herd for two months during the period when pasturage is usually insufficient.

Where little or no permanent pasture is available, both *first* and *second* year sweet clover should provide good grazing throughout the season. An acre of second year sweet clover which has not been grazed too closely the previous fall, will usually produce 360 "cow days" of pasturage.

Rate and method of applying fertilizers to corn. Larger yields of more mature corn (Pride of the North) were obtained from 125 pounds per acre of a 4-10-6 fertilizer applied in an area 3 x 10 inches around the seed than from 500 pounds broadcasted. 250 pounds of 4-10-12 retarded germination, early growth and reduced yields in 3 x 10 inch, but not in 6 x 10 inch hills. July side dressings with nitrate of soda were ineffective in 1929, possibly because of the extremely dry weather during most of that season.

Fertilizing potatoes.

A. On the farm of F. V. Williams of Buckland, using triplicated five row plots, no increases in yields of marketable potatoes were obtained from applying above 750 pounds of 10-16-14 fertilizer per acre. Broadcasting one-half of the fertilizer when the rate was 1500 pounds or over did not influence the yields appreciably. There was a distinct correlation between the number of missing hills and the rate of fertilization. These results are very similar to those obtained in 1928.

B. On pasture land which had received no fertilizer for many years, save one ton of limestone and 500 pounds of 16% superphosphate per acre, nitrogen, phosphoric acid and potash were each broadcasted in commercial fertilizers at four different rates, varying only one nutrient at a time. Plots were replicated three times. Omitting potash reduced the yields appreciably more than omitting either nitrogen or phosphorus. The first 60 pounds of potash increased the yield 50 bushels per acre; the second, 37; and the third only 11 (not significant). These data support previous work at this Station (reported in Bulletin 106), namely, that approximately 80 pounds of potash (160 pounds of the muriate) was sufficient for the potato crop on the Charlton series of soils on the College farm.

The omission of either nitrogen or phosphoric acid was less important than the omission of potash. No increases in yields were obtained from more than 100 and 160 pounds per acre of these nutrients respectively.

Agricultural Economics

The department has continued the general project dealing with farm organization and land utilization in the Eastern Highland and in the Connecticut Valley. Various subprojects falling under these main projects have been initiated, completed, or are in the process of development. Three main lines of attack have been developed in each: (1) studies relating to the economic significance of soil type; (2) studies relating to farm organization and management; and (3) in the case of the Connecticut Valley, a project involving a study of the prices of tobacco.

A special short time study of taxation was conducted during the past summer and brought to completion.

Eastern Connecticut Highland. In the Eastern Highland the five-year study begun in the summer of 1927 is entering upon its fourth year. It is being conducted in cooperation with 160 farmers whose farms were mapped in detail and subjected to soil survey and classification. The labor and other costs of production and the yields expressed in physical, as well as economic terms are measured or estimated each year with respect to measured areas of land on each farm. Part of the farmers keep complete farm records and from all farms complete financial estimates are secured as a basis for studying the organization of the farm business. An attempt is being made to account for the basic relationships between cost, as measured in both the physical and economic terms, and output in the hope that eventually these figures may be used in discovering the most profitable system of farm organization for given sets of prices and given natural conditions. Data have been analyzed along two lines during the past year.

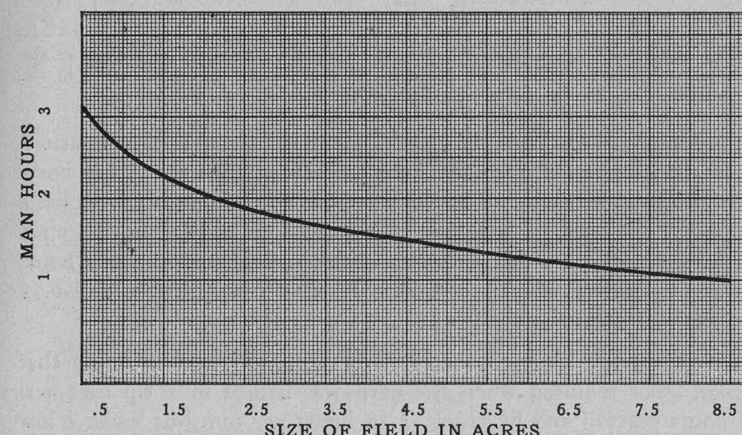

FIGURE 3. Relation between size of field and number of man hours used in cultivating corn.

(a) *Labor costs of producing hay and silage.*

The purpose of the first of these subprojects was to determine the extent of differences in the labor cost of producing hay and silage and to attempt to account for the causes of these differences. The results were embodied in an extensive report which is being revised for publication. It was found, among other things, that the size of fields has an important relationship to labor costs. The following table shows the rate at which man labor cost per acre drops as the size of field increases.

Decrease in the Number of Man Hours Per Acre in Plowing, Cultivating, Mowing, and Raking as the Size of the Fields Increases

	Size of Field in Acres										Total Decrease
	0.5 to 1.5	1.5 to 2.5	2.5 to 3.5	3.5 to 4.5	4.5 to 5.5	5.5 to 6.5	6.5 to 7.5	7.5 to 8.5	8.5 to 9.5	9.5 to 10.5	
	Decrease in Man Hours										
Plowing	1.92	.88	.56	.44	.35	.29	.28		.40*		5.12
Cultivating	.81	.37	.23	.18	.15	.12	.12	.08			2.06
Mowing	.50	.23	.14	.12	.09	.08	.07	.05	.05	.04	1.37
Raking	.26	.12	.08	.06	.05	.04	.04	.02	.03	.02	.72

*This represents the decrease in time between fields averaging 8.5 acres in size and those averaging 6.5 acres, since the only fields between 7.0 and 8.0 acres in size were plowed with a tractor and were therefore not included.

In producing silage corn the yield per acre has an important relationship to the number of man hours per ton necessary for cutting corn. Where the yield is from 4 to 7 tons per acre the average cost with hand cutting is 1.45 hours per ton, but where the yield is 10 to 13 tons per acre the average cost is .84 per ton. With machine cutting, 0.33 hours per ton is necessary when the yield is 7 to 10 tons per acre and 0.23 hours per ton when the yield is 10 to 13 tons per acre.

In studying the labor expenditures in filling silos it was found that the man labor required when the corn was hauled in a tip cart was 2.53 hours per ton and by truck, 2.39 hours per ton, but when a low wagon rack was used the man labor required was reduced to 1.9 hours per ton. Since silo filling is one of the farm operations which makes a very heavy demand on the labor supply of the farm, a careful study was made of the labor costs of silo filling. It was found that 31 man hours per acre, or 3.28 man hours per ton were required to fill silos; that silo filling in competing dairy regions was carried on at considerably lower labor costs; and that there was a wide range of difference in the labor costs on different farms in Connecticut. In order to ascertain the possibility of reducing labor costs in silo filling, three farmers cooperated in putting into practice the best known methods of organized silo filling. This involved the use of no new machinery except the making of a low wagon rack—a job which can be done very quickly and at practically no extra expense to the farmer. On these test farms the labor was reduced from the average of the region, 31 hours per

acre, to 10.18 hours per acre, practically one-third. The labor cost per ton was reduced from 3.28 hours, the average for the region, to 1.22 hours per ton—a saving of approximately 63%. These savings were effected by improved organization of the silo filling crew. The number of men per crew is cut approximately in half without any substantial addition to the amount of work per man.

(b) *Net productivity of different soils in producing hay.*

Another unit of this study was completed with the development of a statistical approach to certain agronomic questions basic to land utilization research. The purpose was to determine the degree to which

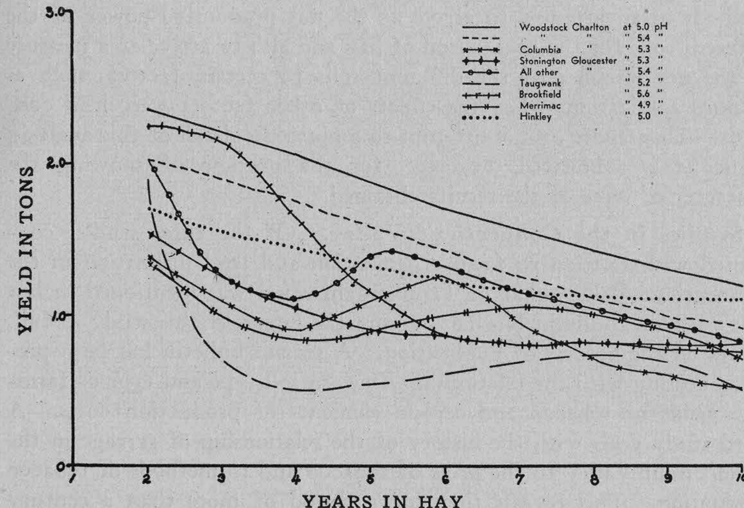

FIGURE 4. Yield of hay on several soils; no manure applied after seeding.

soil type, soil series, amount of manure and fertilizer, soil acidity, and the number of years since the field had been seeded, were responsible for hay yields in Eastern Connecticut. The following table shows the extent of the relationship found to exist between soil type and yield.

Relation of Soil Type to Hay Yield in Eastern Connecticut on 190 Dairy Farms

Soil Groups	1928			1929		
	No. Farms	Av. Crop Index	St. Dev. of Av.	No. Farms	Av. Crop Index	St. Dev. of Av.
I	33	109.1	39.2	29	114.1	41.1
II	37	102.9	33.5	30	104.5	33.9
III	13	94.4	31.8	12	101.0	39.1

Although these averages may be indicative of superior productivity of farms having over 75% of their improved area on soils of Group I, they do not explain why there is such a wide scatter around these averages. The standard deviations are large in every case, about one-third the size of the average, which indicates that there are wide variations in the crop indices of these farms which cannot be explained on the basis of the above soil grouping. The problem of the study was to measure by methods of multiple and partial correlation (Beane's method) the effects of the various factors responsible for the wide dispersion about the average crop index. The effects of these factors were successively eliminated through various statistical and logical methods in an attempt to arrive at the net productive power of the different soils for the production of hay and also to arrive at a measure of the net response of the different soils to certain factors, such as manure application, when the effects of other factors were held constant. This report cannot attempt to go into the detail of this analysis. Figure 4 is submitted, however, for the purpose of showing the character of some of the results obtained.

Studies in the Connecticut Valley. Of the three studies conducted with relation to farm organization and land utilization in the Connecticut Valley, that on farm organization was mentioned in last year's report. Bulletin No. 165, giving the report of this study in full, is now in the process of publication. A second bulletin has been prepared dealing with the relationship between soil type and type of farming, yields of tobacco and certain elements of production costs. A third study deals with the history of the relationship of acreage in the Connecticut Valley to the price of tobacco and to methods of tobacco production. This reveals that for a period of more than a century there has occurred an ebb and flow of tobacco production in the various sections of the Connecticut Valley. The areas have expanded when prices and costs of production have been favorable to the farmer and have contracted when they have become unfavorable. In general, there is a section which may be called "the heart of the Valley" including a few towns on either side of the Connecticut River and adjacent to it, in which tobacco production remains fairly constant irrespective of economic conditions. About this there is a zone in which the volume of production tends to advance and recede as conditions become more or less favorable. The three studies noted above have all been completed and will be published during the coming year.

Factors affecting the price of tobacco. A fourth study relating to the agriculture of the Connecticut Valley is at present being carried on in cooperation with the United States Bureau of Agricultural Eco-

nomics. This project is entitled "The Determination of the Factors Affecting the Prices of the Various Types and Classes of Cigar-leaf Tobacco." Its purpose is to determine the relationships which have prevailed between cigar-leaf tobacco prices and such factors as the supply of tobacco, its quality, numbers of cigars produced, and the general price level, and to deduce from these past relationships probable future trends in tobacco prices.

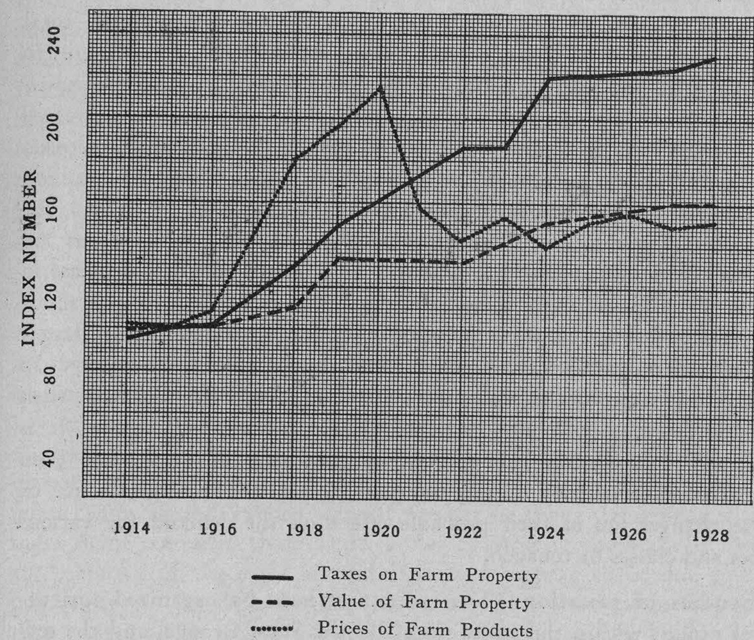

FIGURE 5. The trends of prices of farm products, value of farm property and taxes on farm property.

Since 1922, the annual average prices of the various types and classes of cigar-leaf tobacco have fluctuated widely. The ranges in cents per pounds have been: Connecticut Valley Broadleaf 18.9 to 30.0; Connecticut Valley Havana Seed 16.1 to 31.5; N. Y. and Pa. Havana Seed 15.3 to 37.0; Wisconsin types 9.0 to 16.0; Miami Valley types 8.5 to 17.5; Pennsylvania types 10.4 to 18.1. Preliminary analyses have indicated the necessity of a separate determination of the price factors for each type and class of cigar-leaf tobacco and the inadequacy for that purpose of the data now available. Prior to 1922, crop estimates of cigar-leaf tobacco were made only as state totals. Since that year each type has been estimated separately. Complete separation by types of the stocks of tobacco held by dealers and manufacturers was begun in 1929. Longer series of comparable data are necessary for detailed price analysis.

Tobacco dealers and farmers in Connecticut have cooperated in furnishing information as to the quality and price of their tobacco of each crop and each type. It is planned to obtain similar information from others of these two groups. These sources should yield fairly reliable measures of the price and quality of Broadleaf and Havana Seed during the past 15 or 20 years. Within that period the total acreage of those two types of tobacco has varied from 19,300 acres to 35,134 acres and many significant changes have occurred in the industry. The number of cigar factories in the United States has decreased from 20,555 in 1912 to 7,502 in 1929. The number of large factories has increased; factories producing annually more than forty million cigars each increased in number from 11 in 1921 to 28 in 1928. The total cigar production of the United States has decreased from 7.6 billion cigars in 1913 to 6.4 billion in 1928 with a further decrease in 1929. The use of cigar manufacturing machinery has brought about the concentration of cigar production in fewer factories. A larger proportion of low-priced cigars is now produced than formerly. In 1921, 26 percent of the cigars were intended to retail at not more than five cents each; in 1928, 52 percent were in this price class. It is generally agreed that the quality of this class of cigars has been improved substantially during the past 10 years. The significance of these changes lies in their probable effect on the demand for various types and classes of tobacco.

Studies of taxation. The interest evinced by organized agricultural groups within the state, especially the State Grange, and the setting up of a permanent Taxation Committee by the Connecticut Agricultural Policy Conference, resulted in the undertaking of a special project entitled "A Survey of Taxation in Connecticut with Emphasis upon its Relation to Agriculture." For the prosecution of this study the services of Dr. M. Slade Kendrick of Cornell University, a specialist in public finance, were secured. This study consisted of two parts: first, a study of the taxation loads borne by Connecticut farmers, and second, a survey of public receipts and expenditures, both state and local, and of public debts and their trends, for the purpose of arriving at some conclusions with relation to the interests of the property owner, especially the farmer, in the taxation problem. A full report is in process of publication.

Animal Diseases

Studies on infectious abortion in cattle.

(a) *Establishment and maintenance of abortion-free herds.* At the present time there are 80 herds, representing a total of about 2300 head, under observation. Of this number, five were free from positive reactors to the agglutination test for infection with Br. abortus on the initial test. In 35 herds Bang's disease has been completely eradicated through systematic blood testing and nearly so in 16 others. Nine additional herds which discontinued testing after eradicating the disease make a total of 49 clean herds with a total of over 1400 head. During the past year 29 new herds have been placed under test. Four of these were free from infection on the initial test and seven others, from which the reactors have been removed, were free on the last test made this year. The total number of blood samples tested during the year was 7523, of which 2779 were sent to the laboratory. (Project No. 1a. In cooperation with Dairy Husbandry.)

(b) *Types of Br. abortus recovered from 129 cases of undulant fever.* A comparison of Huddleson's dye plate method and the glucose utilization method of McAlpine and Slanetz has shown that the results obtained by these two methods are in close agreement. Both procedures were employed in a study of 129 strains of Br. abortus of human origin. Of 111 strains isolated from cases of undulant fever in the United States, 45 were found to be of the bovine type and 66 of the porcine type by both methods of differentiation. Eighteen additional strains obtained from Denmark and Sweden were of the bovine type. In regions where more swine are raised than cattle, as for example in the State of Iowa, the majority of the cases of undulant fever appear to be due to the porcine type. On the other hand, in areas where more cattle are raised than swine, as for example in the State of Michigan, the bovine type appears to be the principal causative agent. The ratio of bovine to porcine types, based on the total number of strains studied (129) is 63 to 66, whereas the ratio of the total number of cattle to swine in the states and countries from which these strains were obtained is about 12 to 17.

(c) *Studies on microbic dissociation in the abortus-melitensis group.* Further studies on the "mucoid" form of Br. abortus have shown that antisera prepared by the injection of ordinary Br. abortus cells will agglutinate ordinary cells but will not agglutinate mucoid cells, whereas antisera prepared by injecting mucoid cells will agglutinate both mucoid and ordinary cells of Br. abortus. This condition suggests that the mucoid forms of Br. abortus and possibly Br. melitensis possess a double antigen complex as compared with only one complex in the normal type. In common with other capsulated bacteria, the mucoid cells have poor agglutinogenic properties, and rabbits which have received injections show the presence of agglutinins only after repeated large doses. Further studies are in progress to show the serological relation of the mucoid forms of the bovine and porcine types of Br. abortus to Br. melitensis.

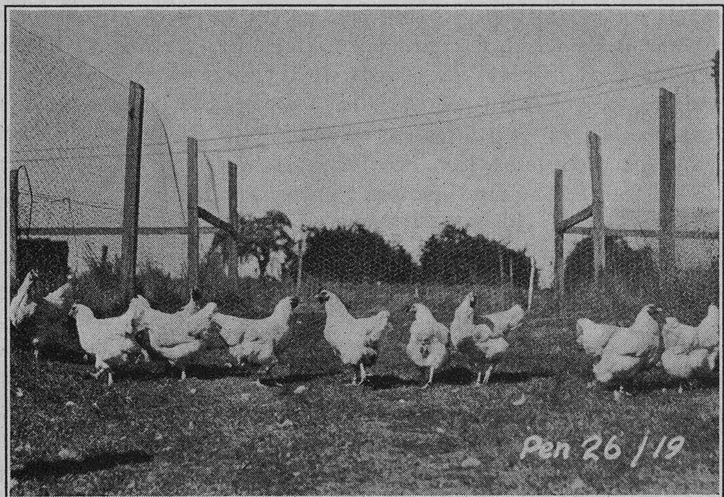

FIGURE 6. White Plymouth Rocks, Egg Laying Contest of 1930. First Prize for all round excellence. Owned by E. H. Rucker, Ottumwa, Iowa.

(d) *The occurrence of Br. abortus infection in man.* Increased interest during the past year in the occurrence of undulant fever in Connecticut has been reflected in the number of human blood samples submitted for diagnosis. This year, 325 samples were received as compared with 174 during the previous year. Fifty-one of these agglutinated Br. abortus antigen in dilutions of 1:100 or higher; 64 in dilutions of 1:50; and 74 in dilutions of 1:25. Clinical histories obtained in 15 cases were characteristic for undulant fever. Seven of ten cases recognized during the last four months of the year occurred in rural and three in urban districts. A greater incidence of infection has been observed in males than females. In 20 of 26 cases on which clinical data are available the agglutinin titer of the patient's serum has been greater than 1:1000, and in only two cases less than 1:100.

Blackhead of turkeys. The work of 1929 was a continuation of the experiments of preceding years which were reported in Station Bulletin No. 156 (April, 1929). The main purpose of the investigation is twofold; namely, to determine further the influence of frequent ground rotation on blackhead mortality, and to obtain additional information regarding the role that the ordinary barnyard fowl plays in the transmission of the infection, the chickens acting more or less as passive carriers.

The experiment of 1929 supported the earlier conclusions that weekly rotation is an important means of reducing blackhead mortality to a low and insignificant rate, as the following table shows.

Turkey Lots	Original Number in Lot	Deaths from Blackhead	Percent. Deaths from Blackhead
(1) Winter Control	51	12	24
(2) Summer Control	51	9	18
(3) Rotation	50	4	8

The experiment also emphasized the importance of allowing the ground to rest during the winter and spring months (Lot 2 as compared with Lot 1). Added evidence has been obtained to incriminate chickens as gross carriers of blackhead. In order to extend this phase of the general investigation two new yards (100 by 100 feet) have been added to the previous plant. These are filling an important need in the 1930 program.

Infectious Mastitis. The prophylactic use of autogenous herd bacterins as a means of preventing the spread of bovine infectious mastitis has been tried on three commercial dairy herds within the state for the past two years. No severe cases of mastitis have occurred in two of the herds during the past 18 months. An occasional case of mastitis has occurred in the third herd. For the most part these have apparently been caused by staphylococci as indicated by bacteriological examinations of the udder secretion from the affected animals. Several animals in the same herd have continued to give "thick milk" at irregular intervals. Failure to detect an appreciable number of bacteria of any kind, either by direct microscopic examination or by cultural examination of the udder secretion of these animals suggests some other cause than bacterial infection as the responsible agent for the "thick milk."

The predominant kinds of bacteria recovered from 102 milk samples from active cases of mastitis received during the past two years are as follows: Beta streptococci 57, alpha streptococci 31, gamma streptococci 6, staphylococci 11, diplococci 4, negative 3. It has been observed that one or several of these organisms may be the cause of udder inflammation in a given herd.

Studies on a pullorum-like disease in domestic fowl. A study of a disease outbreak affecting adult barnyard fowl and young chicks, and apparently caused by an organism which is not identical with any that have hitherto been described was begun in January of this year. The mortality observed in young chicks has varied from five to seventy percent and in adult stock from five to twenty-five percent.

The causative organism was isolated on liver infusion agar and was found to be non-motile and non-sporulating and to stain readily with ordinary dyes. Primary cultures failed to grow on standard nutrient agar and the same agar plus 1 percent glycerol. The isolations from chicks and adult birds all showed marked pleomorphism. Many of the cells were elliptical, averaging 2u x 2.5u in size and occurred singly or in pairs while others were quite large rods or short filaments, assuming giant forms at times and appearing swollen or club-shaped. The diameter of these forms often attained 3-4u and the length from 5 to 20 u. Other cells were decidedly smaller and occasionally resembled S. pullorum.

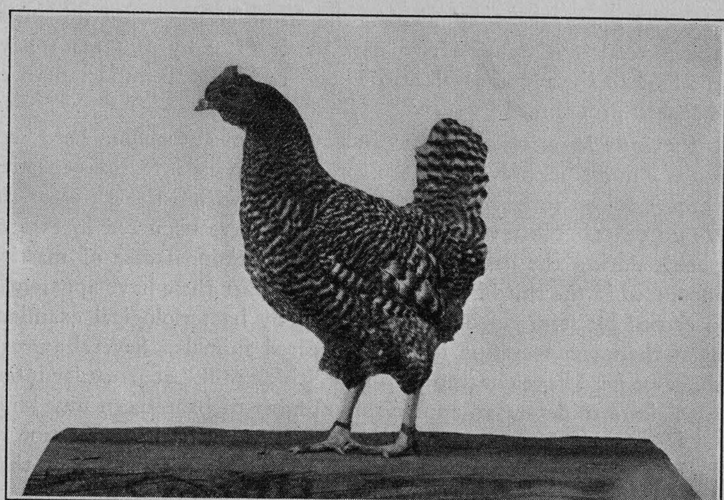

FIGURE 7. Barred Plymouth Rock No. 24, Egg Laying Contest of 1930. 334 eggs in 365 days. Owned by James Dryden, Modesto, Calif.

The organism in question has been found to resemble S. pullorum serologically and also in ability to ferment differential sugars in broths prepared from sugar-free meat infusion. On the other hand, it differs materially from the well known pullorum disease organism in morphology, cultural requirements and virulence for adult birds.

Dairy Husbandry

Infectious abortion in cattle—methods of control and eradication. So far as the college dairy herd is concerned the principal object at present is to determine the practicability of maintaining a herd free from Brucella abortus infection. The herd has been free from abortion since June, 1925. No particular precautions have been taken other than with reference to the introduction of animals. The barns are open to visitors at any and all times and there are animals in the community that are known to be infected. Notwithstanding these conditions the herd has continued to give every evidence that it is entirely free of infection with Brucella abortus. The agglutination reactions of all animals over six months of age in the herd during the past four and one-half years have been studied. 178 females were involved. 1798 individual tests have been made on animals which varied all the way from a few on young heifers to over thirty on cows that had been continuously in the herd during this time. In making the agglutination tests the Animal Diseases Laboratory has continued to use dilutions of 1-25, 1-50, 1-75, 1-100, 1-150 and 1-300. In all of these tests not a single positive reaction has occurred.

1599 of the individual tests have been entirely clear in each tube (0 0 0 0 0 0)
140 tests gave a slight agglutination in the first tube (? 0 0 0 0 0)
9 tests gave a 2 + reaction in the first tube (2 + 0 0 0 0 0)
2 tests gave a 3 + reaction in the first tube (3 + 0 0 0 0 0)
37 tests gave some reaction in the first tube and ? in the second
1 test reacted in the first tube and gave a 2 + in the second
7 tests gave some reaction in the first two tubes and a ? in the third
3 tests on two different animals gave a 2 + ? ? ? 0 0 reading.

Among all of these tests only the latter three would have been looked upon with a degree of suspicion in an infected herd. Those tests reacting slightly in the third tube (1-75) would have been marked doubtful in the summary but would not be looked upon with any great suspicion. It should also be noted that none of the tubes gave a reading of 4 + in either the first or second dilutions.

These results show clearly that full positive reactions do not occur in a clean herd. Also they demonstrate what had been our previous observation, that some non-specific reactions, usually slight, may occur in the lower dilutions, particularly the 1-25 and 1-50.

Corn silage feeding investigations. During the past two winters three trials were conducted to determine the optimum amount of silage for the ration of dairy cows. The combined results of these three trials, all of which were in agreement, may be briefly summarized as follows:

	Heavy Silage	Light Silage
Silage consumed	36,578	18,319
Hay consumed	10,579	14,834
Grain consumed	9,471	9,416
Dry matter consumed	27,677	27,053
4% milk	25,616	25,763
Weight change	—72	—120
Feed cost* 100 lbs. milk	$1.93	$1.73

*Grain valued at $52, hay $16, and silage $9.

In each trial one group of animals was fed about the standard amount, slightly over three pounds of silage per hundred pounds of live weight, while the other group was fed exactly one-half as much. In other respects the conditions were the same for both groups, except that the animals were allowed to eat all of the hay they would clean up in two feedings per day.

The trials demonstrated that the animals on half the usual amount of silage were able to maintain their milk yield and their weight as successfully as the other group. No more grain was required, but naturally the group on limited silage consumed more hay than the other group. When calculated on the basis of cost of feed, with grain at $52.00 per ton, hay at $16.00 per ton, and silage at $9.00 per ton, the group receiving heavy silage produced milk at a cost of $1.93 per hundred as compared to $1.73 per hundred for the light silage fed group. In case the prices of roughage were varied to suit other conditions it may be stated that with silage at $5.00 per ton, hay could be valued at $23.00 per ton before the feed cost of milk production became equal for the two groups.

Effects of freezing on milk. In continuing the project on frozen milk a series of experiments was conducted to ascertain the effect of homogenization on the stability of casein when milk was held in a frozen state. The frozen milk was held at +10°F. and —14°F. for four months. Milk was homogenized at 2000 and 4000 pounds pressure. The results obtained with the control milks both at +10° F. and —14°F. are in perfect agreement with the results of previously reported experiments. That is, there was only a slight precipitation of casein when milk was held at —14° F. but at +10° F. a heavy precipitation of casein occurred.

Homogenization of milk at 2000 pounds per square inch caused a slightly greater increase in precipitation of casein as compared with the control lots when the milk was held at +10°F. When milk was homogenized at a pressure of 4000 pounds per square inch and held at +10°F. the precipitation of casein occurred approximately twice as rapidly as that homogenized at 2000 pounds.

At the holding temperature of —14°F. the precipitation of casein was not influenced by homogenization pressures.

Chemical investigation of gargety milk. A chemical analysis of gargety milk was begun during the past year in an effort to determine some of the chemical characteristics of gargety milk as compared to normal cow's milk.

The total nitrogen content of 56 samples of gargety milk averaged 643.75 milligrams per 100 cc. of milk, varying from 332.30 to 1150.10 milligrams per 100 cc.

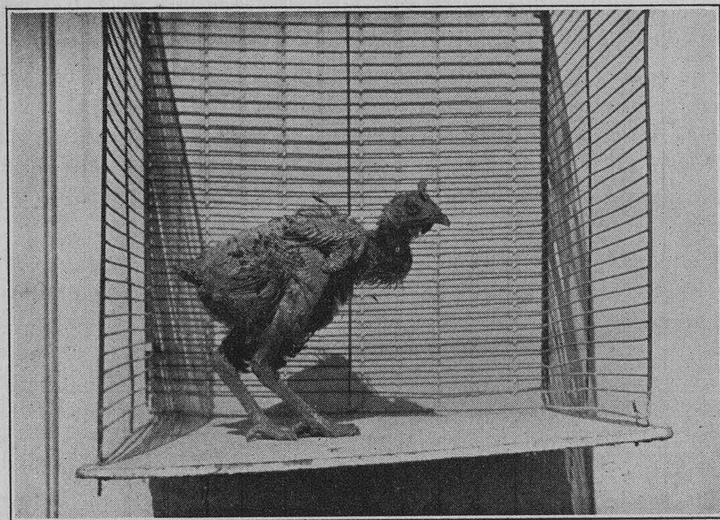

Figure 8. Genetically pure (homozygous) Frizzles are frequently almost bare of feathers. In this condition they are not good breeders.

The total nitrogen content of normal milk was found to be 485.56 milligrams per 100 cc. Thirty-three samples of gargety milk contained more and nineteen samples contained less total nitrogen than the average of the normal milk.

Likewise the amino nitrogen content of gargety milk was higher than that of normal milk. Normal milk was found to contain 12.36 milligrams of amino nitrogen whereas gargety milk contained 36.55 milligrams per 100 cc. of milk. The amino nitrogen content of gargety milk varied from 16.8 to 112.0 milligrams per 100 cc. of milk. In no case was the amino nitrogen content of gargety milk lower than the average of normal milk.

A study of the cost of cooling milk by electrical refrigeration on farms. Data on the cost of cooling milk with electricity have been collected for a period of one year. Cooling tanks of the wet storage type were studied on seven farms in North Coventry, Connecticut. A summary of the year's study shows that:

1. The average cost of cooling 100 pounds of milk with electricity for the wet storage type of cooling tanks on seven farms was 15.07 cents.
2. The average investment in the cooling unit (compressor) and wet tank was $343.57 and $125.41 respectively.
3. The average number of kilowatt hours of power needed to cool 100 pounds of milk was 1.103.

The effect of homogenizing pressure on the body and texture of ice cream. Many ice cream manufacturers have wondered if it is possible to use a higher homogenizing pressure as a substitute for gelatin. In other words, can a suitable body in ice cream be obtained by increasing the homogenizing pressure and reducing the percentage of gelatin?

Preliminary results indicate that it is possible to secure a smooth, velvety body in ice cream by increasing the homogenizing pressures and reducing the gelatin. The additional cost of current used when homogenizing at 3000 pounds rather than at 2500 pounds per square inch is very slight. It was found that 1.5 kilowatts of electricity were needed to homogenize a 50 gallon mix at 2500 pounds pressure while 2 kilowatts were needed when homogenizing at 3000 pounds pressure. The additional power per 50 gallons of mix would cost 1.5 cents at a 3 cent power rate. If the gelatin were reduced from 0.4 to 0.1 percent a saving of 1.425 pounds of gelatin per each 50 gallon batch would be effected. With gelatin at 40 cents a pound the net saving for each 50 gallon mix would be 55.5 cents.

Animal Breeding

Inbreeding experiments with white leghorns. The actual breeding work has been discontinued. A large amount of observations, collected in these experiments, remains to be analyzed. One inbred line, showing a strikingly high embryo mortality early in incubation has been purchased by the Bureau of Animal Industry for a study of the factors involved in this mortality. Another line is being used in inbreeding work at Mount Hope Farm, Williamstown, Massachusetts.

Rumplessness. An attempt is being made to select for a high grade of intermediate rumplessness in order to secure material for a genetic

study of the intermediate condition. It also was decided to search for linkage between rumplessness and any other easily classifiable morphological character. A linkage, if found, would be helpful in differentiating the mode of inheritance of rumplessness and intermediate rumplessness. The first character to be tested for linkage with rumplessness is crest.

The creeper fowl. A series of further matings has added considerable evidence concerning the lethal nature of the Creeper gene in homozygous condition. It was found that not only do the homozygous

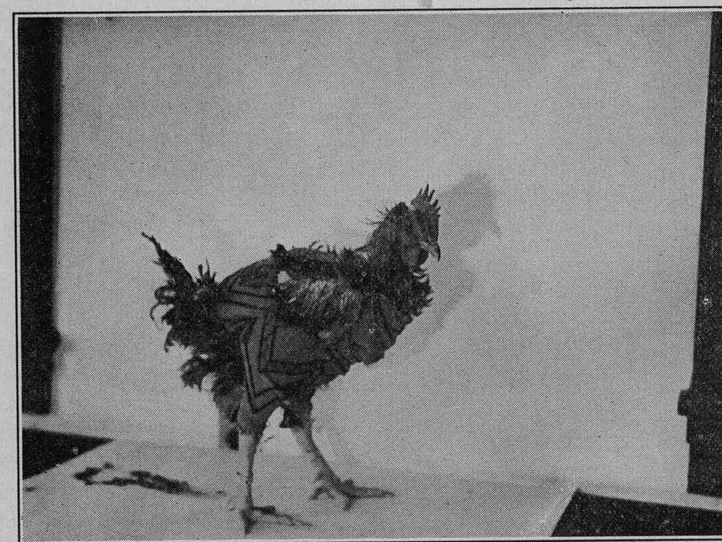

FIGURE 9. If Frizzle fowls are kept in a heated room or provided with a covering as shown above, they will develop good plumage. (See Figure 10.)

embryos not survive but even in heterozygous condition the Creeper gene has a slight lethal effect. This is demonstrated by the fact that in inter-se matings of Creepers as well as in crosses between Creepers and normal fowl there is an excess of Creepers among the chicks which failed to hatch and a deficiency of Creepers among the hatched chicks. These deviations from the expectation are significant and demonstrate the pathological nature of the Creeper condition. A histological comparison of Creeper and normal bones has demonstrated a close relationship of the Creeper condition to chondrodystrophy. The endochondral ossification of the long bones is strikingly deficient.

The frizzle fowl. An analysis of the experiments with Frizzle fowl demonstrates that there are at least three distinct types of frizzling: homozygous Frizzles which are almost bare and if feathered have an extremely curly plumage; exhibition-type Frizzles with a complete body covering consisting of feathers with a rather high grade of frizzling; and F_1-Frizzles from out-crosses to normal fowls, showing only a low expression of the Frizzle character.

Crosses of normal females to a male of any of the three different Frizzle types gives a normal hatchability. In crosses of exhibition-type Frizzles inter-se and of homozygous females to normal males, however,

FIGURE 10. A Frizzle with good plumage as a result of wearing the "overcoat" shown in Figure 9.

the hatchability is very low, while it is normal if F_1-Frizzle females are used.

Among the homozygous Frizzles a high percentage of both males and females remains immature. Males of this type show degenerative changes in the tests.

Exhibition-type and homozygous Frizzles show a higher food consumption than do normal chickens. It is assumed as a working hypothesis that the basal metabolism of Frizzles is increased in proportion to the deficiency of the plumage. This will be tested experimentally.

The feathers of F_1-Frizzles, exhibition-type Frizzles, and homozygous Frizzles show increasing structural deficiencies.

Cross-beak. A mating between two pullets and a cockerel all showing a marked bending of the upper beak gave a considerable progeny consisting exclusively of normal chicks. This indicates that the cross-beak condition is not inherited.

Home Economics

Factors that determine standards of living in farm homes. This is the general title of a series of studies started in 1928 in 160 farm homes in eastern Connecticut. The first phase to be attacked was a sub-project entitled "Factors and Conditions Affecting the Amount and Use of Family Income in the Eastern Highland." The majority of these families have kept monthly accounts of all family expenditures for varying lengths of time.

In a preliminary analysis a random selection of ten account families was taken from the total, in an attempt to discover the trend of expenditures between native and foreign born families. The percentage distribution shows several interesting facts. The amount spent for food among the foreign born families was 4% higher than the amount spent by the native families. On the whole the foreign born expenditures appear higher than those of native born families for food, housing, clothing, and personal items. There is nothing conclusive regarding these percentages, as the sample is too small, but it may show the way the trend lies in this section of the state. It is comparatively simple to get accurate figures for the various items of family expenditures, whereas any workable estimate of the cash income available for farm family living expenses is difficult to obtain. It was finally decided that the cash income, which is the difference between the cash receipts and the cash expenditures gave the best figure for their income. To this was added any outside income they might receive, the farm produce used calculated on a retail basis, wood and ice supplied by the farm, and 10% of the house valuation as rent, in order to make an amount which might be considered a family income figure. During this period, the average income computed in this way for the whole group was $1885.67, of which $1951.34 represented the average income for the native born and $1819.60 for the foreign born families.

Poultry Husbandry

The Storrs laying contest. More 300-egg hens than in all the previous years put together constitute one outstanding feature of the test that ended October 23, 1929. These twenty hens include Barred

Rocks, White Leghorns, Rhode Island Reds, and Australorps, sent from Connecticut, Oregon, New York state, Missouri, Massachusetts, and Vermont. The most significant record, though perhaps not the most sensational, is the flock average of 205 as compared with the best previous record of 188 eggs per bird. This average is based on the 1000 pullets that were entered, irrespective of whether there was a full complement at the finish.

Up to 1923 any pen of ten hens that could lay from 2000 to 2200 eggs was an almost certain winner, whereas in 1928 and 1929 the two leading pens each laid over 2900 in 51 weeks and one of them made the total of 3014 eggs in one year. Obviously, poultrymen are doing better breeding and better grooming, and it is hoped that the station has made some small contribution by way of better feeding and better management.

An examination of the records of all the Rhode Island Reds that have participated in this project during the last 18 years shows that increased production in this breed amounts to almost exactly two eggs per hen per year. Thus the average annual yield for Reds has increased from about 140 eggs in 1911 to nearly 180 eggs per bird.

Analyses are being made of the records of other breeds, including Rocks, Wyandottes, and White Leghorns. These breeds like the Reds, all show a distinct trend upward in the matter of egg production.

Rural Sociology

The character of the rural population. During the past year, investigators again went into the towns of Killingworth, Goshen, Cheshire, Ellington, East Windsor, and Orange, and gathered further material regarding the families in these towns. Previous investigation furnished the basis for the bulletin, "The Genesis to Farming Occupations in Connecticut," published in October, 1929, as Bulletin 161. The new data are now being analyzed with a view toward presenting additional information regarding the characteristics of rural Connecticut population.

As yet, only one very definite result has been reached. It is quite evident that there is no principle or solution which can be applied generally to the social problems of the farmer in this state. The investigations in several towns show quite clearly that there is an individualistic character to each town which differentiates it from any of the others. Because of these marked differences, the problems facing each group and, in fact, those facing single individuals within the separate groups, depend in great measure on the immediate environment and are not applicable to the state at large. For example, it has already been ascertained that income and rate of mobility have a rather low negative relationship in all towns completed, with the exception of Killingworth where there is a comparatively high relationship between these two factors. The latter, no doubt, indicates the rather large group of people who have spent mobile lives and have come into the towns seeking a place to retire. This group, in contrast to the group that has always lived in towns and whose income has depended largely on what they have made from the farm, has an ample sum in investments, and this supplements, to a large degree, the remuneration from farm operation.

FIGURE 11. A row of Italian dwellings in Cheshire, with tidy yards and grape arbors.

Income and home equipment score show the consistently high positive relationship which might be expected. This seems to carry out the adequacy of the method, since it is evident that those families with the largest income will have the better homes regardless of the availability of such community conveniences as electricity and water power.

When the rate of mobility of the head of the family and the organizational membership of the family as a whole were compared, there was a relationship which was slightly negative, except in the case of Orange which showed a fairly high negative relationship. This seems to indicate that the more mobile people do not participate in local activities to the same extent as do the people who have lived in the town most of their lives.

In correlating home equipment scores with years of schooling, and with the number of newspapers and magazines read by the family, it was found that in both cases there were indicative positive relationships. These findings bore out the expectation that the better educated and more widely read people would tend to have more home conveniences.

Comparisons between home rank score and organizational membership have not been completed for all of the towns, but from the results at hand, there is a marked relationship between the higher home rank score and organizational memberships.

FIGURE 12. A prosperous dairy farm in Cheshire, owned by a family of native stock.

In examining the average rate of mobility it was found that the foreign-born cooperators had an average mobility rate only slightly higher than the native-born. This slight difference can no doubt be accounted for by the one extra move necessarily made by the foreign-born people in coming to this country. There is also a brief period of unrest in the lives of these immigrants while they are becoming adjusted to their new status of life. Discounting the brief period of rapid moves, the data would seem to indicate that the foreign-born farm people are more stable than are the native-born.

When the data have been completely analyzed and correlated, it will be possible to present fully the sociological "picture" of each of these towns. The present study aims to discern the problems which are before the residents of these six towns, and to give in that way a suggestion as to the social problems of the rural resident in Connecticut.

PROJECTS ACTIVE—1930-1931

Agronomy

7. Factors that may influence the vigor of seed potatoes.
   a. When free of the virus diseases.
      1. Maturity when dug.
      2. Plant nutrients available for "seed" crop.
   b. Rapidity of spread of the virus diseases in various sections of Connecticut.
12. Alfalfa experiments.
   a. Fertilization.
   b. Nurse crops.
   c. Dates of seeding.
14. The maintenance and improvement of pastures.
   a. The effects of fertilizer treatments on the soil, the flora, and the production as measured by grazing.
   b. Effect of time of cutting on bushes and weeds.
   c. Response of pasture species to plant nutrients.
   d. A study of the adaptability of varieties and species of grasses and clovers for pastures.
   e. Relation between chemical reactions of the soil and the response of vegetation on permanent pastures.
16. Fertilizing the dairy farm rotation to determine:
   a. If manure should be applied to corn or hay.
   b. If manure should be reinforced with superphosphate.
   c. If fertilizer should be used as a "starter" for the corn crop, when manure is applied at 12 tons per acre.
19. Hubam for hay and nurse crop.
20. Test of legumes to seed in small grains.
21. Biennial sweet clover for Connecticut pastures.
25. Rate and method of applying fertilizers for corn.
26. Rate and method of applying fertilizers for potatoes.
27. Response of various crops to different levels of fertility.

Agricultural Economics

2. The economic significance of soil type.
   a. Studies in the Eastern Highland.
   b. Studies in the Connecticut Valley.
   c. Types of farming.
3. The economic conditions affecting agriculture in the Connecticut Valley.
   a. An economic study of the tobacco industry.
   b. A study of tobacco farm organization in selected areas.
   c. The determination of the factors affecting the prices of various types and classes of cigar leaf tobacco. (In cooperation with the U. S. D. A.)
4. Farm taxation studies.

Animal Diseases

1. Studies on infectious abortion in cattle.
   a. Establishment and maintenance of abortion-free herds by periodic blood testing and complete segregation of non-reacting animals and disposal of reactors. (With Dairy Husbandry.)
   b. Studies on the metabolism of the abortus-melitensis group.
   c. Studies on microbic dissociation in the abortus-melitensis group.
   d. The occurrence of bact. abortus infection in man. (With State Department of Health.)
   e. Types of Br. abortus.
   f. Mode of transmission of Bang's disease.
2. Blackhead in turkeys. (With Poultry Husbandry.)

3. Studies on infectious mastitis.
   a. Efficacy of autogenous herd bacterins in the control of bovine mastitis. (With Dairy Husbandry.)
   b. Differential studies on streptococci of bovine origin.
4. Further studies on a pullorum-like disease affecting young and adult domestic fowl.
5. Studies in infectious tracheitis. (With Poultry Husbandry.)

Dairy Husbandry

1. Infectious abortion in cattle—methods of control and eradication. (With Animal Diseases.)
2. Studies on corn silage for dairy cattle.
   a. Influence of the quantity of silage in the ration on the cost of production.
   b. The succulent value of silage.
3. Inheritance of fat percentage in the milk of dairy cows.
7. A study of herd records of four dairy breeds.
13. A study of the effects of freezing and storing in a frozen state upon the physical-chemical properties of milk and milk products.
14. Infectious mastitis.
   a. Efficacy of autogenous herd bacterins in the control of bovine mastitis. (With Animal Diseases.)
15. A study of the cost of cooling milk by electrical refrigeration on farms.
16. The effect of homogenizing pressure on the body and texture of ice cream.

Genetics (Animal Breeding)

2. A study of the factors involved in the hatching of eggs.
   a. Genetic (lethal) factors as a direct cause of low hatchability and a study of the embryonic expression of such factors. (Creeper fowl.)
   b. Genetic factors as an indirect cause of low hatchability. The possible bearing of genetic characteristics upon the metabolism of the chicken and, thereby, upon the hatchability of the egg. (Frizzle fowl.)
   c. External factors acting upon the chicken or directly upon the egg in their relation to hatchability and embryonic mortality.
   d. The influence of external agents upon physical characteristics of the constituents of the egg during incubation as compared with normal conditions, with special reference to viscosity.
4. Studies on the inheritance and linkage relations of morphological characters in poultry. (Frizzle, Creeper, Rumpless, Cross-beak, etc.)
5. Experiments concerning the physiology of moulting and of pigmentation.
6. Experiments concerning the influence of heavy metal treatment of males upon the mortality of their progeny by untreated females.

Home Economics

1. Factors that determine standards of living in farm homes.
   a. Factors and conditions affecting the amount and use of family income in the Eastern Highland.
   b. An economic analysis of the food consumed by a selected group of families in the Eastern Highland.

Poultry Husbandry

6. Storrs International Egg Laying Contest.
8. Blackhead in turkeys. (With Animal Diseases.)
9. Studies on infectious tracheitis. (With Animal Diseases.)

Rural Sociology

1. The origin and character of the rural population.
   a. The vocational genesis of Connecticut farmers.
   b. The mobility of the rural population in Connecticut.
   c. Recreational facilities and their use by the rural population.

PUBLICATIONS

Bulletins

No. 157. THE SHEEP STOMACH WORM.

No. 158. STUDIES ON INFECTIOUS MASTITIS WITH SPECIAL REFERENCE TO STREPTOCOCCI—FIRST REPORT.

No. 159. CORN SILAGE FEEDING INVESTIGATIONS—RELATIVE FEEDING VALUES OF THE DRY MATTER OF DIFFERENT TYPES OF SILAGE CORN ENSILED AT DIFFERENT STAGES OF MATURITY.

No. 160. THE CAUSES OF DEGENERATION OF IRISH POTATOES IN CONNECTICUT.

No. 161. THE GENESIS TO FARMING OCCUPATIONS IN CONNECTICUT.

No. 162. REPORT OF THE DIRECTOR, 1929.

No. 163. STUDIES ON THE PLUMAGE OF THE SILVER SPANGLES FOWL.

Journal Papers

ANDERSON, E. O. and PIERCE, R. L. Some Chemical Changes in Frozen Milk Occurring in Storage. The Milk Dealer, Vol. 18, No. 12, pp. 60-63. September, 1929.

BROWN, B. A. Reseeding Pastures. Rural New Yorker, pp. 670-671. May 17, 1930.

——————. Pasture for Six Months. Rural New Yorker, pp. 696-697. May 24, 1930.

——————. Pasture Fertilization. Rural New Yorker, pp. 320-321. March 1, 1930.

——————. Controlling Weeds and Bushes in Pastures. Rural New Yorker, p. 87. January 18, 1930.

——————. Fertilized Pastures in Dry Weather. Rural New Yorker, p. 1484. December 14, 1929. (Also in Eastern States Cooperator.)

——————. Effect of Time of Cutting on the Elimination of Bushes in Pastures. Jour. Amer. Soc. Agron., Vol. 22, No. 7, pp. 603-605. July, 1930.

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DUNN, L. C. and LANDAUER, WALTER. Further data on a case of autosomal linkage in the fowl. Jour. of Genetics, Vol. 22. 1930.

HYPES, J. L. Sociological Research as a Function at State Experiment Stations. Accepted by Jour. Ed. Soc.

——————. The Immigrant Farmer in New England Agriculture. Accepted by the American Geological Society for publication in "Regional Studies in New England."

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LANDAUER, WALTER and DUNN, L. C. The "Frizzle" character of fowls; its expression and inheritance. Jour. of Heredity, Vol. 21. 1930.

MCALPINE, J. G., PLASTRIDGE, W. N. and BRIGHAM, G. D. Studies on the Metabolism of the Abortus-melitensis Group. 5. Factors Influencing Sugar Utilization. Jour. Inf. Dis., Vol. 45, No. 6, pp. 485-489. December, 1929.

PLASTRIDGE, W. N. Studies on Bovine Infectious Abortion. C. A. C. Review. January, 1930.

—————— and MCALPINE, J. G. Types of Br. abortus Recovered from 129 Cases of Undulant Fever. Accepted for publication by the Jour. Inf. Dis.

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PRATT, AVERY D. and WHITE, G. C. Optimum Amount of Silage. Jour. of Dairy Science, Vol. 13, No. 4, pp. 291-307. July, 1930.

RETTGER, L. F. and PLASTRIDGE, W. N. Eradicating Infectious Abortion. New England Homestead. November, 1929.

—————— ——————, MCALPINE, J. G. and WARNER, D. E. A Comparative Study of the Intradermal Pullorin Test and the Routine Agglutination Test. Jour. Amer. Vet. Med. Assoc., Vol. 77. July, 1930.

CHANGES IN STAFF

Appointments:

J. S. Owens, M.S., *Assistant Agronomist.*
H. B. Boyd, B.S.A., *Assistant Economist.*
E. H. Spaulding, B.S., *Research Assistant (Animal Diseases).*
D. G. Steele, Ph.D., *Assistant Geneticist.*
Carroll D. Clark, M.A., *Associate Sociologist.*
Eileen Kennedy, B.S., *Research Assistant (Rural Sociology).*

Resignations:

J. G. McAlpine, Ph.D., *Bacteriologist.*
J. F. Markey, Ph.D., *Associate Sociologist.*

All of which is respectfully submitted.

WILLIAM L. SLATE,
Director.

REPORT OF THE TREASURER

FOR THE YEAR ENDING JUNE 30, 1930

Receipts

State Appropriations:		
Current Expenses	$40,000.00	
Sheep Fund	2,000.00	
Federal Appropriations:		
Adams Fund	7,500.00	
Hatch Fund	7,500.00	
Purnell Fund	30,000.00	
Miscellaneous Receipts:		
Sales of Produce, etc.	5,004.61	
Fees—Infectious Abortion	5,433.98	
Fees—Advanced Registry	5,763.44	
Interest	350.00	$103,552.03
Balance July 1, 1929		1,874.86
		$105,426.89

Expenditures

Salaries	$57,711.76	
Labor	15,699.72	
Stationery and Office Supplies	1,479.48	
Scientific Supplies Consumable	2,441.27	
Feeding Stuffs	3,958.12	
Sundry Supplies	1,339.38	
Fertilizers	670.80	
Communication Service	622.99	
Traveling Expense	7,015.89	
Transportation of Things	360.48	
Furniture, Furnishings and Fixtures	2,478.11	
Library	820.76	
Scientific Equipment	2,525.59	
Livestock	260.00	
Tools, Machinery and Appliances	94.23	
Buildings and Land	531.50	
Contingent Expenses	993.33	$99,003.41
Unexpended Balance		6,423.48
		$105,426.89

Bulletin 172 April 1931

STORRS

Agricultural Experiment Station

Labor Efficiency in Planting and Harvesting on Eastern Connecticut Dairy Farms

Department of Agricultural Economics

CONNECTICUT AGRICULTURAL COLLEGE

STORRS, CONNECTICUT

BOARD OF CONTROL AND STAFF

TABLE OF CONTENTS

Labor Efficiency in Planting and Harvesting on Eastern Connecticut Dairy Farms

Based on a thesis by Donald O. Hammerberg [1]

Description

Purpose

Many of the farmers' expenses are fixed in character. Taxes and interest on investment in land and buildings are subject to little control by the farmer. On the other hand such expenses as those for labor, fertilizer, seed and machinery are subject to control by the farmer from year to year and even from month to month. Labor is one of the most important of these variable expenditures and it is with labor expenditure that this bulletin is concerned. The general purpose of the study is to determine why varying amounts of labor were used by farmers to achieve the same results. Labor is wasted for many reasons: because enterprises are small, because operations are poorly organized, because the wrong machinery is used, because yields are too low, and for other reasons. The causes are such that in many cases this waste can be eliminated without additional investment. However, before standards of labor efficiency can be set up it is necessary to know the reasons for variation in labor input.

Specifically, the objectives of this study are three:

1. To determine the physical units of labor used in the production of three crops: hay, oats and corn. These data are a part of the basic material necessary for establishing efficiency standards and setting up new forms of adjustment to changing prices.

2. To determine what factors are responsible for the variations in the number of hours used by different farmers in the production of these crops. The increased mechanization of agriculture has made this

[1] This bulletin is a digest and summary of a thesis on the same subject offered in partial fulfillment of his requirements for the degree of Master of Science in 1930 by Donald O. Hammerberg. Digested, summarized, and edited by I. G. Davis, assisted by Cecil G. Tilton and Albert E. Waugh.

This bulletin is the second of a series dealing with the economics of Eastern Connecticut agriculture, the first of the series being Bulletin 139 entitled "Soil Type as a Factor in Farm Economy. The Town of Lebanon."

phase of the study particularly important. It is obvious that before the position of an agricultural area or region can be properly determined or evaluated in comparison with other areas or regions it is necessary to know how uniformly these areas have adapted themselves to the practices which result in the greatest net profit. Data are presented in this paper which suggest, at least in regard to the use of human labor, that the farmers of the Eastern Highland of Connecticut have not made the necessary adjustments. Attention in this study is concentrated on the labor expenditures in planting and harvesting operations. The periods of these operations are essentially peak load periods, hence economies effected at such times are relatively more important than comparable savings in operations which are distributed throughout the year.

3. To contrast the results obtained by different methods of statistical approach in the same problem. The third objective appeared after the analysis was well under way. Different methods of approach yielded varying results; hence it appeared desirable to show contrasts wherever possible, especially when certain methods revealed significant facts which had not been disclosed by the attempts previously made. This probably has more significance for the research worker than for the extension teacher, or the farmer, although an appreciation of the limitations of statistical methods is useful to all.

Description of the Area and Types of Farms

The area studied[1] consisted of twenty dairy farms selected by methods of random sampling from eight representative towns in the Eastern Highland of Connecticut. Only farms with five or more head of neat cattle were selected, hence these were predominantly dairy farms on which approximately seventy percent of all labor was spent on cows and feed crops. The balance was devoted to poultry, fruit, forest products, outside labor, and miscellaneous crops. About seventy-five percent of the labor devoted to the care of cows and feed crops was used in the care of cows alone, and twenty-five percent was used in the care of crops. These percentage figures are not necessarily indicative of their relative importance however. The demand for labor on crops is large within short periods of the year, particularly during the spring work, haying and silo-filling operations.

[1] For a detailed description of the area see Appendix, page 43.

Comparison with Other Regions

Another rather important reason for undertaking a study of labor inputs on crops rather than on livestock was that Connecticut farmers have been more conservative in their response to labor-saving changes in the technique of crop production than they have in their response to similar changes in the care of livestock. Some comparisons of the representative efficiency of agricultural labor in dairying in different parts of the United States are given below:

TABLE 1. *Man-Hours per Cow, Milk Production per Cow, and Pounds of Milk Produced per Hour Spent on the Cows for Different Areas in 1926*[1]

Area	Man-Hours per Cow		Milk Production per Cow	Lbs. Milk per Hour Spent on Cows
Northern Vermont	129.9		5,110	39.3
Southeastern Vermont	125.9		4,893	38.9
Maine-New Hampshire	150.6		4,879	32.4
Southern New England	140.9	148.4[2]	6,588	46.8
Southeastern New York	135.4		5,203	38.4
New Jersey-Penn.-Delaware	143.5		5,786	40.3
Ohio-Indiana-Mich.	131.0		5,468	41.7
Wisconsin	141.5	138[3]	6,221	44.0
Iowa-Minn.	117.9		6,004	50.9

It will be observed that the regions which had a large number of man-hours per cow generally had high milk production figures. This probably means that a considerable portion of the extra labor actually represents extra care of the cows and not ineffective use of labor.

On the other hand, a comparison of labor inputs on crops shows very marked differences whether the comparison is made between the man-hours per acre or per ton for the different regions.

[1] Taken from "The Position of Northern Vermont Among American Dairy Farming Regions." Vt. Agr. Expt. Sta. Bul. No. 307.

[2] Average of figures obtained from 115 survey records obtained in study of Soil Type of Dairy Farms. Conn. Agr. Expt. Station. 1929.

[3] From "Farm Costs and Practices," Research Bul. 83. Wis. Agr. Expt. Station.

TABLE 2. *Number of Man-Hours Used per Acre and per Ton in the Production of Hay, Oats, and Corn Silage in Minnesota, Wisconsin, New York, and the Eastern Highland of Connecticut*[5]

Crop	Man-Hours per Acre				Man-Hours per Ton			
	Wis.[1]	Minn.[2]	N. Y.[3]	Conn.[4]	Wis.[1]	Minn.[2]	N. Y.[3]	Conn.[4]
Hay	10.78	6.9	9	6.31	4.07	4.6	5.29	5.89
Oats								
Spring Labor	4.39	3.7		10.55				7.67
Fall Labor	8.06	7.0		7.53				5.70
Total	12.45	10.7	14	18.08				13.37
Corn Silage								
Spring Labor	9.73	12.9		23.58	2.26	2.01		2.56
Fall Labor	7.80	12.8		29.53	1.82	2.00		3.16
Total	17.53	25.7	36	53.11	4.08	4.01	4.39	5.72
Silo Filling Alone	6.18	11.1		19.97	1.44	1.73		2.14

It will be observed that on the spring work Eastern Connecticut farmers used nearly twice as much man labor as Wisconsin and Minnesota farmers. The figures for spring work on oats as compared to corn would seem to indicate that Connecticut farmers were relatively more efficient in doing the spring work on corn than on oats.

The Eastern Connecticut farmers used nearly fifty percent more man-hours per ton of hay than Minnesota and Wisconsin farmers. Comparisons of the *per acre* figures for hay do not show such marked differences. This is primarily because Wisconsin farmers had a very high yield of hay; hence the man-hours per acre were high, but man-hours per ton were low.

[1] Research Bull. 83. "Farm Costs and Practices," by McNall and Ellis. Wis. Agr. Expt. Sta. Page 50, Table XXXIV; Page 30, Table XX; Page 19, Table XIII. The average of the 1924 data was used throughout.

[2] Technical Bull. 44. "A Study of Dairy Farm Organization in Southeastern Minnesota," by George A. Pond. Minn. Agr. Expt. Sta. Table XLVII, Appendix; Table XLV, Appendix; Tables XXXVIII and XLI Appendix. The average of the 1924 data was used throughout.

[3] "Preliminary Statistical Report of the Results of Farm Cost Accounting on Selected Farms in Various Parts of New York. Crop Year 1929," by J. F. Harriott; Cornell Univ. Agr. Expt. Sta.

[4] Survey records of 115 farms in the Eastern Highland of Connecticut in 1929.

[5] Note: The figures for Wisconsin and Minnesota were obtained from cost account records, while the Connecticut figures were obtained from survey records taken from farmers chosen at random. This perhaps raises the question of the comparability of the data, because the cost account farmers are not representative of the average farmer. The data for the Connecticut farmers were obtained in 1929, however, and there have been decided changes in the labor inputs in Connecticut since 1924, so that it is probable that there have also been marked changes in Wisconsin and Minnesota since that time. The averages for the cost account farmers in 1924 is probably fairly representative of the average farmer in those areas in 1929.

On corn silage spring labor the Connecticut farmers used only about twenty-five percent more man-hours per ton than did the Minnesota farmers, and only about twelve percent more than the Wisconsin farmers. This is primarily due to the lower yields in Minnesota and Wisconsin. However, a comparison of *fall* labor input yields more striking differences. In the harvesting operations the Connecticut farmers used 3.35 man-hours per ton as compared with 1.82 for Wisconsin and 2.0 for Minnesota, nearly seventy-five percent more than the average for the two Western states. Anyone who has given thought to the subject might expect that physical conditions such as stoniness and small fields would have much more effect on spring operations which are directly concerned with the soil, such as plowing, disking, planting, and cultivating, than on harvesting operations. To determine the reasons for this seemingly inefficient use of labor in harvesting corn silage was one of the aims in the study.

Acreage of Crops Grown

Before beginning the more detailed analysis of individual operations, it will be well to present some of the general descriptive data. The distribution of crops by towns is shown in the following table:

TABLE 3. *Number of Acres of Hay, Oats, and Miscellaneous Crops on the Farms Studied in Eight Towns of the Eastern Highland of Connecticut in 1929*

Towns	Acres in				
	Total	Hay[1]	Oats[2]	Corn	Misc.[3]
Columbia	428.09	286.40	43.72	54.94	43.03
Coventry	426.70	285.53	31.03	57.41	52.73
Woodstock	915.54	672.45	36.95	75.73	130.41
Brooklyn	944.09	667.38	79.81	85.60	111.30
Canterbury	757.30	542.09	63.79	74.74	76.68
Griswold	767.42	547.92	72.40	65.95	81.15
Stoningtons (two towns)	1161.35	854.88	57.28	162.98	86.21
Grand Total	5400.49	3856.65	384.98	577.35	581.51

[1] Includes Timothy, Mixed Hay, Clover and Alfalfa.

[2] Includes some Rye cut for Hay.

[3] Miscellaneous—includes Potatoes, Sweet Corn, Apples, Small Fruits and Garden Truck. Most of these crops were for family use.

Of the total tilled land 71.41 percent was in hay, 7.13 percent in oats, 10.69 percent in corn, and 10.77 percent in miscellaneous crops. The average yield per acre was 1.07 tons for hay, 1.33 tons for oats, 2.08 tons for clover, 1.84 tons for alfalfa, and 9.34 tons for corn silage, showing that acreages used for different crops are not comparable from the standpoint of the contribution which they make to the nutrients available from the farm for cattle feeding. No figures were obtained for corn husked for grain because most of the husking was not yet done when this survey was taken, but very little corn is grown for grain.

Even when the differences in yield per acre for the common crops have been considered, the figures have not been reduced to a common denominator. To be strictly comparable, the yields should be reduced to a basis of nutrients per acre. The composition of mixed hay is so variable that the different grades cannot be classified. About all that can be said is that usually three tons of silage are equivalent to one ton of mixed hay, and hence an acre of silage corn with a yield of more than nine tons per acre is roughly equivalent to three acres of ordinary hay. This changes the aspect of the figures shown in Table 3. Even though the acreage of corn is trebled, in order to weigh it according to its nutrient content, hay is still more than twice as important as any other forage crop. With this expression of the relative importance of these crops before us, we can proceed to the analysis of the factors which affect the efficiency of the production of these crops.

Size of Fields

One of the important features of Eastern Connecticut farms is the relatively small-sized fields. On the 115 farms surveyed, there were 5,400 acres of tilled land, an average of 47 acres per farm. This area was split up by natural or artificial barriers into 1,353 fields, making the average size of the fields 3.99 acres. Only 35.46 percent of the fields were four acres or more in size. Only 80 fields, or 5.91 percent of all fields, were over 10 acres and more in size, although these relatively large fields included 24.10 percent of the tilled land in the area. The distribution of number of fields and acreage by size of fields is shown below.

TABLE 4. *Distribution of Number of Fields and Acreage Included, by Size of Fields in One Acre Intervals*

	Size of Field in Acres											
	0.0 to .99A	1.0 to 1.99A	2.0 to 2.99A	3.0 to 3.99A	4.0 to 4.99A	5.0 to 5.99A	6.0 to 6.99A	7.0 to 7.99A	8.0 to 8.99A	9.0 to 9.99A	10 Acres and Over	Total
No. of Fields	195	252	257	169	145	90	63	47	32	23	80	1353
% of Total	14.41	18.63	19.00	12.50	10.70	6.65	4.66	3.47	2.37	1.70	5.91	100.00
Acreage Included	119.5	379.2	629.2	587.1	649.5	491.9	402.5	350.9	270.0	219.0	1301.94	5400.49
% of Total	2.21	7.02	11.65	10.87	12.03	9.11	7.45	6.50	5.00	4.06	24.10	100.00

These fields are all bounded by more or less permanent natural or man-made barriers, such as roads, brooks, and stone walls,[1] particularly the latter.

Even the figures in Table 4 are an inadequate expression of the extent to which subdivision has taken place. There was a total of 2,338 *field* divisions in this area of 5,400 acres, which makes the average size of the field divisions or units only 2.31 acres. The table on Page 13 shows the distribution of these by size.

The relatively large concentration in the less-than-one-acre class is due to the fact that many of these extremely small field divisions are devoted to the production of garden truck and miscellaneous crops, which are usually grown on a small scale. It has been the writer's observation that even these activities are dispersed, and frequently separated from each other by considerable distance.

Attention should be called to the facts made apparent in Table 5: First, 59.5 percent of all field divisions, containing 21.57 percent of the tilled land in these farms, are less than two acres in size; second, 89.35 percent of all field divisions, containing 62.44 percent of the tilled land, are less than five acres in size. The tables presented later call attention to the extent to which this subdivision has occurred in each of the different crops. To summarize Tables 3, 4, and 5, we may say that the total acreage in hay, oats and corn was 4,818.98 acres. This brings the total number of field divisions used for the production of field crops up to 1,635, or 262 more than the total number of fields bounded by permanent barriers. It makes the average field division used for the production of field crops less than three acres. Nearly one-half the fields of hay and corn and more than one-half the fields of oats contained less than two acres. More than three-fourths of the miscellaneous fields, containing more than one-third of the total acreage, are less than one acre in size.

[1] The removal of stone walls involves a tremendous amount of labor. For the sake of illustration, let us assume that two square fields, each one acre in size, are separated by a stone wall. These walls are usually at least one and one-half feet wide and four feet above the ground, and usually one foot below the ground. The wall separating these two fields would be 209 feet long. This wall would contain 1567 cubic feet of rock, or 58 wagon loads if a cubic yard of rocks were hauled each time. It would probably take two men and a team nearly a week to haul this rock, particularly if it was necessary to haul it any great distance, to say nothing of the time that would be required to pry the bottom stones out of the ground. Occasionally farmers have been fortunate enough to dispose of their stone walls for road building or other construction purposes.

TABLE 5. *Field Divisions and Included Acreage Classified by Size of Field Divisions*

	Size of Field Division											
	0.0 to .99	1.0 to 1.99	2.0 to 2.99	3.0 to 3.99	4.0 to 4.99	5.0 to 5.99	6.0 to 6.99	7.0 to 7.99	8.0 to 8.99	9.0 to 9.99	10.0 and Over	Totals
No. of Field Divisions	879	512	347	203	148	84	51	36	29	11	38	2338
% of Total Number	37.60	21.90	14.84	8.68	6.33	3.59	2.18	1.54	1.24	.47	1.63	100.00
No. Acres Included in Above Field Divisions	410.53	754.10	851.15	695.28	660.89	455.55	326.41	269.64	246.76	105.16	625.02	5400.49
% of Total Acres	7.6	13.79	15.76	12.87	12.24	8.44	6.04	4.99	4.57	1.95	11.57	100.00

The tables included in the Appendix show the number of fields of different acreages in hay, corn, oats, and miscellaneous crops and the percent of the number of fields in the different sized crops.

It would be possible to use most of the fields which are less than one acre in size for garden and miscellaneous crops usually occupying a small area. Instead of this, we find that 237 field divisions, or 19 percent of all of the field divisions in hay, are less than one acre; and 61 field divisions, or 33 percent of the field divisions in oats, are less than one acre.

This extreme sub-division cannot be explained as an adjustment to achieve a rotation because there are few evidences of definite rotation systems.

Effect of Size of Fields on Labor Expenditure

It is difficult to obtain quantitative data to show all the effects of these small field divisions on production operations. The table shown on Page 15 illustrates one of them, i.e., the decrease in the number of man-hours required for specific operations as the size of the field increases:

The following charts present these results graphically.

It was impossible to work out corresponding figures for disking and harrowing because the number of times the field was gone over was not specified. There is every reason to believe that the figures for these operations would have exhibited the same general tendency as those contained in Table 6.

The decrease in the number of man-hours used in plowing as the size of the field increases may, it is quite obvious, be accounted for on the ground that smaller fields are shorter, requiring more turning, that the time spent in going to and from the field is the same regardless of field size, and most important of all, that smaller fields have a tendency to break up the day's work. Often the farmer finishes a small field in the middle of the day and may wait until the following day before he begins work on a new field.

TABLE 6. *Relation between Size of Field and Number of Man-Hours Used in Plowing, Cultivating, Mowing, and Raking*

	Size of Field Division in Acres										
	0.0 to .99	1.0 to 1.99	2.0 to 2.99	3.0 to 3.99	4.0 to 4.99	5.0 to 5.99	6.0 to 6.99	7.0 to 7.99	8.0 to 8.99	9.0 to 9.99	10.0 and Over
Man-Hours per[1] Acre Plowing	9.82	7.90	7.02	6.46	6.02	5.67	5.38	5.10	—	4.70	—
Man-Hours per[1] Acre Cultivating	3.07	2.26	1.89	1.66	1.48	1.33	1.21	1.09	1.01	—	—
Man-Hours per[1] Acre Mowing	2.25	1.75	1.52	1.38	1.26	1.17	1.09	1.02	.97	.92	.88
Man-Hours per[1] Acre Raking	1.26	1.00	.88	.80	.74	.69	.65	.61	.59	.56	.54

[1] These are not simple averages, but are computed from regression equations. See Appendix, Page 46, for discussion of the statistical procedure and **its validity.**

RELATION OF SIZE OF FIELD TO NUMBER OF MAN HOURS USED IN PLOWING

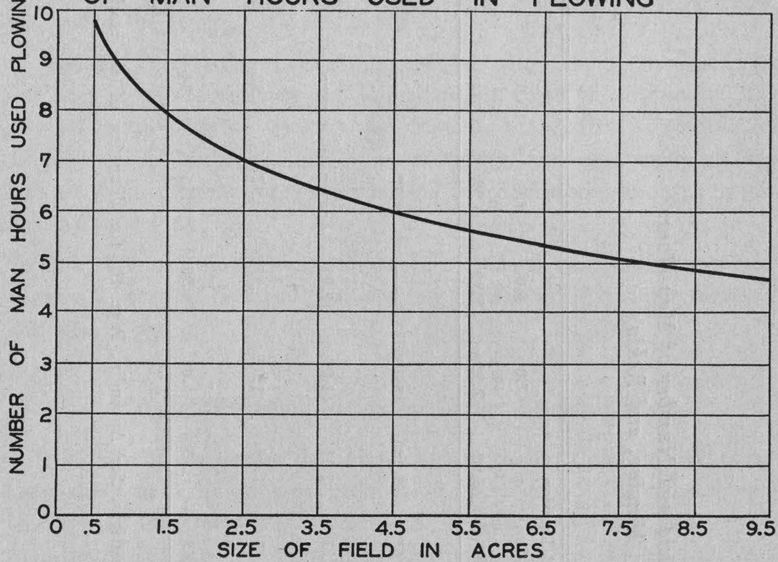

Figure 1

RELATION OF SIZE OF FIELD TO NUMBER OF MAN HOURS USED IN CULTIVATING

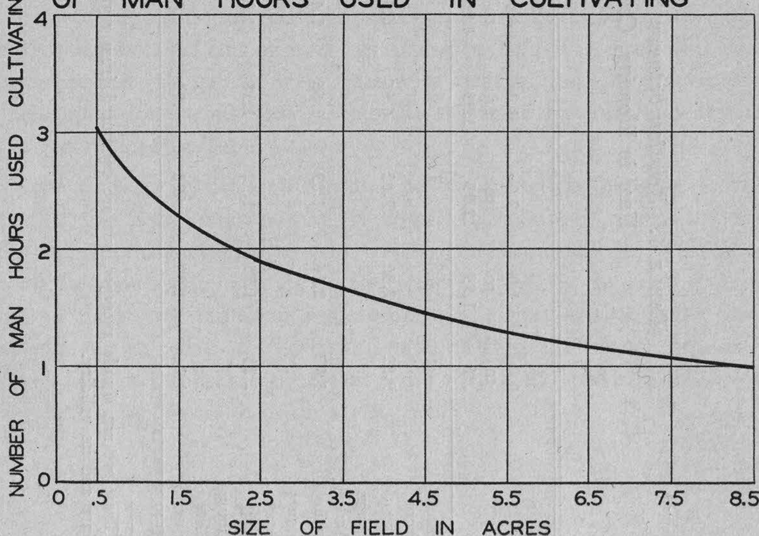

Figure 2

RELATION OF SIZE OF FIELD TO NUMBER OF MAN HOURS USED IN MOWING

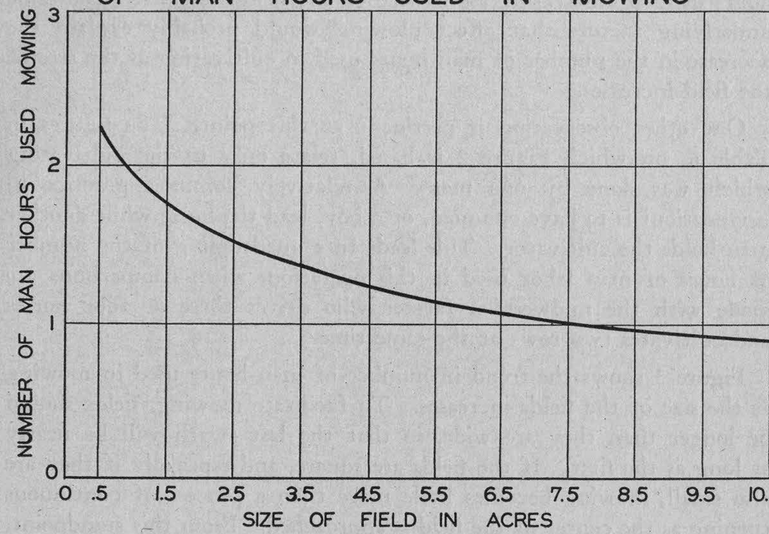

Figure 3

RELATION OF SIZE OF FIELD TO NUMBER OF MAN HOURS USED IN RAKING HAY

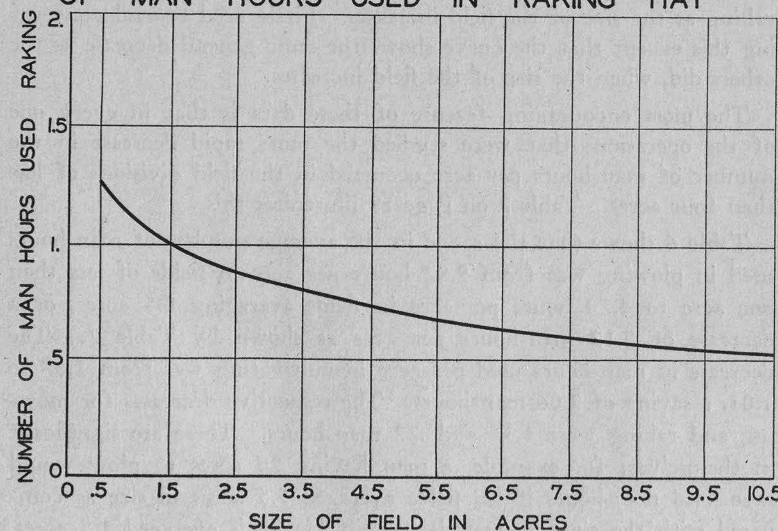

Figure 4

Figure 2 presents graphically the decrease in the number of man-hours used in cultivating as the size of the field increases. The same underlying factors that affect plowing would probably explain the decrease in the number of man-hours used in cultivating as the size of the field increases.

One other observation is pertinent at this point. The figures in Table 6, on which Figure 2 is based, relate only to the cultivating which was done by one man. A relatively common practice in Connecticut is to have one man, or a boy, lead the horse while another man holds the cultivator. This leads to a quadrupling of the number of hours of man labor used in this operation, when comparisons are made with the midwestern farmer who drives three or four horses and cultivates two rows at the same time.

Figure 3 shows the trend in number of man-hours used in mowing as the size of the fields increases. To facilitate mowing, fields should be longer than they are wide, so that the last swath will be nearly as long as the first. If the fields are square, and especially if they are also small, mowing becomes little more than a process of continuous turning as the center of the field is approached. From this standpoint, the practice of using a small area in what would otherwise be a fairly large and easily handled field is particularly objectionable.

Figure 4 shows the trend in the number of man-hours used in raking as the size of the field increases. Little need be said concerning this except that the curve shows the same general decrease as the others did, when the size of the field increases.

The most encouraging feature of these data is that in every one of the operations that were studied the most rapid decrease in the number of man-hours per acre occurred in the field divisions of less than four acres. Table 7 on Page 19 illustrates this.

Table 6 shows that the range in the average number of man-hours used in plowing was from 9.82 hours per acre in fields of less than one acre to 4.70 hours per acre in fields averaging 8.5 acres, or a decrease of 5.12 man-hours per acre as shown by Table 7. The decrease in man-hours used per acre in cultivating was from 3.07 to 1.01, a saving of 2.06 man-hours. The respective decreases for mowing and raking were 1.37 and .72 man-hours. These are significant in themselves; for example, a man having 20 acres to plow would save 44.6 man-hours if his fields averaged 5.5 acres in size as compared with the time he would spend if his fields averaged 1.5 acres. This would represent nearly a week's work in plowing alone.

TABLE 7. *The Decrease in the Number of Man-Hours Used per Acre in Plowing, Cultivating, Mowing, and Raking as the Size of the Fields Increases from 0.5 to 1.5, and from 1.5 to 2.5 Acres, etc.*

	Decrease in Number of Man-Hours Used per Acre as the Average Size of Field Increased from:										
	0.5 to 1.5	1.5 to 2.5	2.5 to 3.5	3.5 to 4.5	4.5 to 5.5	5.5 to 6.5	6.5 to 7.5	7.5 to 8.5	8.5 to 9.5	9.5 to 10.5	Total Decrease
Plowing	1.92	.88	.56	.44	.35	.29	.28		.40[1]		5.12
Cultivating	.81	.37	.23	.18	.15	.12	.12	.08			2.06
Mowing	.50	.23	.14	.12	.09	.08	.07	.05	.05	.04	1.37
Raking	.26	.12	.08	.06	.05	.04	.04	.02	.03	.02	.72

[1] This represents the decrease in time between fields averaging 8.5 acres in size and those averaging 6.5 acres, since the only fields between 7.0 and 8.0 acres in size were plowed with a tractor and were therefore not included.

Of more importance, however, is the consideration of where the greatest decreases occur. Table 7 shows that in each of the operations listed the decreases occur in going from the 0.5-acre group to the 1.5-acre group, and that the decrease in the number of man-hours becomes less as the size of the fields increases. This becomes tremendously significant when we consider that it is in precisely these groups that a great deal of subdivision occurs. Of the decrease of 5.12 man-hours noted in plowing, 3.36 hours or 65.6 percent of the total decrease occurred in fields less than four acres. Sixty-nine percent of the total decrease of 1.43 man-hours for cultivating occurred in fields of less than four acres, and 64 percent of the decrease for both mowing and raking occurred in this group. Table 5 shows that there were 873 more or less permanent fields which were less than four acres, but Table 19 of the Appendix reveals that there were 1,260 field divisions in the three crops, hay, oats, and corn, which were less than four acres, to say nothing of the number of field divisions in these groups which were used for other crops. This demonstrates both the possibility and the desirability of eliminating much of the subdivision of fields which has taken place on these farms.

The foregoing constitutes an explanation of part of the losses of labor time incurred on Eastern Connecticut farms and points the way to the remedy. There is no reason to believe, however, that these losses which can be quantitatively demonstrated are the most important part of the total loss of time incurred. The time used in making trips to and from a large number of fields and in conveying machinery and equipment to and from these fields has not been taken into account. Most important of all, extreme subdivision itself indicates lack of planning in many cases and gives rise to conditions in which careful planning of labor operations to utilize completely the labor time available is very difficult, if not impossible. While the contention cannot be supported by figures, it is the opinion of the research workers who have been in close touch with these farms for two years that the indirect causes of loss of time just mentioned are even more important than the direct causes of loss which have been measured in the foregoing tables.

As has already been pointed out, Table 7 shows that the important decreases in man-hours per acre for the specific operations listed in the table occur mainly in the groups of the smaller field sizes. The fact that there are no substantial decreases beyond this point does not preclude the possibility of such decreases; it simply means that with the methods now in general use, eight or ten acres are as efficient a unit as any larger, and that the number of natural divisions larger than this has not been sufficiently great to constitute an incentive for employing new methods adapted to larger acreages. In the meantime competition from areas capable of making use of machines and methods adapted to reducing labor costs on larger acreages will compel continuous adjustment in the direction of reducing the number of small fields and field divisions. The survival of our Eastern Connecticut farm types depends to a considerable degree on our ability to make adjustments of this kind.

Falconer in his Ohio Extension Bulletin No. 85, 1928-1929[1], shows that as the size of field increases from less than 10 acres to more than 20 acres, the number of acres plowed in 10 hours increases from 1.82 to 2.27. If the number of acres is from under 8 to over 18, the acres cultivated by a one-row cultivator in 10 hours increases from 5.1 acres to 6.7, and the acres cultivated by a two-row cultivator in 10 hours increases from 9.8 to 13.5. Falconer also finds that the county having the largest fields—16.8 acres per field—has 55 crop acres per man, while the county having the smallest fields has 30 crop acres per man. In general in the intermediate counties the crop acres per man vary with the size of the field. Falconer's work makes it plain that as field divisions increase beyond 10 acres, changes in labor efficiency accompany the increases in the size of fields.

The Effect of Other Physical Conditions on Labor Expenditures

The subject of the effect of physical condition on labor inputs is by no means exhausted when the influence of the size of fields has been discussed. Drainage, slope of the land, soil series, soil type, shape of the field, and stoniness all have some effect, although probably no one of them, with the exception of stoniness, has as much effect as has size of the field.

Many of the physical factors such as stoniness, slope of land, and streams have their effect in determining the size and shape of fields. The direct effect of some of these factors on labor efficiency we are not able to measure. The data on drainage are extremely poor and consequently the effect of drainage has been omitted. Neither were measurements made of the steepness of slope which are at all com-

[1] J. I. Falconer: "The Arrangement of Farm Fields," Ohio Extension Bulletin No. 85, 1928-1929.

parable from one farm to another. Soil type undoubtedly has an influence on labor expenditure per unit of output through its effect on yields. This problem is so involved that it is left for another study. It is undoubtedly true that soil type has more influence on labor expenditure than soil series. Stoniness, also, has a distinct effect on the labor expenditure and will be considered later.

Shape of Field

1. The factor of the shape of field has been mentioned before. Largely because of the difficulty of classification, the influence of this factor was studied only in relation to the operation of mowing. Three classes were defined, oblong, square, and irregular. A field was considered oblong if it had four sides and length at least one and one-half times its width. A field had to have four sides to be considered square, and one dimension could not exceed the other by more than 49 percent. All the other fields were thrown into the class of "irregular."

TABLE 8. *Showing the Effect of Size and Shape of Field Division on Number of Man-Hours Used in Mowing*[1]

Size of Field in Acres	Man-Hours Oblong Field	Man-Hours Square Field	Man-Hours Irregular Field
0.0— .99	1.58	2.18	2.10
1.0—1.99	1.43	1.50	1.67
2.0—2.99	1.33	1.35	1.22

This illustrates what has already been said, that if field divisions are to be small they should by all means be long and narrow rather than square or irregular. The objection to square or irregular field divisions grows less as the size of the division increases, until in the 2.0 to 2.99-acre group no significant difference is seen. The figures do not indicate any decided advantage one way or the other between "square" and "irregular" fields, probably because the latter group includes such a multitude of shapes. Irregularity is probably considerably more important in plowing, disking, harrowing, planting, and cultivating than it is in mowing.

[1] No attempt was made to determine the effect of a field larger than three acres because a square field of more than three acres would probably be cut into two oblong strips and hence the purpose of the classification would be defeated.

Stoniness

An attempt to measure the effect of stoniness was also made. This involves difficulties of classification, and no fine conclusion can be drawn from the data; but certain general conclusions are possible. When these farms were mapped each field was described as being stone-free, slightly stony, stony or very stony. This classification obviously rests upon a subjective evaluation by the man who did the mapping; but although no formal definitions were set up, it was felt that at least two classes, stony and stone-free, could be made with reasonable accuracy. There were 203 fields out of the total of 1,353 fields which were designated as stony. Fifty-three of these had occasional boulders, or relatively few stones, 138 were definitely stony, and 12 were exceedingly stony. There is probably a considerable overlapping in this classification, as some of the fields which were called slightly stony should have been called stony and vice versa, and there probably is nearly as much overlapping in the last two classes; but the total probably represents the degree of stoniness fairly well.

When the fields were classified on this basis the following results appeared:

TABLE 9. *Showing the Relation between Stoniness, Hand Mowing, and Man-Hours per Acre for Mowing*[1]

Method of Mowing	Stoniness	Acres	Man-Hours per Acre
1. Fields on Which Hand Mowing Was Done.			
a. Machine and Hand Mowing	Stony	55.8	2.86
b. Machine Mowing Only	Stony	55.8	1.80
2. Fields on Which no Hand Mowing Was Done.			
a. Machine Mowing	Stony	190.55	1.32
b. Machine Mowing	Stone-Free	208.02	1.30

Perhaps the most important conclusion to be drawn from the figures presented in this table is that there was no appreciable difference between the number of man-hours used in mowing fields that were classed as stone-free and those that were classed as stony, unless the field was stony enough to require some hand mowing. It will be

[1] These figures are based upon records of those farmers who had both stony and stone-free fields. The data for those farmers who had only stone-free fields are not included. Only two-horse mowing is included.

observed that the stony fields required 1.32 man-hours for mowing, while those that were stone-free required 1.30 man-hours.

There were only 13 fields or field divisions on which some hand mowing was done along with machine mowing. These, of course, required considerably more time. Most of the hand mowing was done around rocks and rock piles, so that it did not appreciably affect the acreage mowed with the machine. It will be observed that even if the labor spent in hand mowing is disregarded, the number of man-hours per acre for machine cutting is still higher than for either the stony fields that were mowed only with a machine or the fields that were free of stone. When hand mowing is included, the difference of course becomes appreciable. The encouraging feature of these data is that there were so few fields in which hand mowing was done. Of the 3,856.65 acres in hay, only 246.35 acres were stony, and of this area, 190.55 acres were apparently mowed in approximately the same length of time as the stone-free area on the same farms, which leaves only 55.8 acres that were stony enough to offer any serious obstacles to the operation of mowing.

An attempt was also made to determine the influence of stoniness in plowing. On the average it took 8.37 hours of man labor per acre to plow stony fields, and 7.32 hours per acre for stone-free fields. The same criteria of stoniness were used as above. These are probably quite inaccurate because they consider only visible stoniness. Although it is probable that a field which has a great deal of surface stone also has stone beneath the surface, it does not follow that a field which does not have surface stone does not have stone beneath the surface. If these fields had been accurately classified on a basis of stoniness, whether stones were above or below the surface, the difference between the number of man-hours used in plowing would undoubtedly have been considerably greater.

The foregoing represents an attempt to measure the direct effects of stoniness. There are some reasons for believing that the indirect effects of stoniness are more important. Some of the indirect effects are measured in the data showing the effect of the size of the fields on cultural and harvesting operations. Unquestionably, fields would have been much larger in this area if there had not been such an abundance of stone. Another indirect effect of stoniness is its influence on the use of machinery. This cannot be demonstrated except by contrast between areas, because many of the practices which are common in stone-free areas are not found at all in the Eastern Highland of Connecticut.

Location of Fields

The location of the fields is another factor responsible for considerable variation in the amount of time used to accomplish a specific task. This factor is particularly important in hauling hay. On the average, the center of each hay field was about 1,100 feet from the barn. When the effect of the variations in all the other factors was eliminated in so far as possible, it was found that an increase of 100 feet in distance from the barn was accompanied by an increase of .044 man-hours per ton in the time for hauling. The difference in time for hauling hay from a field adjoining the barn, whose center is about 100 feet from the barn, and from one whose center is a quarter of a mile away would be about 0.5 of a man-hour per ton. It is probable that the importance of the variation in distance is not so great when the distance is relatively short as when it is long. For example, it is entirely possible that just as many loads of hay are hauled in an afternoon when the field is 1,000 feet from the barn as when it is 500 feet. Increasing the distance by an additional 500 feet may make it impossible to haul more than four loads in an afternoon, whereas if the distance had been 500 feet less, five might have been hauled. It simply means that from the farmer's point of view minor variations in distance are not so important. Increasing the length of the working day by 15 minutes or even half an hour is not as serious as preventing him from hauling that extra load.

This is illustrated in the data on hauling silage corn. The following table shows the effect of distance on this operation:

TABLE 10. *Showing Relation between Distance and Man-Hours Used per Ton in Filling Silos*

	Distance in Feet			
	0—999	1,000—1,999	2,000—2,999	3,000—3,999
Man-Hours per Ton	2.06	2.05	2.04	2.69

The slight decreases in the first three groups are immaterial; and in this operation it appears as if the distance must be considerably over 0.6 of a mile, in fact, before it makes any appreciable difference. There is apparently very little that can be done to improve the situation in this respect except possibly to refrain from raising such bulky feed as silage on fields extremely far removed from the barn.

Effect of Yield Per Acre on Labor Expenditure

Of the factors which influence labor inputs, there is none that is more important in its direct effects than yield per acre. In contrast to many of the other factors, the influence of yield per acre is direct.

Hay

The size of field divisions is relatively unimportant in contrast to yield per acre as a determinant of labor cost per ton of hay. The average yield was 1.07 tons per acre. The average number of man-hours used in mowing a ton was 1.659. With each increase of one-half ton per acre in yield, the number of man-hours used in mowing a ton of hay was reduced by .552 hours on any particular field size.[1] Reducing the yield by half a ton increased by .552 hours the number of man-hours used in mowing. One of the most significant results of this correlation was that apparently yield per acre had little or no effect on the number of man-hours per acre for mowing.

The computed range in the number of man-hours used per acre in mowing with an average yield was 1.32, from this correlation, while reference to Table 6 shows a range of 1.37 man-hours per acre. This is extremely significant from the standpoint of saving labor. From these results it may be said with reasonable certainty that with a given size of field the number of man-hours used per ton in mowing is inversely proportional to the yield per acre. The farmers in the Eastern Highland now have an average yield of 1.07 tons of hay per acre. If they could double this yield, as many of them have done, twice the quantity of hay could be mowed with the same amount of man labor that is now being used.

No correlations were computed for raking, but there is every reason to believe that the same sort of relationships exist in this operation as in mowing. Raking, however, takes less time than mowing, hence the savings to be effected are proportionately less.

Yield per acre also had some effect on the number of man-hours used in hauling hay. Each increase of one-half ton in yield per acre was accompanied by a decrease of .175 man-hours per ton for hauling.[2] An increase of one ton per acre was accompanied by a decrease of .35

[1] Derived from a multiple correlation between the log of 10 times the size of the field, yield per acre, and number of man-hours per ton for mowing. See Appendix, page 47 for presentation of correlation results.

[2] Derived from a correlation between use of hay loader, number of horses used in hauling, number of men used in hauling, distance from the barn, size of field and man-hours per ton for hauling. See Appendix, page 48 for correlation results.

man-hours per ton and vice versa. There are also some evidences of relationships in the data that are difficult to demonstrate. For example, it is probable that the effect of yield per acre on the number of man-hours used per ton in hauling is more pronounced in small fields than it is in larger ones.

There is also some reason for believing that there is a joint relationship between yield and the number of men used in hauling. A high yield is probably more important when three men are used than when only two are used. The reasons for this will be taken up later in the discussion of the influence of the size and organization of the crew.

The relationships just discussed are somewhat difficult to demonstrate. None of the ordinary correlation methods has brought out what we believe to be the the true effects, and when there is a multiplicity of causal factors operating in data collected by the survey method, and when these causal factors have curvilinear and joint as well as straight line relationships, presentation of effects and relationships becomes complicated.

Silage

The same general effects were noted in studying the influence of yield per acre on man-hours per ton for cutting silage corn. The range in yield for silage corn was from 4.31 to 14.02 tons per acre, with an average yield of 9.47[1] tons per acre.

The following table shows the effect of increasing the yield on the number of man-hours used per acre and per ton in cutting corn:

TABLE 11. *Showing Relation between Yield per Acre and Number of Man-Hours Used per Acre and per Ton in Cutting Corn by Hand or by Machine*

Number of Fields	Hand Cutting			Machine Cutting		
	Av. Yield per Acre	Hrs. per Acre	Hrs. per Ton	Av. Yield per Acre	Hrs. per Acre	Hrs. per Ton
4.0— 6.99	5.72	8.27	1.45	——	——	——
7.0— 9.99	9.00	8.52	.95	7.86	2.56	.33
10.0—12.99	11.14	9.32	.84	11.06	2.50	.23
13.0—15.99	13.34	12.51	.94	——	——	——

Although there were relatively few cases of machine cutting, there was a considerable volume. The figures indicate an appreciable

[1] This differs slightly from the figure average given in Table 11. This was because yield data were collected from some farmers from whom no labor data were obtained.

decrease in the number of man-hours used per ton as the yield increases. The figures for machine cutting do not indicate any increase in man-hours per acre as the yield increases. There is a slight decrease, although this is so small that it may be simply an accidental variation. This indicates that within the ranges given an increase in yield is accompanied by an almost proportionate decrease in the man-hours used per ton in cutting. Using one man, three horses and a binder, it would take a farmer approximately one whole day's labor less to cut eighty tons of corn if he had a yield of eleven tons than it would if he had a yield of eight tons.

Most of the corn in this area was cut by hand, however, so that for the present, at least, the influence of yield on man-hours per ton for hand cutting is probably of more immediate concern. There is a strong contrast in this table between the number of man-hours per acre for machine and for hand cutting. It is to be noted that there is no material change in the time for cutting an acre with a binder as yield increases. The increase in man-hours per acre for hand cutting with increasing yield is very strongly marked, particularly in the upper groups. Material decreases in man-hours per ton are effected by increasing the yield from an average of 5.72 tons per acre to a yield of 9.00 tons per acre; but after this yield is attained, the heavier corn apparently becomes correspondingly difficult to cut, so that no appreciable savings are effected. The difference between the time for cutting a ton with an average yield of 5.72 tons per acre and with an average yield of 9.00 tons per acre is of decided importance. The saving of 0.5 man-hours per ton which this represents would mean that one man could cut eighty tons of silage in about five days less with the former yield than with the latter. The effect of yield per acre on hauling corn is difficult to determine because so many factors are involved. There is little or no question but that it is possible to handle a ton of corn with less labor when the yield is high than when the yield is low because the horses do not need to be started and stopped as often and the bundles are closer together, which involves less walking. At exactly what point the corn becomes so heavy that it is extremely difficult to handle is another question. Within the range of yields in the present data there was no indication that the heaviest yields required more man labor per ton. With an average yield of 9.67 tons per acre, and the effects of all the other factors eliminated (so far as possible), each increase of a ton in yield per acre caused a decrease of .06 man-hours per ton in the time for hauling corn for silage. Each decrease of a ton in yield caused an

increase of .06 man-hours per ton. The difference between a six and a ten-ton yield on a farm with seventy tons of silage—an average amount—would cause a difference of approximately two eight-hour days of man labor.

An analysis of harvesting operations must proceed along different lines than an analysis of spring labor. In the former it is obviously desirable to harvest a ton of hay or oats or corn with the smallest possible amount of labor. This is not quite true of spring operations. If the marginal inputs of labor have not yet been reached it is entirely possible that additional labor inputs, even though accompanied by decreasing physical output per unit of input, may be economically desirable. Analysis of these operations can not well ignore prevailing prices and alternative uses of the input elements nor the prices of the product. The effect of yield is correspondingly qualified. Certain spring operations such as plowing and planting are somewhat in the nature of fixed inputs. With reasonably favorable physical conditions little if any more time is required to do a good job in these operations than to do a poor job. To a certain extent, then, yield is independent of the amount of time spent in these operations, and the output per unit of input varies almost directly with the yield. This is not true of such operations as disking, harrowing, or cultivating, which are performed a varying number of times in addition to the qualitative differences found in plowing and planting. There is some evidence that the number of times a corn field is cultivated has a direct bearing on yield. Simple classification by the number of times a field was cultivated gave the following results:

TABLE 12. *Showing Relation between the Number of Times a Field was Cultivated and Yield per Acre in Tons*

	Number of Times Cultivated					
	1	2	3	4	5	6
Yield per Acre (tons)	8.26	8.83	10.25	9.76	11.06	13.20

This is, of course, rather flimsy evidence, especially in the last two classes where there is a paucity of cases; but unless there is an extremely high intercorrelation between the number of times that a field was cultivated and the amount of fertilizer or manure applied, which are probably the chief determinants of yield, the data appear conclusive enough to justify the statement that in certain operations labor inputs play an important role in determining yields, as well as the converse. It was impossible to draw any conclusion as to what the optimum number of cultivations would be, because of the lack of data at hand in the upper groups. Moreover, over 60 percent of the acres that were cultivated only once were hoed by hand, thereby adding on the average 1.87 man-hours per acre. 9.0 percent of the acreage that was cultivated three times was hoed by hand. None of the fields that were cultivated four times or more was hoed by hand.

It was impossible to draw any conclusion with regard to the effect of disking or harrowing on yield because the number of times a field was disked or harrowed was not given. For the same reason, it was not possible to show the effect of yield on labor inputs in these operations. To the extent that yields are not dependent upon these cultural operations, high yields naturally reduce the labor inputs per ton for any of them.

Although an analysis of the effect of yields on all labor inputs has not been possible, enough has been said and illustrated to justify the conclusion that the labor-saving aspect of high yield has not been sufficiently emphasized, and that the farmer who overlooks this possibility is neglecting one of the most favorable opportunities for increasing the effectiveness of his own or his hired labor.

Effect of the Use of Machinery

Thus far in our analysis we have been considering only such factors as involve little or no initial capital outlay. In contrast to this, the use of machinery calls for considerable cash outlay. The decision in regard to the use of machinery rests almost entirely on the basis of the saving of labor which it makes possible.

Tractors

Unfortunately there are not enough data available from this study to draw any conclusions with relation to tractors. Not only is the number of farmers who had tractors few, but the figures on tractor operations are not comparable with the figures on horse operations and the whole question is sufficiently complicated to justify separate study.

If only one man is used with a one-row planter, it is possible to plant corn with less man labor than when it is done by hand, but more than one-half of the farmers who use a one-row planter use two men to run it. This is an extremely inefficient use of labor, and it is difficult to believe that farmers can persist in it. Two-row cultivators

TABLE 13. *Showing Man and Horse-Hours per Acre for Planting Corn by Hand with a One-Row Planter and with a Two-Row Planter*

Method of Planting		Man-Hours	Horse-Hours
Hand Planting		3.79	——
	Average [1]	4.07	2.58
One-Row Planter	Two Men and One Horse	4.83	2.42
	One Man and One Horse	3.13	3.13

were not used, and between the three types of one-row cultivators, the one and two horse-walking cultivators and the two horse-riding cultivator, there is little choice. The waste involved in using two men with a one-row cultivator is extremely important, very expensive, and seems to indicate that farmers have not developed a consciousness of the importance of labor economy as they have of the importance of using feed and fertilizer economically.

Plows

As with cultivators, so with plows. There is little choice between the walking plow and the sulky plow from the standpoint of labor efficiency.

Corn Binders [2]

Of the 56 farms with silos included in the study, only 11 used corn binders.

Table 9 shows the great difference between the amount of labor used when the corn is cut with a machine and the amount used in hand cutting.

With a yield of slightly over eleven tons per acre, the farmers who cut their corn by hand used on the average 9.32 man-hours per acre, while those who cut the corn with a machine used only 2.50. The respective figures per ton were .84 and .23 man-hours, or a difference of .61 man-hours per ton. If a farmer had 70 tons of silage it would take one man approximately five days longer to cut the corn by hand than it could be done with a machine. There should also be an

[1] This average is not the average of the figures that appear in the table. There were more farmers who used two men and one horse than there were who used one man and one horse, and this average is the total time for all men who used the one-row planter divided by the total acreage planted in this way.

[2] For a refutation of argument against the use of binder for silage corn see N. H. Extension Bul. 80, Mar. 1928, "Silo Filling with Less Labor," by H. C. Woodworth and M. F. Abell.

appreciable saving in handling the corn afterward, since it is much easier to handle bound corn than loose corn. The usual practice in using a binder is to cut lanes in the field by hand before going in with the binder. This need not be done. All that is necessary is to cut the row that was tramped down from the opposite direction with the machine. Woodworth and Abell have computed that the value of the corn lost as a result of this method will in most instances be less than 10 percent of the labor cost of cutting the land by hand.

The labor saved in the use of a corn binder is not, of course, in itself a proof that all farmers should own binders. Whether or not to purchase a binder depends on the amount of labor that would be saved, the cost of the machine, its annual maintenance including depreciation, and the availability and cost of the labor for hand cutting. General observations by the field workers on this study indicate that there are no farms producing corn for silage at the present time that would find stoniness an obstacle to the use of a corn binder.

Hay Loaders

Seventeen out of these one hundred and fifteen farmers used hay loaders. The savings in man labor which can be attributed to the use of hay loaders, after the effects of all the other factors are eliminated in so far as possible, amount to approximately 0.65 man-hours per ton.[1] If a farmer had forty tons of hay together, it would require approximately three days more of man labor to gather this hay by hand than it would if a loader were used. The same considerations apply to the purchase of a loader that were mentioned with regard to a corn harvester. The availability of harvest labor and the alternative uses of a farmer's time are equally important. There is one other factor that needs to be considered in this connection, the fact that it is much more important to get as much work as possible accomplished during fair weather in the haying season than at any other time of the year. A hay loader may enable a man to harvest in a few days of favorable weather a large quantity of hay which would otherwise have been exposed to rain and would, therefore, have been of appreciably poorer quality. Most of the desirable varieties of hay need to be harvested in relatively short time, too, or they will become too mature and fibrous to make good feed. To many farmers the latter inducement is probably as important as the labor-saving feature. Under

[1] From a correlation showing effects of use of hay loaders, number of horses used in hauling, number of men used in hauling, distance from the barn, yield per acre, on man-hours per ton for hauling hay. See page 48 for presentation of correlation results.

most circumstances a farmer would probably need to have at least 35 tons of hay to justify the purchase of a hay loader from the standpoint of labor saving alone. In particular circumstances, the purchase could, of course, be justified with a much smaller tonnage.

It does appear that it would be very desirable for many of these farmers to own some of their machines cooperatively with a neighbor. This is very commonly done in some regions, and enables the farmers with a small acreage to use machines which they could not afford to own alone. This requires some give and take on the part of the joint owners.

The need for cooperative ownership and operation of the more expensive labor-saving tools is greater in Eastern Connecticut and in the upland regions of Southern New England than in most areas, because physical conditions make many farms too small to carry the overhead expenses of owning a full complement of labor-saving machinery and because it is more difficult to combine these farms into more economical units.

Wagons and Racks

The use of high-wheeled wagons with short, narrow racks for hauling hay is extremely common. In general, the racks used for hauling hay are too small and too high. The same criticism applies to the wagons and racks use for hauling silage. Even dump carts are used for this purpose. Woodworth and Abell found in their silo study that on some of the New Hampshire farms the men lifted the corn an average height of seven feet in loading dump carts. Such practices still further confirm the opinion that Eastern Connecticut farmers, while efficient in many respects, have not yet turned their attention to the possibilities of more economical use of their labor.

Over 30 percent of the farmers used tipcarts for hauling silage corn. A great many more used high wheel wagons. Still others used trucks on short hauls. All in all, at least 50 percent of the farmers used a machine which was very poorly adapted to the task at hand. The following table illustrates the difference in man-hours per ton for hauling corn silage with the type of equipment mentioned above:

TABLE 14. *Showing Man-Hours Used Per Ton for Filling Silos When Hauling is Done with a Wagon, Truck, or Tipcart*

	Wagon	Truck	Tipcart	Average
Man-Hours per Ton	1.90	2.39	2.53	2.32

These figures would have been greatly modified if an accurate description of the wagons had been made as well as of the racks that were used with them, because some of these wagons were probably no better than tipcarts. But the comparison is striking enough as it is. On the average, there are .63 man-hours wasted for every ton that is hauled to the silo on a tipcart. On a farm having 70 tons of silage, 45 hours of man labor would be wasted. The statement has been made and is repeated that tipcarts are one of the most inefficient implements with which Connecticut farms are burdened, and it should be repeated that tipcarts should *not* be used in hauling silage corn.

Trucks are apparently not much better, especially on short hauls. The reasons are obvious: one man is required to drive the truck, the loading surface is high, and one man is needed on the load. Further discussion of this question will be presented later in this paper.

Size and Organization of the Crew

No labor efficiency analysis would be complete without some consideration of the effects which differences in the size as well as in the organization of the crews have upon labor expenditure. To be really effective, such a study should be carried on painstakingly and methodically throughout the seasons of the year, so as to determine the effects of planning and organization, not only upon the major operations, such as have been described thus far, but also upon the daily tasks. Extreme variations in the efficiency and dispatch with which even the simplest of them are accomplished are probably just as usual as the variations in the operations that have been considered.

To the extent that this is true, it is to be expected that inefficiencies would be found in every operation. Many of the effective practices are the expression of superior managerial ability. Many of them are specific adaptations to particular conditions. As such they are not easily duplicated on other farms. But a great many of them are equally applicable to practically all farms, and it is thought that these important contributions can be made by study and detailed observations.

It is precisely because farm work is not continuous like work in a factory, for instance, that a study of a large number of different tasks needs to be made. In the first place, it is necessary to convince people that inefficiencies are not confined to any one operation; and in the second place, economies in any one operation do not appear as significant as do the results when a large number are analyzed and it is

found that variations are the rule. The decrease in the amount of labor that is used, which accompanies general efficiency in all tasks, is very important. In fact there are a considerable number of farm businesses where the effective use of labor is the explanation of success.

In Haying

In hauling hay, after the effects of the variations in all the other factors had been eliminated in so far as possible, the two-man crews used .94 man-hours per ton less than the three-man crews.[1] This is not due to any inherent inefficiency of the three-man crews, but simply to the fact that they were not properly organized and were used under conditions where three men could not be used to advantage. Three men should not be used on long hauls where the time spent in going to and from the field makes up the largest part of the time spent in hauling. It has already been mentioned that there may be something of a joint relationship between yield per acre and the number of men used in hauling hay. When the field is low and the windrows are far apart, if the farmer drives between two windrows, so as to have one man loading on each side of the wagon, both of the men must carry the hay some distance. If the hay is carried any distance beyond the step or two needed to get the momentum to throw the hay up on the wagon, the process becomes exceedingly laborious and time-consuming. Observations of this sort may appear trifling, but these practices persist and are common. One other rather important reason why three men are less effective than two is that while three men can undoubtedly haul in a ton of hay in less time than two, they cannot haul it in so much faster as to permit hauling an extra load in an afternoon.

The most effective three-man crew was just as effective as the best crew of two men. The fact that on the average they accomplished less work with a given number of man-hours of labor does mean, however, that the conditions in which this crew should be used must be very carefully considered. A comparison of the records of those farmers who used both sizes of crews reveals the surprising fact that in very few cases did they haul more hay in a given unit of time with the crew of three men than they did when they used only two.

There were a few cases where one man accomplished his haying alone. The average number of man-hours used per ton by these

[1] Taken from multiple correlation. See page 48. The figures included only crews of two or three men. The results referred to later concerning one and four-men crews were obtained by simple subsorting.

men was considerably below the average for either of the others. In four-man crews, the time of the fourth man is wasted.

In Silo-filling

The size of the crew also has some effect on the amount of man-labor used per ton in silo-filling. The following table illustrates this:

TABLE 15. *Relation between Size of the Crew and Number of Man-Hours Used per Ton in filling Silos*

	Number of Men Used in Hauling and Filling		
	1-4	5-8	9-12
Man-Hours per Ton	2.17	1.89	2.95

The crews of one to four men are the family sized crews where little or no outside help is hired. These crews are apparently not as effective as crews of five to eight men, probably because there are not enough men to keep the cutter supplied with corn continuously, and as a result some time is lost between loads in starting and stopping the machines. To many farmers this system recommends itself, even though it is not the most efficient, because it calls for no cash outlay.

The extremely large crews of nine men or more were decidedly inefficient, at least with the types of machines that were used to fill the silos in this region, the crew probably exceeding the capacity of the cutter and engine. The additional men, therefore, aside from making the job easier for the rest of the crew, represent so much waste labor.

Silo-filling on the Test Farms

The planning and organization of the work on these test farms is considerably more important than the size of crew. Eastern Highland farmers do too much carrying. They carry the hay and they carry the corn instead of exercising care and forethought so that the wagon can be placed exactly where the work is to be done. This is particularly true of silo-filling. In this operation they not only carry the corn in the field, but since they frequently haul the corn on tip-carts from which it is dumped somewhere in the vicinity of the cutter, it is also necessary to carry the corn to the silage cutter.

To determine whether material economy in the use of labor would accompany the use of different types of equipment and a detailed supervision of the crew, silo-filling tests were made by members of the Departments of Agricultural Economics and Farm Management of this college in cooperation with these farmers. On one of these farms, the only one where the work was actually supervised, a silo 12 feet by 29 feet in size was filled by a crew of eight men in an hour less than it was filled the previous year by a crew of seventeen men. On the second farm a silo 14 feet by 26 feet was filled by the same crew of eight men in one hour more time than it was filled the previous year with a crew of 19 men. The third farmer had a 14 by 28 foot silo which was filled to a height of 26 feet. This man did not remember how much labor was used the year previous, but he did know that his costs were about twenty-three dollars less than they were the previous year in spite of the fact that at least nine feet, or about 25 tons more silage, had been put into the silo.

The corn on all three farms was cut with a corn harvester so that the bundles were all bound. Special low-slung racks were constructed to effect a minimum of human effort in loading. They were built as follows: Two 4-inch by 8-inch timbers, 16 feet long, were bolted together in the form of a V at the front axle, while the other ends were fastened to the under side of the rear axle; on these timbers were nailed 2-inch by 6-inch planks, laid flat and crosswise to serve as a platform which when completed was about four and a half feet wide and ten feet long. The rack was adapted from the illustration in New Hampshire Extension Bulletin No. 80 to which reference has already been made.

The crews on these farms consisted of eight men distributed as follows: Three teamsters, each with a wagon as described above, one man who helped unload, one man tending the engine and cutter, one man in the silo, and two who helped load in the field. On one of the farms there were four teamsters with one man less in the field. The farm owners and their neighbors made up the entire personnel. The average haul from the field to the silo on these farms was about forty rods.

Table 16 illustrates the difference between the amount of man labor used on the average Connecticut farm and the amount used on these test farms.

TABLE 16. *Average Amount of Labor Used in Cutting Corn and Filling Silos in 50 Connecticut Farms Compared with Amount Used on the Three Test Farms*

	Hours per Acre		Hours per Ton	
	Average Farms	Test Farms	Average Farms	Test Farms
Man-Hours	30.86	10.18	3.28	1.22
Horse-Hours	14.27	10.35	1.42	1.24

The table shows a very decided contrast between the amount of labor used on the average farm and on the test farms. The latter used considerably less horse labor, in spite of the fact that the cutting was all done with horses; less than a third as much man labor was used per acre, and a little over a third as much was used per ton. These figures include the time for cutting. It should be noted that only one of the 50 farmers used less than two hours of man labor per ton. This man used 1.79 man-hours per ton. The distribution is shown in Figure 5.

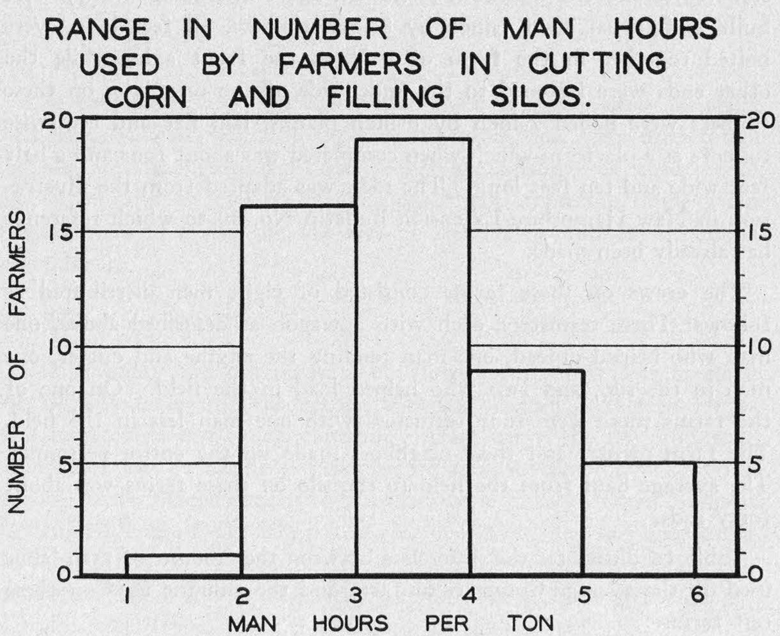

Figure 5

The following table presents the figures for filling silos:

TABLE 17. *Amount of Labor Used in Filling Silos on Connecticut Farms Compared with Amount Used on the Three Test Farms*

	Hours per Acre		Hours per Ton	
	Average Farms	Test Farms	Average Farms	Test Farms
Man-Hours	22.54	8.12	2.40	.97
Horse-Hours	12.26	6.23	1.30	.75

It should be noted that even after the labor used in cutting the corn is taken out, the differences are still marked. Each farmer used at least 65 percent more labor than the average of the test farms, and the majority of them used 100 percent more labor. The average of the 50 farms is just about two and one-half times as high as the average of the test farms. The average farms used nearly twice as much horse labor as was used on the test farms. These figures illustrate that it is not always possible to study an area and discover the best practices. A study of the practices in this area would have revealed an extreme amount of variation both in the methods that were followed and in the amount of time used, but it would not have revealed that there were other methods equally applicable and far more efficient than any actually in use.

It was believed at the time that at least one man might have been eliminated even from the test crew. If a little care is taken at the time of loading, the teamster should be able to unload fast enough to keep the silage cutter busy without the extra man to help him.

A number of other methods by which the labor efficiency in the test crews might have been increased are worth consideration. When three wagons are used and two men help load in the field, there are times when all three men must be loading on one wagon. This lowers their efficiency appreciably. Care should always be taken in planning the planting to see that the corn rows are long enough, if possible, so that two rows taken the whole length of the field will at least make a load. Only two rows should be loaded at once and there should never be more than two men loading on one wagon at the same time.

The efficiency of the test crews as compared with the usual methods of harvesting and ensiling corn is largely to be attributed to the following factors:

1. Greater ease in handling bound corn. Bound corn is both loaded and unloaded more easily than the unbound.

2. The greater efficiency of using long, low-slung racks on which to load the corn and haul it to the silo rather than high, small-bodied tipcart or truck. The inefficiency of the tipcart or truck from the standpoint of height of load, size of load, and the labor required in loading have already been sufficiently emphasized.

3. Attention to details in the organization of the work. The more important of these are:

a. The importance of loading but two rows at a time, to eliminate carrying. One man can load two rows in practically the same time that the second man can load a third row.

b. Planning the shape and size of the fields as far as possible so that the fields will be long enough to permit a full load to be secured from two rows.

c. Starting to load near the edge of the field and stopping the horses or truck frequently so that there will be no unnecessary carrying. Often the first ten or fifteen bundles are carried twenty or thirty feet. This means a minute or two of wasted time and hard effort for each man; and when three men are working in a crew of this kind, it may constitute a total loss of three and one-half hours for one man in a day. If two minutes were wasted in this way, the loss would amount to nearly a day's work for one man. The changes made possible by such an organization of labor are easily applicable to most farms with little expense. This statement should not be construed as a recommendation of a particular method. In fairness to the plan, however, it should be said that the use of these, in preference to the present methods, would result in very material reduction in the cost of corn silage on Eastern Connecticut farms.

GENERAL CONCLUSIONS

The efficient organization and application of labor at periods of peak load is important not only from the standpoint of the savings directly effected but also because of its effect on size of business and efficiency of farm operations as a whole.

Marked savings can be effected without increased capital investment by reducing the extent of field subdivision, planting in large fields rectangular in shape where possible, and increasing yield per acre. Even more significant economies can be effected through more efficient organization of some of the main planting and harvest operations, particularly corn planting and cultivating, haying, and silo-filling. The wastefulness of using tipcarts and trucks for hauling corn to the silo and the loss of labor efficiency resulting from using two men with a one-row corn cultivator deserve special mention. The capital outlays involved in these changes are relatively small and the results are to be obtained not through increasing human effort but through better organization of labor and equipment. Certain machines can be used under proper conditions with increased saving of labor. This study has not attempted to define exactly under what conditions such use is profitable. The possibility, however, of cooperation in the use of larger and more expensive machines is worthy of serious attention. The results of the study and the experience of the field men in obtaining data on these farms over a period of four years make it plain that Connecticut dairy farmers are not as sensitive to inefficiency and waste in the use of labor as they are to waste of feed and fertilizer and to unproductiveness of their livestock. The layout of the farms is not particularly well adapted to efficient use of labor. This condition could be quite largely overcome through systematic efforts to make farmers conscious of the importance of labor efficiency, particularly in the peak load periods, and to help in developing methods of increasing the efficiency in the use of labor. If Connecticut dairy farmers are capable of meeting the competition of areas where labor operations are so much more efficiently organized, then in this territory under proper conditions we should be optimistic about the possibilities of improving our competitive position through more effective organization of these operations. It does not appear unreasonable to conclude that a region which can meet competition despite a large number of such unnecessary handicaps should be able to hold its own if these were eliminated.

In addition to the improvements in labor efficiency which can be effected along the lines specifically indicated in this bulletin, there are possibilities of combining under a single management a number of farms into larger and more efficiently organized units and there are possibilities of farmers' cooperating in the use of large-scale machinery. Farm management experts, and especially those in our agricultural colleges interested in farm machinery problems, might well study the possibilities of devising new types of machines particularly adapted to efficient use of labor under the conditions which prevail in farms like those in Eastern Connecticut.

APPENDIX

Description of the Area and the Method of Obtaining the Data.

The data which have been presented in this paper were obtained as part of the study of the influence of soil type on farm organization which has been conducted by the Department of Agricultural Economics of the Connecticut Agricultural College. This study is now in its fourth year.

The towns in which these farms were located were selected, first, as being representative of the various physical conditions that are commonly found in the Eastern Highland, and second, as being so located as to have the advantage of nearness to market and social centers without being subject to the influences of proximity to any large cities. The towns were Woodstock, Brooklyn, Canterbury, Griswold, North Stonington, and Stonington, which make up a tier of towns extending between Massachusetts and the coast. This tier is unbroken except between Woodstock and Brooklyn. Two other towns, Coventry and Columbia, were included. These towns are west of the others but are nevertheless distinctly representative of the agriculture to be found in the Eastern Highland.

Twenty farmers were selected in each town except Woodstock, Stonington and North Stonington. Thirty farms were selected in the first and fifteen in each of the other two. Ten alternates were also chosen in each town, since there were always some farmers who could not cooperate for various reasons. The names of all the farmers in the town who had at least five head of neat cattle were obtained from the town clerk. A random selection was then made by drawing names from a hat.

These farms were mapped on a scale of one inch to three hundred feet. It was felt that a high degree of accuracy was attained, particularly in determining the size of the cultivated areas, since on these areas numerous checks could be used. Each map was built up by mapping one field or small area at a time. Each of these was automatically checked because it was necessary for the starting and stopping points to coincide. Farm buildings, fences, cultivated areas, brooks, swamps, and a great many other permanent features were indicated. The tillage, drainage, and slope of each field were described on maps. The man who made the map estimated how much 100 percent open pasture there was in each acre of the pasture land that was being mapped. A five percent open pasture meant, in his estimation, that twenty acres of the sort of land that he was mapping would be equivalent to one acre of 100 percent open pasture.

Two men from the Soils Department of the Connecticut Agricultural Experiment Station at New Haven then made detailed soil maps of these farms.

Detailed farm records have been obtained from nearly all of these farmers for two years, and from some of them for three years. These records include all expenses and receipts including inventory changes as well as an evaluation of family labor and farm privileges. Other items of economic interest were also determined.

Most of these records have been taken by the survey method although a considerable number of the farmers are keeping the farm account books with which the college provides them.

In order to obtain accuracy, data on the various crops and fields were collected as soon after the harvesting of these crops as possible. The input-output data on these crops were gathered at the same time. The data were gathered during the months of July and August, 1929, during and immediately after the haying season, and therefore at a time most favorable to accuracy. All of the figures were obtained from farmers' estimates except in the silo-filling tests on the three farms where the operations were actually timed.

Accuracy of the Data

Questions naturally arise as to the accuracy of the data collected by the survey method. It was found that the data collected early in the season were more accurate than those collected later. The following table brings out the comparison between the coefficients of variation in the time for mowing per acre in the different groups in the first 149 fields on which data were collected and the last 140.

TABLE 18. *Relation between the Coefficients of Variation and the Date of Record Taking and Size of Field*

Coefficients of Variation	Size of Field in Acres 0.0 to .99	1.0 to 1.99	2.0 to 2.99	3.0 to 3.99	4.0 to 4.99	5.0 and over
Records Taken First	41.91	39.60	30.09	20.30	24.23	24.40
Records Taken Last	49.77	39.06	26.79	39.48	45.42	30.57

It should be noted that in four of the six groups here represented the coefficient of variation is larger on those records taken late in the season than it is on those taken early. In the 1.0 to 1.99-acre group

there is no essential difference, and in the 2.0 to 2.99-acre group the coefficient of variation is smaller for the last records. There are a number of other considerations involved in this besides errors of estimate. Chief among these are differences in the speed with which the horses walk, differences in shape of the field and in other physical obstructions, qualitative difference in mowers, etc. There is no evidence that over-estimates were either more or less common than under-estimates, and we conclude from the table merely that the farmer's memory was more accurate soon after harvest than it was later.

The reason for the decrease in the size of the coefficients as the size of the fields increase is obvious. An error of 15 minutes is not serious in a field of five acres, since it makes a difference of only three minutes per acre. In a field of 0.5 acres a similar error of estimate would make a difference of 30 minutes per acre. This should not be taken to mean that the difference in the time for mowing a five-acre field compared with the time for mowing a 0.5-acre field, as expressed in terms of averages, is not accurate. It simply means that there was more deviation around the mean in the latter case.

Where dispersion, as in this case, is largely the result of errors in estimate, it constitutes an important source of difficulty in interpreting correlation results. The first coefficients of correlations which were computed were between size of field and man-hours per acre for mowing. The computation on 120 cases, one-fifth of the total number picked at random from all of the records, yielded a coefficient of correlation of —.3877 ± .0524, low but significant. Examination of the original data suggested that the first records taken were more accurate. A second computation based only on the records taken by one enumerator in the first two towns and including 149 cases, yielded a coefficient of correlation of —.4534 ± .0439. Both of these were straight-line correlations.

It then became apparent that even if each farmer experienced the same difficulty in mowing small fields and if his time for mowing was affected to exactly the same extent by the influence of the size of the field, there would still be a considerable scatter around the regression line simply because one farmer mows faster than another on all fields. In an attempt to eliminate the variation caused by this factor which could not be measured, an average time for mowing an acre was computed for each farmer, based on his average mowing time on all fields more than three acres in size. Mowing time on each field was then expressed as a percentage obtained by dividing the actual mowing time per acre for each field by this average time. The correlation between the size of the field and these percentage figures was —.5076 ± .0410. The average on which this ratio is based is, of course, subject to criticism. Most farmers had at least 10 acres in fields more than three acres in size, and those that did not were dropped from this list. A farmer's average mowing time was, of course, influenced by the character of the fields which were included in computing the average. All fields which were extreme variations in mowing time from the average were excluded in computing the average, but not in the computation of the correlation. Stony fields had been eliminated from the start.

Statistical Methods Employed

It was apparent throughout that a straight line was an imperfect means of expressing the relationship between size of field and man hours per acre for mowing. Several curves were now fitted to the data. Of those tried, the line which best described the relationship was found to be described by the formula $\overline{X} = 2.97669 - 1.04003A$ in which $\overline{X}$ is the man-hours used per acre in mowing and A is the logarithm of ten times the size of the field in acres. The coefficient of correlation between the time for mowing and the log of ten times the size of the field in acres was —.5979 ± .0355.

An attempt was then made to eliminate the effects of the differences in the rapidity with which different farmers mow regardless of the size of the field. A combination of the logarithmic method and the ratio method explained earlier was therefore tried. The coefficient of correlation between the ratio of the number of man-hours used per acre, determined by dividing the actual time for a particular field by the average mowing time for all fields over three acres in size on each farm, and the logarithm of ten times the size of the field in acres was found to be —.6990 ± .0305. This coefficient of correlation indicates that, with this sample, almost 49% of the squared variation in mowing time was associated with variations in size of field. Taken in conjunction with the probable error, we find that the size of field in other similar groups of farms might be expected, in 50% of the cases, to account for from 45% to 53% of the squared variation in mowing time. In both of these last statements, the term "variation in mowing time" refers to the percentage which the time taken on a given field is of the average time per acre taken by the particular farmer on fields of three acres and over.

The size of the coefficient of correlation in all these cases is undoubtedly materially reduced by errors of estimate. There was much more scatter about the line of regression in the small fields. It is to be

expected that there would actually be more variation in these groups, so it seems reasonable to conclude that a large part of this variation is due to errors of estimate.

The regression equation was found to be in substantial agreement with the averages obtained by simple sorting except that there was less range between the time per acre for the small fields and the large ones. The regression equation rather than the averages was used in Table 7.

For the operations of plowing, cultivating, and raking, the same principles were applied. The averages displayed the same characteristics as the averages for mowing, hence no coefficients of correlation were computed. Regression lines were fitted to the line of averages by the method of least squares, and these regression lines have been presented numerically in Table 7. The regression lines were used because it was possible through their use to smooth apparently meaningless fluctuations in the line of averages.

The second correlation to which reference has been made was the correlation between yield per acre, size of field, and man-hours per ton for mowing hay. The results are briefly presented below:

$R = .610$
$S_e = 1.0428$
$M_x = 1.6593$
$X = 3.98388 - .770900 \log 10\ A - 1.104315\ B$
Net Determination of A = .036
Net Determination of B = .336
Total Determination = .372

A refers to the size of the field, B refers to the yield per acre, and X is the number of man-hours per ton.

The same criticism can be made of this correlation that was made in regard to the others, that it does not take into consideration the effect of shape of field or other physical obstructions. Stony fields were not included in these data. Nor do they take account of the difference in the rapidity with which different farmers mow regardless of these factors. Errors of estimate are probably just as important in reducing the size of the coefficient of correlation in this analysis as they were in the others. Errors in estimating the yield as well as the time for mowing are possible, and probably do not give rise to any bias. A slight upward bias may have been introduced into these data because extremely small fields which also had low yields were not included in the original data. More variation in yield per acre occurred on small fields than on large fields, which again suggests errors of estimate.

The results of the computations listed above indicate that, with this sample, 37 percent of the squared variation in mowing time per ton was associated with variations in the size of the field and in yield per acre.

The standard error of estimation of X is 1.04283, which indicates that in 67 percent of similar fields the mowing time per ton would be approximately within an hour of the time estimated by the formula.

The next coefficient of correlation to which reference has been made was computed in an effort to determine the effect of the use of a hay loader, and the effect of the number of horses used in hauling, number of men used in hauling, distance of the field from the barn, size of the field, and yield per acre, on the number of man-hours used per ton in hauling hay. Subsorting had been tried, but, although there were more than 1,200 field divisions in hay, even this was not enough for purposes of detailed subsorting. Six variables were used in this correlation. The distance from the barn and the size of the field in acres had the greatest influence of any of the factors measured in the correlation on the labor cost of harvesting hay. The net determination in the case of distance from the barn was .094 and in the case of size of field, .075. The whole procedure is subject to a number of criticisms:

1. No data were collected on what is believed to be the most important factor—type of wagon and size of rack.

2. The factors apparently have little influence on labor efficiency in hauling hay.

The results of the computation are presented below:

$R = .534022$

$E_r = .027837$

$S_e = 1.27075$

$$X = 3.01303 - .643746\ A - .827661\ B + .940560\ C + .044821\ D - .034651\ E - .350412\ F.$$

Net Determination of A = .026249
" " " B = .005030
" " " C = .055413
" " " D = .094329
" " " E = .075300
" " " F = .028858

A refers to whether or not a hay loader was used; not using a hay loader was coded 0, and using a loader was coded 1; B refers to the number of horses used in hauling; C refers to the number of men used; D refers to the distance from the barn expressed in terms of 100 feet; E refers to the size of the field in acres; and F refers to the yield per acre in tons; and X is the number of man-hours used per ton in loading, hauling, and unloading hay.

These data indicate that, with this sample, 29 percent of the squared variation in time for hauling per ton was associated with variations in the factors indicated.

Taken in conjunction with the probable error, we find that in other similar groups of farms these factors might be expected to explain, in 30 percent of the cases, from 26 to 32 percent of the squared variation in the time for hauling hay.

The standard error of estimation indicates that in 67 percent of similar fields the time per ton for hauling hay would be within 1.27 hours of the time estimated by the formula.

The statement was made early in this paper that different methods of statistical approach yielded varying results. Simple sorting of these data on the basis of size of field showed that apparently this factor had considerable influence on the time for hauling hay, although no reason could be given for this. Reference to the net determination coefficients shows that only 0.5 of one percent of the squared variation in time for hauling was associated with variations in this factor. Similarly, even after all cases of one-horse hauling and all cases in which hay-loaders were used had been excluded, and on records in which the yield per acre varied less than one ton, subsorting yielded a difference of 0.7 hours between two and three man crews in the time for hauling, while the correlation which eliminated the effects of the variations in the other factors as well showed a difference of 0.94 hours per ton. On the other hand, subsorting within this same range in yields attributed a gain of 1.20 hours per ton to the use of a hayloader with the effects of differences in the crews eliminated, while the correlation results indicated that the saving which could be attributed to the use of a hayloader was only .64 hours per ton.

Distinct differences in method, such as the difference between using a hay-loader and not using a hay-loader, can usually be handled fairly well by subsorting, but when there are a large number of other factors it is necessary to be extremely careful. When such a large number of causal factors are operating as were evidenced in this material, the data can be subsorted on the basis of a few factors only, and the results become erratic because of the scarcity of numbers. Correlation analysis combined with good judgment becomes the only possibility.

TABLE 19. *Number of Hay, Oats, Corn, and Miscellaneous Field Divisions, and Number of Acres Producing These Crops Classified by Size of Field Divisions*

	SIZE OF FIELD DIVISION											
	0.0 to .99	1.0 to 1.99	2.0 to 2.99	3.0 to 3.99	4.0 to 4.99	5.0 to 5.99	6.0 to 6.99	7.0 to 7.99	8.0 to 8.99	9.0 to 9.99	10.0 and Over	Totals
No. Field Divisions in Hay	237	296	242	134	97	65	43	32	24	9	37	1216
No. Acres in Hay	145.48	441.63	599.54	462.58	435.82	351.18	275.61	240.33	203.69	85.88	614.92	3856.65
No. Field Divisions in Oats and Rye	61	52	27	17	14	3	4		3	1	1	183
No. Acres in Oats and Rye	37.51	76.12	62.56	59.48	61.81	15.88	25.84		25.74	9.94	10.10	384.98
No. Field Divisions in Corn	52	62	45	35	25	7	4	4	1	1		236
No. Acres in Corn	32.71	91.41	110.11	121.61	110.20	39.01	24.96	29.31	8.69	9.34		577.35
No. Field Divisions in Misc.	529	102	33	17	12	9			1			703
No. Acres in Misc.	194.83	144.94	78.94	51.61	53.06	49.48			8.65			581.51
Total No. of Field Divisions	879	512	347	203	148	84	51	36	29	11	38	2338
Total No. Acres	410.53	754.10	851.15	695.28	660.89	445.55	326.41	269.64	246.76	105.16	625.02	5400.49

TABLE 20. *Percent of Total Number of Field Divisions and Number of Acres Used in Hay Production, Classified by Size of Field Divisions*

	SIZE OF FIELD DIVISION											
	0.0 to .99	1.0 to 1.99	2.0 to 2.99	3.0 to 3.99	4.0 to 4.99	5.0 to 5.99	6.0 to 6.99	7.0 to 7.99	8.0 to 8.99	9.0 to 9.99	10.0 and Over	Totals
Percent of Total No. of Hay Fields	19.49	24.34	19.90	11.02	7.98	5.35	3.54	2.63	1.97	.74	3.04	100.00
Percent of Acreage in Hay	3.77	11.45	15.55	11.99	11.30	9.11	7.15	6.23	5.28	2.23	15.94	100.00

TABLE 21. *Percent of Total Number of Field Divisions and Number of Acres Used in Oat and Rye Production, Classified by Size of Field Divisions*

	Size of Field Division											
	0.0 to .99	1.0 to 1.99	2.0 to 2.99	3.0 to 3.99	4.0 to 4.99	5.0 to 5.99	6.0 to 6.99	7.0 to 7.99	8.0 to 8.99	9.0 to 9.99	10.0 and Over	Totals
Percent of Total No. of Oat and Rye Fields	33.33	28.42	14.75	9.29	7.65	1.64	2.19		1.64	.55	.55	100.00
Percent of Acreage in Oats and Rye	9.74	19.77	16.25	15.25	16.06	4.12	6.71		6.69	2.58	2.62	100.00

TABLE 22. *Percent of Total Number of Field Divisions and Acres Devoted to Corn, Classified by Size of Field Divisions*

	Size of Field Division											
	0.0 to .99	1.0 to 1.99	2.0 to 2.99	3.0 to 3.99	4.0 to 4.99	5.0 to 5.99	6.0 to 6.99	7.0 to 7.99	8.0 to 8.99	9.0 to 9.99	10.0 and Over	Totals
Percent of Total No. of Corn Fields	22.03	26.27	19.07	14.83	10.59	2.97	1.69	1.69	.42	.42		100.00
Percent of Acreage in Corn	5.67	15.83	19.07	21.06	19.09	6.76	4.32	5.08	1.51	1.62		100.00

TABLE 23. *Percent of Total Number of Field Divisions and Number of Acres Used in Production of Miscellaneous Crops, Classified by Size of Field Divisions*

	Size of Field Division											
	0.0 to .99	1.0 to 1.99	2.0 to 2.99	3.0 to 3.99	4.0 to 4.99	5.0 to 5.99	6.0 to 6.99	7.0 to 7.99	8.0 to 8.99	9.0 to 9.99	10.0 and Over	Totals
Percent of Total of Misc. Fields	75.25	14.51	4.96	2.42	1.71	1.28			.14			100.00
Percent of Acreage in Misc.	33.50	24.92	13.58	8.88	9.12	8.51			1.49			100.00

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Agricultural Experiment Station

Hay Requirements of City Work Horses

J. A. Simms
and
J. O. Williams

In Cooperation with the Bureau of Animal Industry, Bureau of Public Roads and Bureau of Agricultural Economics, United States Department of Agriculture.

CONNECTICUT AGRICULTURAL COLLEGE
STORRS, CONNECTICUT

Hay Requirements of City Work Horses

J. A. Simms[1] and J. O. Williams[2]

In 1924 and 1925 a series of feeding trials was conducted by the senior author, in stables of city work horses in two cities in Connecticut, and reported in Bulletin No. 132 of the Storrs Agricultural Experiment Station under the title, "Preliminary Experiments in Feeding City Work Horses." (1) These trials demonstrated the possibility of using animals kept under normal city stable conditions for certain types of feeding experiments and also showed convincingly that large numbers of horses are necessary for such experiments, since the variations in the weights of individuals within a group were often greater than the differences between groups.

These preliminary experiments also led to this hypothesis: There is a minimum amount of roughage required by the horse at work, and nothing is gained by feeding roughage in excess of this minimum; additional feed required to maintain weight can be supplied more economically in grain than in hay. For idle horses there may be advantage in feeding large amounts of roughage with a very limited grain ration, but the present investigation was limited to horses at work.

In order to test this hypothesis and to determine the minimum hay requirement, more carefully controlled trials were necessary. A cooperative arrangement between the Storrs Agricultural Experiment Station and the United States Department of Agriculture made this possible, and the data here presented are the result of the trials so conducted.

The plan as finally arranged included cooperation on the part of the Bureau of Animal Industry, the Office of Public Roads, and the Bureau of Agricultural Economics. Mr. J. O. Williams, Senior Animal Husbandman, represented the Bureau of Animal Industry throughout the experiment. Dr. Paul E. Howe of the same bureau made many helpful suggestions. Mr. M. A. R. Kelley of the Office of Public Roads personally secured draft records on the wagons used. The hay used was graded by the Bureau of Agricultural Economics under the direction of Mr. K. B. Seeds. To all of these the authors gratefully acknowledge their indebtedness.

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Mr. R. E. Simms, Field Agent of the Bureau of Animal Industry, was in direct charge throughout, handling the details and obtaining the records. For the first six months of 1927 the senior author was on sabbatic leave, during which period Professor A. G. Skinner of the Connecticut Agricultural College had general supervision.

Special credit is due Mr. E. H. Walker and Mr. E. S. Sprague of the Bridgeport Ice Delivery Company and Mr. W. L. Worden and Mr. R. E. Fisher of R. F. Worden & Sons, who made this work possible

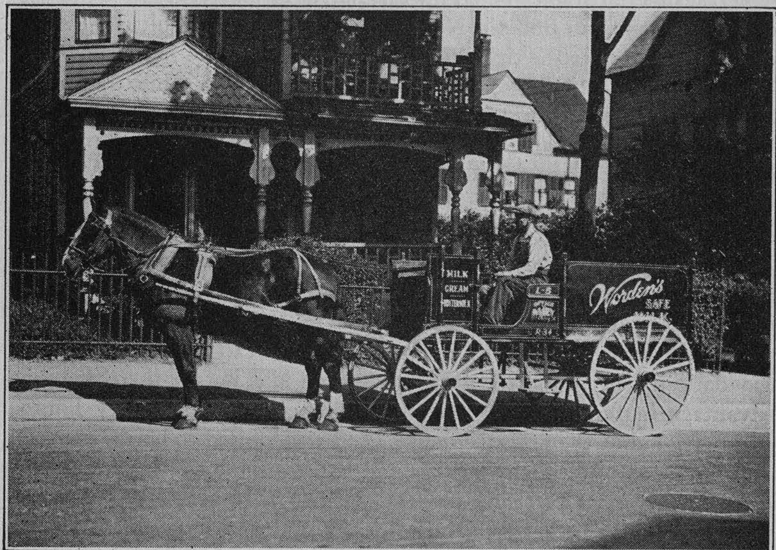

FIGURE 1. ONE-HORSE HITCH
Worden Stables, Waterbury, Conn., June, 1928

by furnishing the animals, stables, feed and labor used in carrying out the experiments.

The photographs were taken by the Bureau of Animal Industry photographic staff.

Review of the Literature

The amount of hay fed to horses in experimental trials seems to vary widely. In the Fort Riley experiments (2) McCampbell fed from 10 to 16 pounds daily of timothy, prairie or alfalfa hay, or alfalfa meal, to horses weighing 1100 to 1200 pounds. The amount of hay fed varied from 0.85 percent to 1.4 percent of the weight of the

animals. Templeton, in mule feeding experiments at the Mississippi Station (3), fed hay in amounts varying from 1 percent to 1.5 percent of the weight of the animals, while Trowbridge averaged 1.18 percent in a two-year trial at the Missouri Station (4). Edmonds and Kammlade (5) report four years' experiments during which the hay fed to horses averaged from 0.93 percent to 1.14 percent, while the mules received from 0.85 percent to 1.22 percent. "Each animal received as much grain and hay, weighed separately, as it would eat readily."

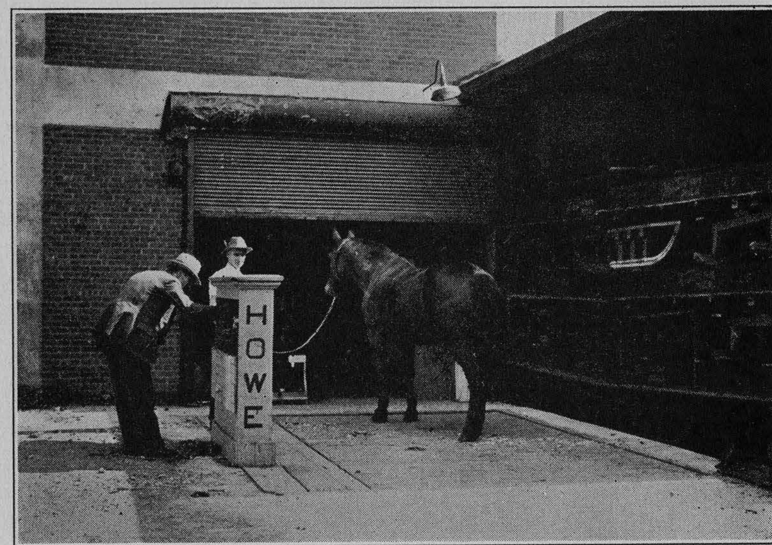

FIGURE 2. WEIGHING HORSE
Worden Stables, Waterbury, Conn., June, 1928

Clark (6), however, at the Montana Station found that horses would eat from 1.5 percent to 3 percent or more of their weight if the quality of the hay was good. One horse weighing about 1400 pounds was reported to have consumed an average of 60 pounds of hay per day, or 4.3 percent of his weight. In an experiment at the Nebraska Station (7), Gramlich fed only 0.78 percent to mules and 1.17 percent to horses. Carroll (8) stated that horses at the Utah Station ate 35 to 40 pounds of hay daily, or between 2.5 and 3 percent. Alfalfa hay was the roughage and they were given all they would eat.

Again, little experimental data are available regarding the optimum amount of hay to be used in feeding horses. At the Montana Station, Clark (6) fed four horses for about five months. Two of them received all the hay that they would eat readily and two were fed on two-thirds as much as the others were consuming. Those on the heavy hay ration received an average of 25.8 pounds per day and those on the light ration, 17.2 pounds. Those getting the smaller hay ration did not maintain their weights quite as well as the others did, but Clark states that the horses receiving the smaller amount of hay had more life and sweat less than those that were not limited in their hay. Harper (9) reports two tests carried out by the reversal method, in

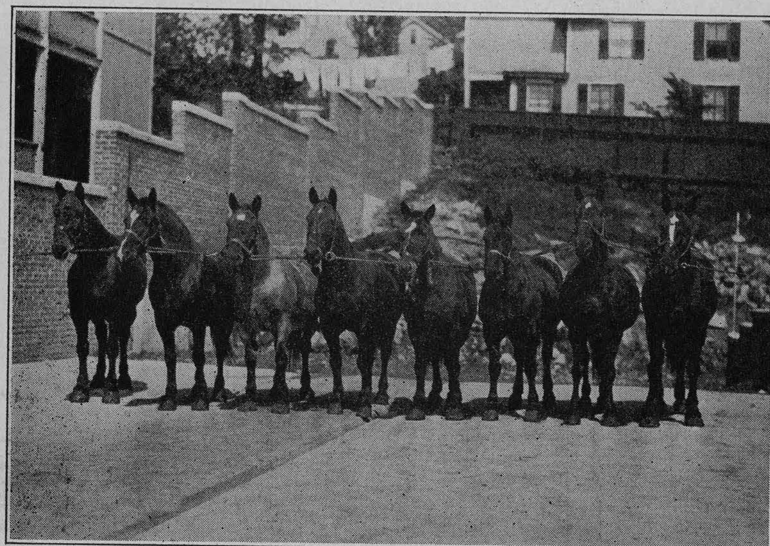

Figure 3. Horses—Lot I
Worden Stables, Waterbury, Conn., June, 1928

which he varied the proportion of grain to hay. Each group was fed for 56 days on each of the two rations in one test and for 50 days on each of the rations in the other test. The advantage for the "light hay—heavy grain" group was 24.6 pounds gain per horse for each of the four periods. In these tests 100 pounds of hay replaced 73 pounds of grain and the result was a considerable and uniform loss in the weight of the "heavy hay" group as compared with the "light hay" group.

Hansson (10) carried out a series of eight experiments, in six of which grass hay was compared with oats, and in the other two, grass hay with corn. These tests lasted 48 to 100 days, including the preliminary periods, and either four or five horses were used in each of two lots throughout the series. Assuming one kilo (2.21 pounds) of

barley, 0.95 kilo (2.09 pounds) of corn, or 1.2 kilos (2.65 pounds) of oats equal to one food unit each, Hansson gave timothy and other hay "rich in grasses" a value of one food unit for each 2.5 kilos (5.51 pounds). The hay fed in these tests varied from 0.3 percent to two percent of the weight of the animal, but where the smaller amounts were fed, straw amounting to nearly one percent of the weight of the animal was fed also. Hansson concluded that "horses are able to consume as much as 18 to 20 kilos (39.68 to 44.09 pounds) of hay

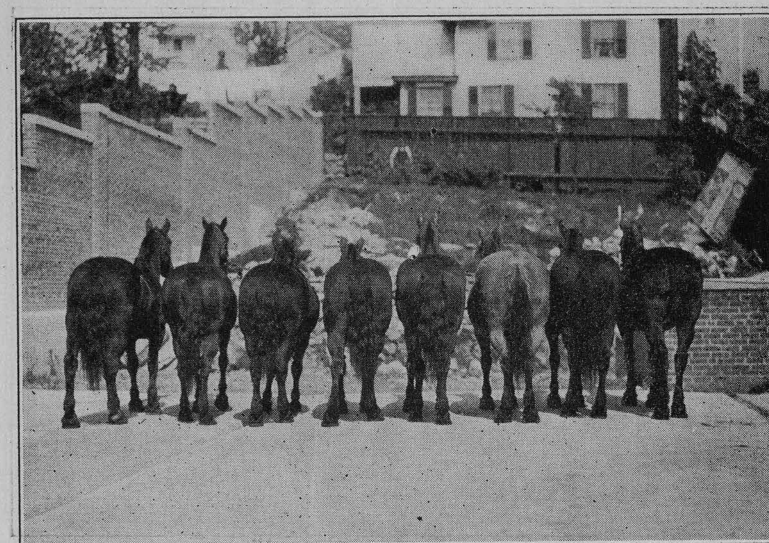

Figure 4. Horses—Lot I
Worden Stables, Waterbury, Conn., June, 1928

per head per day when hay alone is used as fodder, but the great bulkiness of the hay and the low nutritive concentration value of the same cause a considerable reduction in the working capacity of the horses," and "With a quantity of 12 to 14 kilos (26.46 to 30.86 pounds) per head per day a clearly perceptible reduction in the efficiency of the hay is brought about and the hay has been utilized best when the maximum quantity given was restricted to about 6 to 8 kilos (13.23 to 17.64 pounds)." Most of the horses used in these tests weighed from 1300 pounds to 1400 pounds.

Common Feeding Practices

The variations in amounts of hay fed in both city and farm stables are fully as great as those cited above. In 1919 and 1920 the senior author obtained the approximate weights of hay fed to more than 2,000 horses and mules in the cane, rice and cotton belts. The amounts fed in different stables ranged between 15 and 30 pounds per day, with the average about 25 pounds. The animals, mostly mules, weighed about 1200 pounds. The waste was quite large on most of the plantations

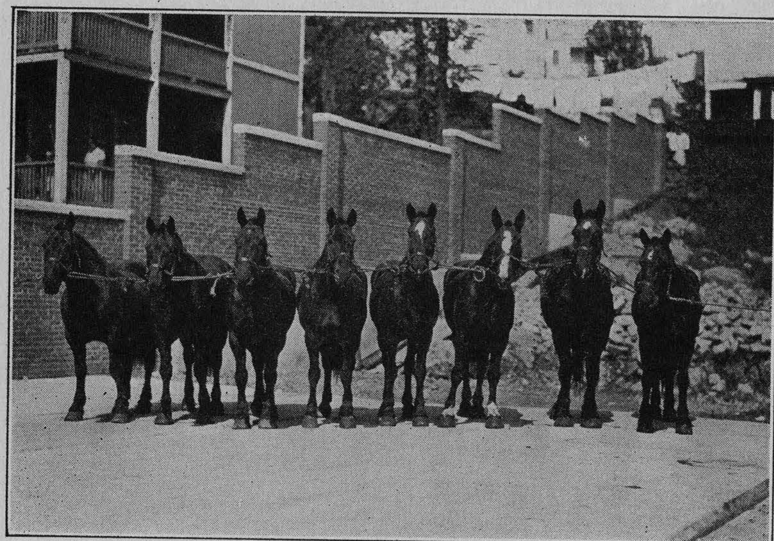

FIGURE 5. HORSES—LOT II
Worden Stables, Waterbury, Conn., June, 1928

as the common method of feeding was to fill long racks around which all of the animals were allowed to eat. All of the hay that fell on the ground was trampled under foot. Records secured from 1921 to 1924 on 40 Connecticut farms showed an average hay ration of about 25 pounds. The estimated average weight of the horses was 1350 pounds.

Estimates on about 50,000 city work horses have been secured which indicate that they are fed a little less hay than are country horses. Some of these estimates are quite accurate, being based on the amount of hay purchased divided by the total number of horses, over periods up to six years. Others are based on the hay fed during periods as short as thirty days, and still others are feeding schedules. The latter are not accepted as being sufficiently accurate for inclusion in averages

here unless other checks on the horses have been made, which indicate that they are approximately correct.

The large corporations owning 1,000 or more horses seem to feed hay more economically than the smaller horse owners. Their averages range from 15.5 pounds per horse to 22 pounds, or from 1.2 percent of the weight of the animal to 1.8 percent. In one corporation with horses scattered from Boston to St. Louis and from Detroit to New Orleans, the average hay consumption in the various stables ranged from

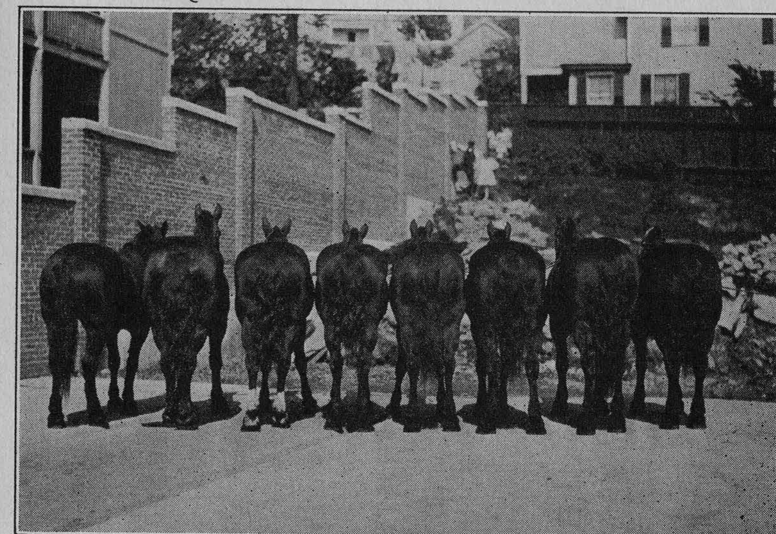

FIGURE 6. HORSES—LOT II
Worden Stables, Waterbury, Conn., June, 1928

11.4 pounds to 40 pounds per day, with a general average for all the stables of 18.7 pounds. The average hay consumption of 8,342 horses owned by companies with less than 1,000 horses was 24.4 pounds per day or 1.75 percent of their weight, assuming the mean weight of horses was 1400 pounds.

The stables from which estimates could be secured were usually those in which better than ordinary care was taken of the horses. It is probable that the amount of hay fed in such stables is above the average for both city and country horses.

The figures secured from the various stables and from the experimental literature cited shows little if any fixed relation between the amounts of hay and grain fed.

Experimental

The preliminary trials mentioned above (1) indicated that the hay ration can be reduced materially below the amount commonly fed without causing the animals to lose weight and with a considerable saving in cost of feed. However, the conditions did not permit accurate control of the feeding and the plan was necessarily simple. No attempt could be made to determine either the minimum or the optimum hay requirement.

With the cooperation of the United States Department of Agriculture it was possible to secure the services of Mr. R. E. Simms, Field Agent in the Bureau of Animal Industry. Mr. Simms had immediate charge of the feeding and records throughout the several trials reported herein.

The feeding trials were conducted in two series, the first at Bridgeport in the stables of the Bridgeport Ice Delivery Company and the second at Waterbury in the milk plant of R. H. Worden & Sons. The conditions and procedure were different in the two stables and they will be discussed separately.

The Bridgeport Experiments

Most of the preliminary experiments reported earlier (1) were conducted in the stables of the Bridgeport Ice Delivery Company. Mr. E. H. Walker, the manager, had kept good records since 1919, so that conditions were very favorable. Beginning in 1925, the feeding instructions called for 15 pounds of grain per day (5 pounds on Sunday) and 12 pounds of hay. This was less than half the hay ration fed in previous years. Mr. Walker was greatly interested and readily cooperated in an experiment to determine the minimum hay requirement.

Description of Horses, Equipment and Work Performed

The horses were typical western work animals used on city ice delivery and weighed about 1400 pounds. They were worked in pairs, but in some cases there was shifting of horses. In the "Naugatuck" stable each team covered the same route each day with the same driver. In the "Sprague" stable, the drivers kept the same routes but the teams were shifted. The loads varied from day to day, hot weather greatly increasing and cool weather decreasing the demand for ice. The wagons used there were the heavy, covered, two-horse ice delivery type, all equipped with roller bearings. The horses worked six days a week, resting on Sunday.

It was impossible to determine the amount of work done or even the average load, but it is safe to say that the work would be about the average for city work horses.

Plan of the Trials

Two stables (designated as "Naugatuck" and "Sprague") were used, but the plan was the same for both. In each stable the horses were divided into three lots. As a basis for balancing these lots there was available a series of weights secured at intervals during the previous 24 months. These, with the age and condition of the horses, the work performed, and the skill of the drivers, were all taken into consideration in making up the groups.

The grain to be fed was fixed for all horses at 15 pounds per day, this being reduced to 5 pounds on Sundays when the horses were idle. This had been the regular ration for some years. The only difference, then, was in the hay allowed,—Lot I, 8 pounds, Lot II, 12 pounds, and Lot III, 16 pounds per day. Eight pounds was arbitrarily chosen as an irreducible minimum. For a 1400 pound horse this is 0.57 percent of the live weight, somewhat lower than anything reported in the literature reviewed.

At the outset, each lot consisted of 10 horses, but because of sales, changes in work, or injury, the number was reduced. In the data presented there are included only those animals that completed the tests without interruption. None of these lost a single day because of sickness or other disability.

Feed and Feeding

The grain fed was a mixture of crushed barley and oats, in the ratio of one to two by weight. In the Naugatuck stable where the test was continued for eight weeks only, the grain was fed by measure, one man doing all feeding. A measure was provided that held just five pounds, the amount fed at each meal. In the long test of 36 weeks at the Sprague stable, canvas bags were provided, three for each horse. Mr. R. E. Simms personally weighed the grain for each day into these bags and hung them behind the stalls. The barn man emptied one of these into the manger at each feeding, or in case of feeding on the road, the noon meal was put in the nose bag carried on the wagon.

The hay fed in the 36 week trial at the Sprague stable was sampled three times during the period and sent to the Bureau of Agricultural

Economics. The report of Mr. Seeds is given below—

Sample No. 1—U. S. No. 2 Mixed Hay, approximately 55 percent grass, 25 percent clover, 15 percent timothy and 5 percent foreign material.

Sample No. 2—U. S. No. 2 Mixed Hay, approximately 60 percent clover, 15 percent grass, 10 percent timothy and 15 percent foreign material.

Sample No. 3—U. S. No. 2 Mixed Hay, approximately 55 percent timothy, 20 percent grass, 15 percent clover and 10 percent foreign material.

While there would seem to be considerable variation in the percent of clover present, Sample No. 2 being higher than the others, there seems to be no reason to believe that this was a significant factor under the conditions of this test.

All of the hay was fed at night, the entire allowance being placed in the rack at one time by the barn man. A scale was installed in the loft and the hay for each horse was weighed until the feeder became able to judge quite accurately the amount desired. Throughout the trial the weight of hay actually fed was checked frequently by Mr. Simms.

Weighing

Weights on three successive days were averaged for the initial and final weights. For the others, the horses were weighed bi-weekly after the day's work was done but before they were fed or watered.

Results

The results are presented below in Tables 1 and 2 with the pertinent data.

Table 1

Bridgeport Experiments—Naugatuck Stable

LOT I—HAY, 8 POUNDS; GRAIN, 15 POUNDS

Weighing Dates	Horse Number							Average of Lot
	No. 259	No. 258	No. 226	No. 230	No. 214	No. 200	No. 63	
1927	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Aug. 10	1410	1510	1230	1310	1420	1410	1380	1381
Aug. 25	1410	1500	1220	1315	1400	1375	1375	1371
Sept. 7	1430	1570	1275	1320	1460	1425	1420	1414
Sept. 21	1450	1550	1275	1325	1450	1420	1415	1412
Oct. 5	1450	1560	1275	1325	1435	1430	1400	1410

Difference between initial and final weights, + 29 pounds. Hay as percent of live weight, 0.58 percent.

LOT II—HAY, 12 POUNDS; GRAIN, 15 POUNDS.

Weighing Dates	Horse Number						Average of Lot
	No. 254	No. 75	No. 8	No. 85	No. 68	No. 79	
1927	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Aug. 10	1460	1500	1280	1270	1475	1435	1403
Aug. 25	1420	1465	1280	1280	1410	1410	1376
Sept. 7	1415	1480	1315	1310	1460	1470	1408
Sept. 21	1415	1480	1310	1310	1470	1470	1409
Oct. 5	1400	1500	1285	1310	1455	1435	1398

Difference between initial and final weights, — 5 pounds. Hay as percent of live weight, 0.86 percent.

LOT III—HAY, 16 POUNDS; GRAIN, 15 POUNDS

Weighing Dates	Horse Number							Average of Lot
	No. 17	F.F.S.	No. 7	No. 233	No. 22	No. 96	W.L.R.	
1927	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Aug. 10	1220	1260	1250	1245	1350	1500	1510	1334
Aug. 25	1200	1245	1235	1235	1330	1500	1500	1321
Sept. 7	1225	1280	1245	1280	1340	1500	1500	1339
Sept. 21	1225	1275	1245	1275	1350	1500	1520	1341
Oct. 5	1250	1305	1205	1300	1335	1475	1500	1339

Difference between initial and final weights, + 5 pounds. Hay as percent of live weight, 1.2 percent.

Table 2

Bridgeport Experiments—Sprague Stable

LOT I—HAY, 8 POUNDS; GRAIN, 15 POUNDS

Weighing Dates	Horse Number							Average of Lot
	No. 237	No. 209	No. 18	No. 122	No. 23	No. 108	No. 109	
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Sept. 8	1200	1450	1305	1405	1435	1450	1350	1371
Sept. 22	1225	1445	1290	1375	1430	1465	1355	1369
Oct. 6	1220	1440	1295	1380	1420	1450	1350	1365
Oct. 20	1235	1430	1295	1365	1415	1445	1360	1364
Nov. 3	1205	1400	1270	1350	1400	1450	1350	1346
Nov. 17	1200	1410	1240	1375	1405	1445	1390	1352
Dec. 1	1190	1390	1250	1395	1400	1450	1400	1353
Dec. 15	1195	1375	1270	1390	1410	1450	1385	1354
Dec. 29	1200	1375	1260	1390	1430	1425	1390	1353
Jan. 12	1185	1390	1260	1375	1405	1415	1395	1347
Jan. 26	1190	1385	1265	1390	1400	1425	1385	1349
Feb. 9	1205	1395	1290	1385	1405	1400	1365	1349
Feb. 23	1210	1420	1280	1385	1400	1420	1365	1354
March 9	1195	1400	1295	1395	1410	1445	1350	1355
March 23	1225	1400	1280	1385	1400	1440	1345	1353
April 6	1250	1395	1270	1390	1410	1450	1340	1358
April 20	1265	1395	1260	1390	1400	1435	1355	1357
May 4	1220	1380	1295	1395	1420	1445	1350	1358
May 18	1235	1370	1290	1385	1410	1430	1360	1354

Difference between initial and final weights, — 17 pounds. Hay, as percent of live weight, 0.6 percent.

LOT II—HAY, 12 POUNDS; GRAIN, 15 POUNDS

Weighing Dates	Horse Number No. 69	BH	No. 3	No. 114	No. 16	No. 56	WAK	Average of Lot
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Sept. 8	1350	1325	1295	1350	1690	1590	1360	1423
Sept. 22	1350	1350	1255	1340	1730	1620	1370	1430
Oct. 6	1345	1335	1270	1310	1720	1600	1365	1421
Oct. 20	1345	1350	1275	1330	1700	1610	1360	1424
Nov. 3	1360	1345	1280	1340	1685	1585	1370	1423
Nov. 17	1375	1365	1275	1365	1675	1590	1365	1430
Dec. 1	1410	1380	1255	1370	1680	1580	1370	1435
Dec. 15	1390	1375	1280	1375	1680	1565	1360	1432
Dec. 29	1395	1380	1260	1360	1695	1570	1365	1432
Jan. 12	1395	1370	1275	1355	1690	1575	1365	1432
Jan. 26	1395	1370	1265	1355	1700	1590	1360	1432
Feb. 9	1370	1395	1270	1345	1690	1605	1370	1435
Feb. 23	1380	1390	1265	1325	1685	1610	1380	1433
March 9	1375	1380	1285	1315	1690	1600	1360	1429
March 23	1370	1365	1285	1335	1695	1605	1365	1431
April 6	1370	1325	1290	1345	1695	1585	1380	1427
April 20	1340	1230	1290	1350	1695	1590	1375	1410
May 4	1335	1235	1285	1325	1690	1595	1390	1408
May 18	1340	1245	1285	1350	1700	1590	1395	1415

Difference between initial and final weights, — 8 pounds. Hay as percent of live weight, 0.84 percent.

LOT III—HAY, 16 POUNDS; GRAIN, 15 POUNDS

Weighing Dates	Horse Number No. 120	BM	No. 240	No. 252	No. 113	Average of Lot
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Sept. 8	1190	1430	1275	1330	1520	1349
Sept. 22	1180	1415	1300	1380	1520	1359
Oct. 6	1185	1410	1275	1340	1515	1345
Oct. 20	1180	1420	1285	1345	1520	1350
Nov. 3	1200	1415	1265	1360	1505	1349
Nov. 17	1220	1435	1290	1355	1510	1362
Dec. 1	1245	1420	1285	1390	1500	1368
Dec. 15	1235	1405	1275	1380	1505	1360
Dec. 29	1245	1420	1255	1390	1525	1367
Jan. 12	1235	1405	1255	1385	1515	1359
Jan. 26	1240	1415	1265	1380	1520	1364
Feb. 9	1230	1420	1275	1380	1515	1364
Feb. 23	1225	1410	1265	1375	1525	1360
March 9	1230	1425	1245	1360	1520	1356
March 23	1225	1420	1260	1365	1530	1360
April 6	1230	1410	1245	1380	1550	1363
April 20	1200	1425	1265	1345	1535	1354
May 4	1210	1420	1275	1330	1540	1359
May 18	1205	1435	1265	1350	1540	1359

Difference between initial and final weights, + 10 pounds. Hay as percent of live weight, 1.2 percent.

Discussion

The Naugatuck stable trial (Table 1) was of such short duration, eight weeks, that no conclusions may be drawn safely. However, it may be pointed out that the differences are within the limits of experimental error.

At the Sprague stable (Table 2) where the trial continued for 36 weeks, we find no marked differences in the three lots. In Lot I on eight pounds of hay, Horse No. 209 lost rather steadily a total of 80 pounds. In Lot II, Horse No. BH gained for 24 weeks and then lost rather rapidly, finishing 80 pounds below the initial weight. All of the rest ran along evenly, when one considers that weights of horses may vary normally within a range of 50 pounds from day to day.

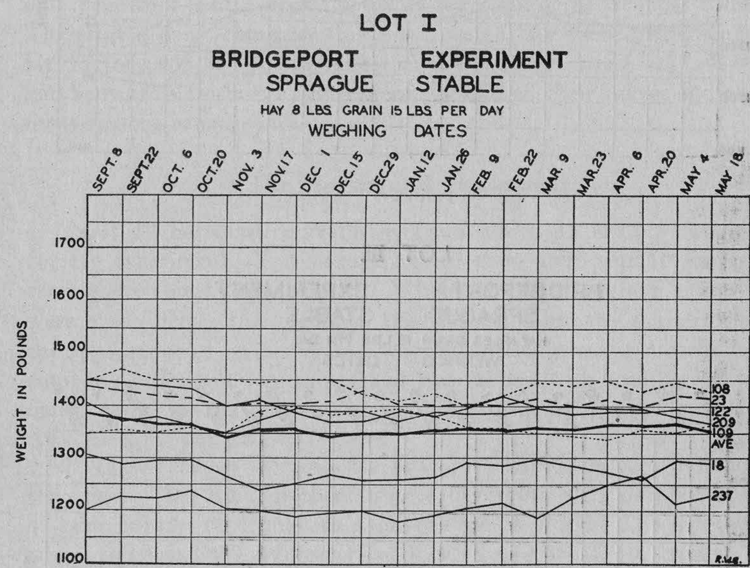

FIGURE 7

All the horses were carefully judged at the beginning and at the end of the trial by those in charge. In addition, other horsemen went over the animals on several occasions. The stablemen and drivers also were asked to give their opinions. None of these could detect any differences between the lots in health, spirit, appetite, appearance, or ability to work.

However, there is a distinct trend in the data. On 8 pounds of

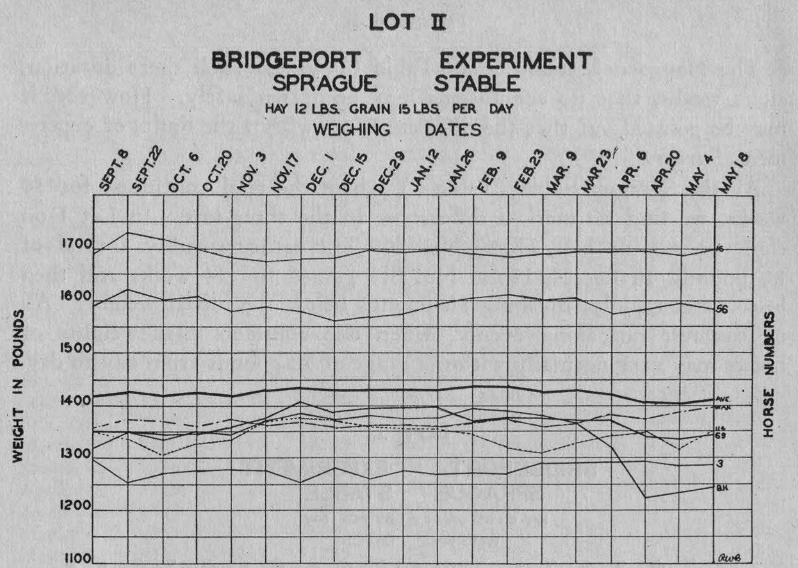

Figure 8

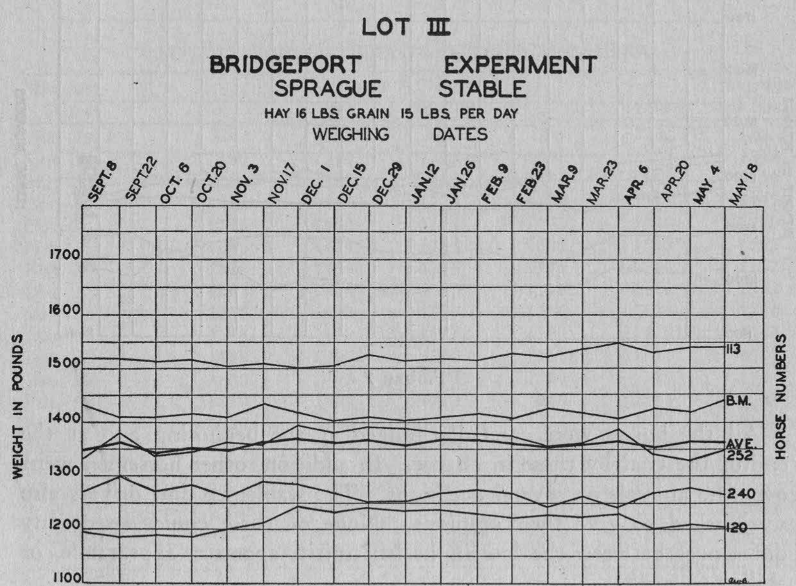

Figure 9

hay there was an average loss of 17 pounds, on 12 pounds a loss of 8 pounds, and on 16 pounds of hay, a gain of 10 pounds. All of the horses received 15 pounds of grain. If these differences are considered significant, then the optimum amount of hay for these conditions is about 14 pounds per horse, or one percent of the live weight.

THE WATERBURY EXPERIMENTS

(Worden Stables)

The horses at Bridgeport were on ice delivery, an enterprise that recently has undergone great changes due to the introduction of mechanical refrigeration. The regular delivery routes are being abandoned and the volume of retail business is decreasing. The one city enterprise that continues to use horses regularly is that of milk delivery. Therefore a dairy company stable was sought for more permanent and satisfactory conditions. Arrangements were made with R. H. Worden and Sons of Waterbury, who generously offered their horses and equipment for the experiments.

The Horses and Equipment

About 50 horses were available, from which 33 head were selected for the experiment. The average age of those used was 10 years, and the weight about 1300 pounds. While not of the highest grade, they were much better than average, the Worden Company taking pride in the appearance of its horses and wagons. Based on cost records in the company office, the hay ration had been about 30 pounds per day for many years. In 1925, at the suggestion of the senior author, this was reduced to 15 pounds.

Of the 33 horses starting the test, 24 finished and are included in the tables. Thus nine, or three from each group, were dropped because of sales, injury, or change to another type of work. The average age was as follows: Lot I, 12 years; Lot II, 9 years; Lot III, 10.5 years.

The wagons were all exactly the same—light, single rigs designed by Mr. Worden. They had plain axles, no tops, and weighed 975 pounds.

The Work Performed

All animals were worked single on milk delivery routes seven days per week. During the 314 days of the trial, all horses included in the tables were worked every day. Nineteen of the 24 had the same driver throughout. For the five on which drivers were changed, the data show no significant effect. Naturally the loads varied, but the average, including wagon and driver, was about 2000 pounds. On four routes the loads varied from 2400 to 3000 pounds but the horses used suffered no loss in weight or condition. Zuntz (11) reports that the energy required to draw a load up a grade of 10.7 percent is three times that required on a level road. Waterbury is a hilly city and some of the streets are not well paved. The wagons were not equipped with brakes, so that the horses worked both up and down the hills. However, every effort was made to balance the groups in respect to hills, loads, condition of streets, and the like.

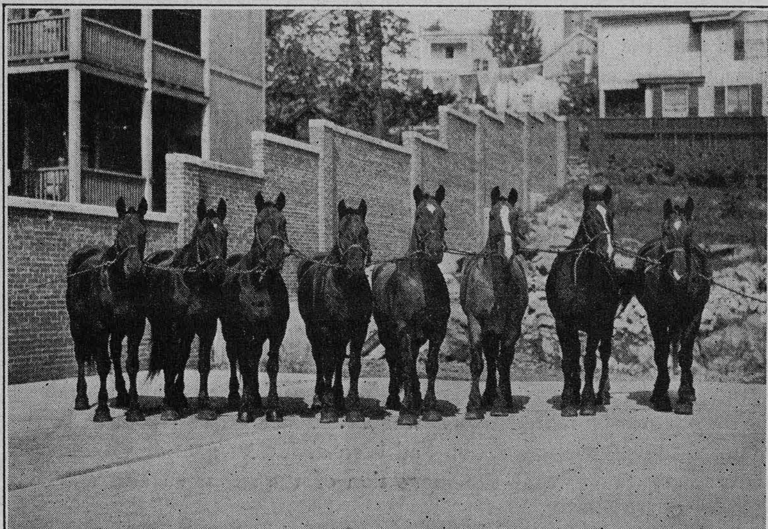

FIGURE 10. HORSES—LOT III
Worden Stables, Waterbury, Conn., June, 1928

Records were kept on temperature and precipitation during the period of the trials. Snowfall was unusually light during the winter of 1927-1928 and did not constitute a disturbing factor. During a hot week in June 1928, all of the lots lost some weight, the average being six pounds per horse.

The routes were measured by following each wagon with an automobile, this being repeated to insure accuracy. In the same manner the hills, the condition of the streets, the frequency of stopping, and the like were obtained. These with other data are presented in Table 3.

TABLE 3

Conditions Affecting Waterbury Experiments

Horse No.	Age 1927	Distance Traveled	Hills	Streets	Load	Sickness	Changed Drivers
			LOT I				
4	7	4.4	None	Good	Light	None	
5	15	6.7	Many	Good	Light	None	Apr. 22
6	7	6.4	Few	Good	Light	None	
11	14	2.0	Several	Fair	Light	None	
14	18	3.3	Few	Good	Light	None	
27	9	3.6	None	Good	Light	None	Mar. 5
29	9	2.8	Many	Good	Light	None	
32	13	1.9	Very many	Fair	Light	None	
			LOT II				
3	7	5.9	Many	Fair	Light	Nov. 1 slight colic	Mar. 25
9	10	8.1	Many	Good	Light	Sore withers several weeks	
10	8	9.0	Many	Fair	Heavy	None	
13	12	3.7	Some	Good	Light	None	
15	8	6.5	None	Good	Heavy	None	
22	8	4.2	Few	Good	Light	None	Jan. 16
25	9	5.9	None	Good	Heavy	None	
30	8	6.5	None	Good	Light	None	
			LOT III				
2	8	7.4	Few	Good	Light	None	June 17
7	7	7.4	Very many	Poor	Light	None	
8	12	10.4	Many	Fair	Heavy	None	
12	8	8.6	Many	Fair	Light	None	
17	13	3.7	Many	Good	Light	None	
18	9	5.8	Many	Fair	Light	None	
21	14	7.1	Few	Good	Light	None	
23	8	4.5	Few	Fair	Light	None	

Plan of the Experiment

The purpose of the experiment was to determine the minimum and optimum amounts of hay required by city work horses and the relative cost of increments of feed in hay and grain. The general plan was similar to that followed at the Bridgeport stables, but greater refinements were possible. Two preliminary determinations were deemed necessary: (1) The normal weight of each animal; (2) the amount of grain necessary to maintain this weight with a minimum amount of hay. For this purpose the amount of grain normally fed each horse was determined. Then all horses were put on eight pounds of hay

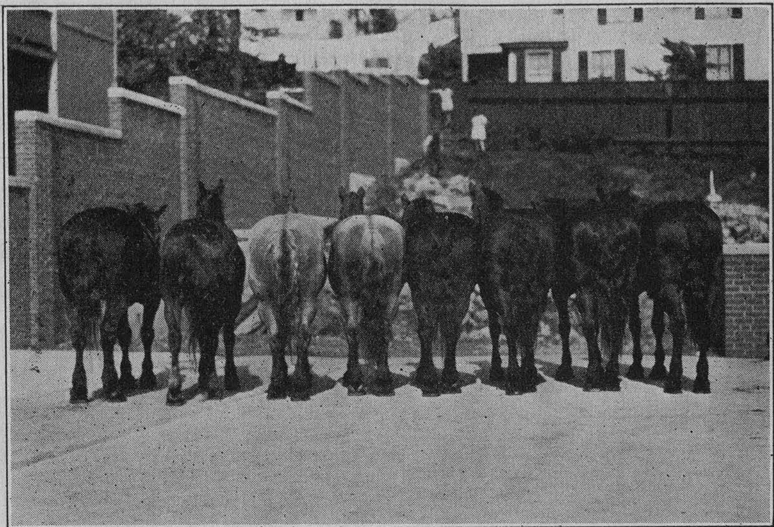

FIGURE 11. HORSES—LOT III
Worden Stables, Waterbury, Conn., June, 1928

(Sept. 21, 1927) and the grain gradually adjusted to the changing weights. By October 12 the grain requirement seemed to stabilize and no changes were made in grain or hay until January 18. October 12 to January 18, or 98 days, was the *Preliminary Period.*

On January 18, Lot II was put on 12 pounds of hay and Lot III on 16 pounds, and the grain gradually reduced for these lots. The 20 days, January 18 to February 8, were considered an *Adjustment Period.*

The *Experimental Period* began on February 8. The object was to determine the minimum amount of grain required to maintain weight and condition in Lots II and III, for which the hay was increased. This minimum seemed to have been reached by February 8 and was continued on the same level to June 27, or 139 days. The data are presented in Table 4 and represented graphically in Figures 12, 13 and 14.

Feeds and Feeding

The hay used was graded by the Bureau of Agricultural Economics, U. S. Department of Agriculture, as No. 2 timothy. The oats were purchased in the open market as No. 2 white clipped, 38 to 40 pounds per bushel.

For weighing the hay a scale with a rack was installed in the loft over the stable. The hay for each horse was weighed and placed in a pile near the chute leading down to the feed rack.

The oats were weighed into canvas bags, three for each day, and set out for the barn man to empty into the mangers. The three bags were numbered to correspond to the number of the horse for which they were used.

Weighing

A large scale was installed in a covered driveway beside the barn. Weights were taken on Monday, Wednesday and Friday of each week, the three being averaged. The dates used in Table 4 are as of the middle day, Wednesday. The horses were weighed when they came in from work, but before feeding hay and grain.

Discussion of Results

No differences were noted in the horses of the three lots in ability to perform work, in health, in appetite, or in spirit. The one case of colic reported in Lot II cannot be considered as significant. Two horses in Lot III were below the average in condition and spirit throughout the entire experiment and the change in the ration failed to show any effect on them in any way. The average variation in weight per horse during the entire experiment was 73 pounds per horse for Lot I, 72 pounds for Lot II, and 81 pounds for Lot III. This includes all of the horses.

TABLE 4

Waterbury Experiments—Worden Stable

LOT I

Weighing Dates	Horse Number No. 5	No. 6	No. 27	No. 29	No. 32	No. 11	No. 4	No. 14	Average of Lot
PRELIMINARY PERIOD—Hay, 8 lbs.; Grain, 11.34 lbs.									
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Oct. 12	1292	1420	1256	1223	1251	1445	1342	1343	1322
Oct. 19	1288	1405	1250	1220	1253	1430	1335	1342	1315
Oct. 24	1290	1415	1247	1245	1252	1430	1328	1335	1316
Nov. 2	1285	1403	1238	1231	1257	1426	1325	1328	1312
Nov. 9	1300	1400	1229	1245	1257	1430	1325	1325	1314
Nov. 16	1300	1390	1239	1241	1260	1425	1335	1330	1315
Nov. 23	1300	1400	1239	1248	1264	1415	1334	1334	1317
Nov. 30	1300	1405	1254	1250	1258	1408	1338	1334	1318
Dec. 7	1300	1450	1257	1245	1265	1410	1335	1336	1325
Dec. 14	1302	1458	1252	1255	1263	1400	1335	1334	1325

TABLE 4—(*Continued*)

Waterbury Experiments—Worden Stable

Dec. 21	1320	1460	1240	1254	1275	1390	1355	1335	1329
Dec. 28	1310	1450	1254	1250	1280	1400	1335	1335	1327
Jan. 4	1314	1450	1267	1262	1281	1409	1325	1340	1328
Jan. 11	1315	1450	1246	1259	1281	1407	1330	1327	1327
Jan. 18	1318	1454	1261	1255	1280	1419	1321	1337	1331
ADJUSTMENT PERIOD—No change for Lot I									
Jan. 25	1310	1457	1250	1264	1283	1414	1320	1335	1329
Feb. 1	1310	1470	1244	1260	1271	1414	1320	1334	1328
Feb. 8	1320	1465	1248	1260	1286	1410	1320	1323	1330
EXPERIMENTAL PERIOD—No change for Lot I									
Feb. 15	1321	1462	1249	1260	1284	1410	1322	1335	1331
Feb. 22	1324	1464	1252	1250	1287	1419	1320	1338	1332
Feb. 29	1328	1458	1254	1250	1275	1417	1315	1329	1328
March 7	1333	1460	1254	1249	1280	1414	1318	1330	1330
March 14	1325	1450	1251	1249	1271	1401	1325	1325	1325
March 21	1320	1454	1249	1255	1274	1398	1329	1325	1325
March 28	1331	1453	1230	1244	1280	1400	1326	1325	1324
April 4	1325	1450	1235	1247	1271	1405	1333	1334	1325
April 11	1323	1448	1235	1251	1260	1406	1347	1327	1325
April 18	1325	1460	1245	1254	1260	1405	1330	1325	1326
April 25	1321	1463	1265	1255	1254	1415	1334	1325	1329
May 2	1326	1477	1275	1250	1253	1410	1330	1323	1330
May 9	No weights	....	....	....	....	....	....	....	....
May 16	1327	1495	1285	1255	1257	1410	1325	1315	1333
May 23	1333	1495	1283	1245	1270	1410	1303	1315	1332
May 30	1323	1490	1257	1253	1260	1410	1330	1303	1328
June 6	1325	1502	1263	1258	1270	1405	1323	1300	1331
June 13	1315	1507	1273	1250	1273	1398	1327	1283	1328
June 20	1325	1495	1265	1242	1260	1388	1327	1282	1323
June 27	1318	1493	1260	1257	1247	1387	1338	1272	1321

Hay, 0.68 Percent; Grain, 0.85 Percent of Live Weight.

LOT II

Weighing Dates	Horse Number No. 9	No. 13	No. 30	No. 25	No. 15	No. 3	No. 22	No. 10	Average of Lot
PRELIMINARY PERIOD—Hay, 8 lbs.; Grain, 12.67 lbs.									
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Oct. 12	1167	1242	1258	1300	1380	1298	1249	1343	1280
Oct. 19	1168	1228	1252	1297	1375	1282	1244	1338	1273
Oct. 26	1168	1225	1255	1290	1373	1282	1250	1338	1273
Nov. 2	1168	1215	1255	1296	1368	1263	1235	1335	1266
Nov. 9	1160	1225	1255	1301	1375	1275	1227	1325	1268
Nov. 16	1160	1220	1250	1298	1385	1285	1238	1340	1272
Nov. 23	1145	1215	1246	1288	1384	1288	1241	1335	1268
Nov. 30	1143	1215	1246	1293	1392	1300	1241	1336	1271
Dec. 7	1135	1215	1244	1293	1391	1300	1248	1337	1270
Dec. 14	1136	1200	1245	1295	1383	1295	1250	1335	1267
Dec. 21	1134	1207	1250	1275	1384	1290	1250	1325	1264

TABLE 4—(*Continued*)

Waterbury Experiments—Worden Stable

Dec. 28	1130	1200	1245	1278	1388	1300	1250	1321	1264
Jan. 4	1127	1204	1234	1276	1375	1300	1250	1320	1261
Jan. 11	1125	1206	1225	1271	1380	1300	1255	1323	1260
Jan. 18	1120	1202	1225	1280	1380	1300	1257	1304	1259
ADJUSTMENT PERIOD—Hay, 12 lbs.; Grain, 12.67 lbs.									
Jan. 25	1114	1210	1245	1283	1379	1312	1254	1303	1261
Feb. 1	1137	1220	1255	1280	1400	1314	1250	1305	1271
Feb. 8	1137	1225	1250	1292	1400	1332	1275	1320	1279
EXPERIMENTAL PERIOD—Hay, 12 lbs.; Grain, 11.77 lbs.									
Feb. 15	1138	1235	1240	1292	1402	1335	1285	1320	1281
Feb. 22	1132	1239	1240	1283	1410	1337	1290	1300	1279
Feb. 29	1128	1235	1235	1281	1404	1335	1291	1288	1275
March 7	1125	1235	1235	1281	1412	1335	1292	1280	1275
March 14	1128	1225	1249	1300	1398	1328	1293	1295	1280
March 21	1133	1230	1251	1293	1395	1328	1290	1300	1278
March 28	1126	1230	1250	1280	1395	1325	1279	1300	1273
Apr. 4	1125	1227	1253	1287	1395	1325	1280	1300	1274
Apr. 11	1125	1235	1250	1283	1390	1325	1280	1300	1274
Apr. 18	1135	1242	1255	1285	1395	1330	1277	1305	1278
Apr. 25	1133	1250	1257	1285	1403	1330	1280	1317	1282
May 2	1137	1250	1270	1285	1405	1335	1280	1320	1283
May 9	No weights	....	....	....	....	....	....	....	....
May 16	1147	1255	1262	1285	1415	1332	1277	1315	1286
May 23	1170	1250	1268	1298	1420	1330	1283	1327	1293
May 30	1183	1248	1268	1288	1408	1310	1288	1320	1289
June 6	1192	1250	1277	1298	1413	1325	1308	1323	1298
June 13	1188	1258	1283	1317	1408	1329	1309	1323	1302
June 20	1187	1262	1268	1280	1387	1311	1310	1328	1292
June 27	1180	1255	1280	1292	1392	1290	1297	1315	1288

Hay, 0.94 Percent; Grain, 0.92 Percent of Live Weight.

LOT III

Weighing Dates	Horse Number No. 12	No. 2	No. 7	No. 21	No. 23	No. 8	No. 17	No. 18
PRELIMINARY PERIOD—Hay, 8 lbs.; Grain, 15.82 lbs.								
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Oct. 12	1233	1277	1313	1338	1242	1215	1393	1243
Oct. 19	1224	1275	1310	1343	1248	1225	1402	1248
Oct. 26	1236	1255	1307	1348	1247	1223	1398	1252
Nov. 2	1225	1255	1297	1355	1248	1222	1390	1258
Nov. 9	1227	1250	1300	1360	1250	1225	1392	1268
Nov. 16	1235	1260	1310	1358	1267	1225	1388	1272
Nov. 23	1234	1264	1308	1361	1250	1232	1378	1275
Nov. 30	1228	1260	1308	1367	1248	1233	1377	1279
Dec. 7	1230	1265	1310	1365	1250	1245	1375	1280
Dec. 14	1225	1268	1300	1368	1255	1248	1380	1275
Dec. 21	1225	1275	1280	1352	1260	1255	1380	1275
Dec. 28	1225	1282	1292	1375	1270	1260	1375	1245

TABLE 4—(*Continued*)

Jan. 4	1218	1283	1300	1375	1273	1270	1370	1245
Jan. 11	1220	1275	1303	1375	1260	1275	1365	1230
Jan. 18	1216	1269	1298	1365	1260	1270	1370	1233
ADJUSTMENT PERIOD—Hay, 16 lbs.; Grain, 15.82 lbs.								
Jan. 25	1221	1276	1310	1366	1275	1280	1373	1233
Feb. 1	1240	1280	1325	1388	1300	1300	1400	1252
Feb. 8	1240	1300	1320	1390	1300	1325	1385	1255
EXPERIMENTAL PERIOD—Hay, 16 lbs.; Grain, 14.32 lbs.								
Feb. 15	1233	1300	1320	1400	1295	1345	1375	1260
Feb. 22	1230	1296	1319	1392	1301	1350	1376	1260
Feb. 29	1225	1295	1321	1400	1304	1345	1377	1250
March 7	1225	1295	1315	1403	1304	1341	1372	1245
March 14	1233	1290	1300	1395	1300	1330	1375	1245
March 21	1236	1292	1300	1395	1300	1330	1375	1245
March 28	1235	1295	1307	1395	1300	1325	1380	1245
Apr. 4	1230	1300	1312	1390	1297	1320	1380	1250
Apr. 11	1235	1300	1310	1380	1295	1320	1375	1253
Apr. 18	1225	1307	1325	1395	1300	1320	1375	1272
Apr. 25	1225	1317	1340	1400	1310	1317	1355	1272
May 2	1225	1315	1345	1410	1315	1320	1355	1275
May 9	No weights	....	....	....	....	....	....	....
May 16	1215	1322	1370	1410	1327	1320	1350	1280
May 23	1235	1328	1348	1405	1330	1338	1355	1255
May 30	1220	1303	1328	1408	1328	1325	1355	1258
June 6	1225	1310	1335	1405	1328	1332	1352	1252
June 13	1232	1308	1328	1407	1342	1327	1345	1247
June 20	1233	1318	1312	1395	1340	1320	1355	1238
June 27	1242	1297	1320	1393	1325	1322	1353	1238

Hay, 1.23 Percent; Grain, 1.1 Percent of Live Weight.

A study of Table 4 and Figures 12, 13 and 14 reveals the following:

	Average Weight During Preliminary Period Pounds	Gain or Loss During Experimental Period Pounds
Lot I	1321	nothing
Lot II	1267	+ 21
Lot III	1287	+ 23

For Lot I the average weight curve is very regular throughout the entire period. For Lot II a gradual rise begins when the hay is increased, and holds at a higher level throughout the greater part of the experimental period. For Lot III a rise occurs rather suddenly when the hay is increased, and this is maintained. In themselves, these small gains in weight are insignificant, but as averages and trends they would seem to indicate that the reduction in grain for Lots II and III might have been greater.

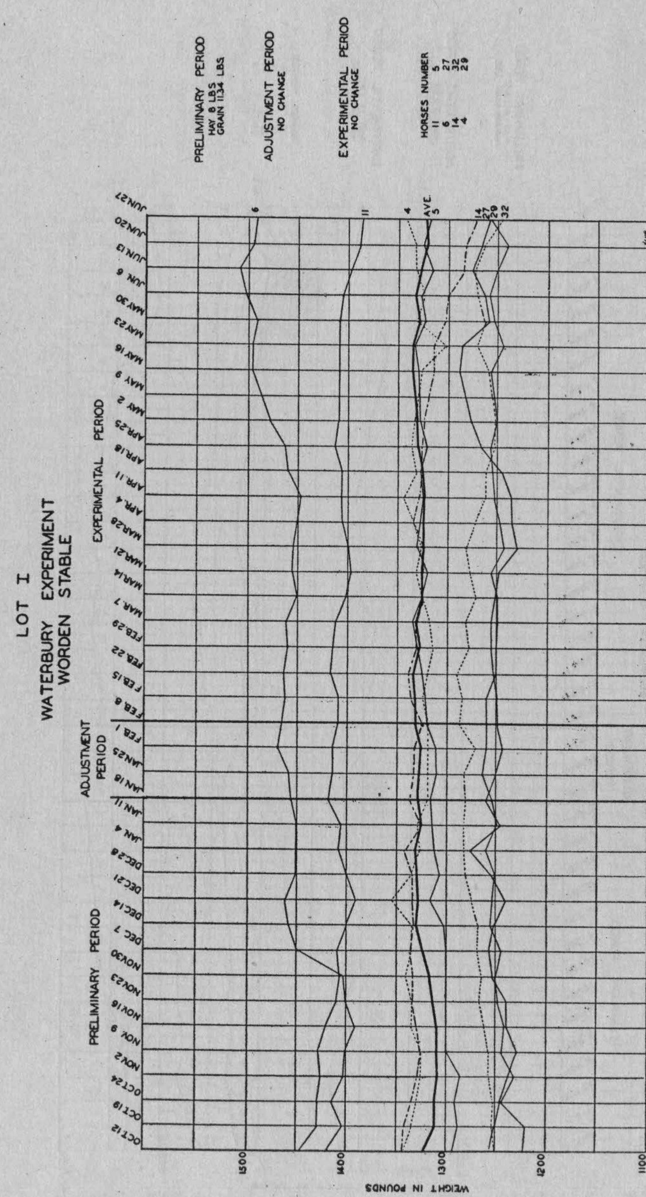

FIGURE 12

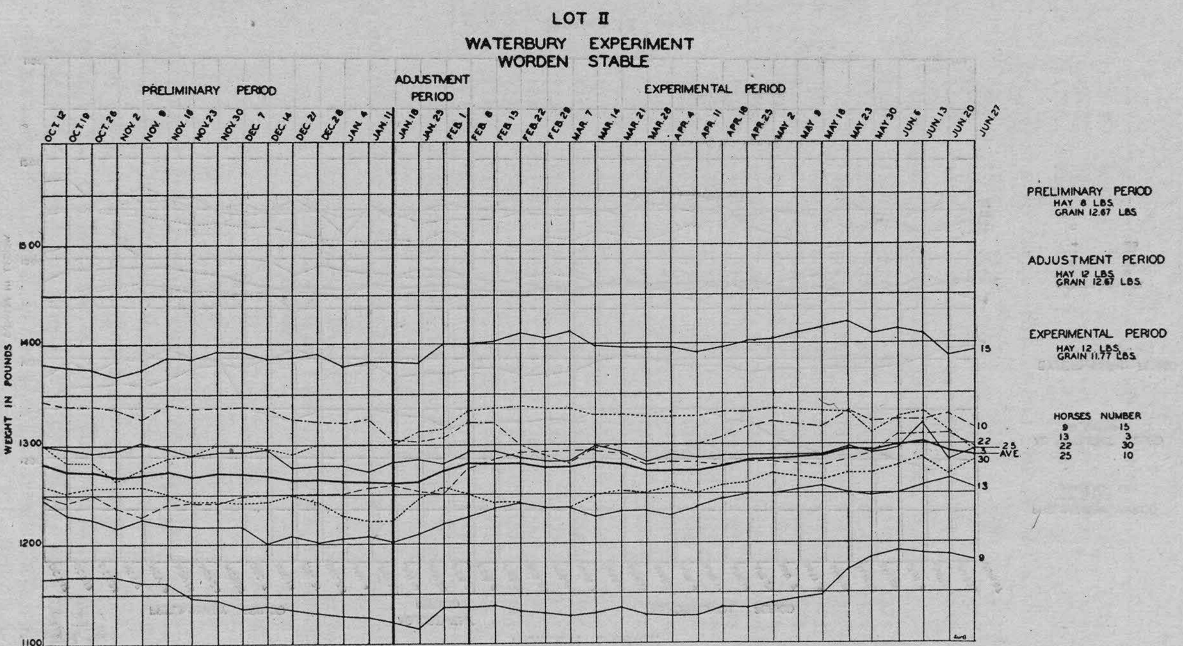

FIGURE 13

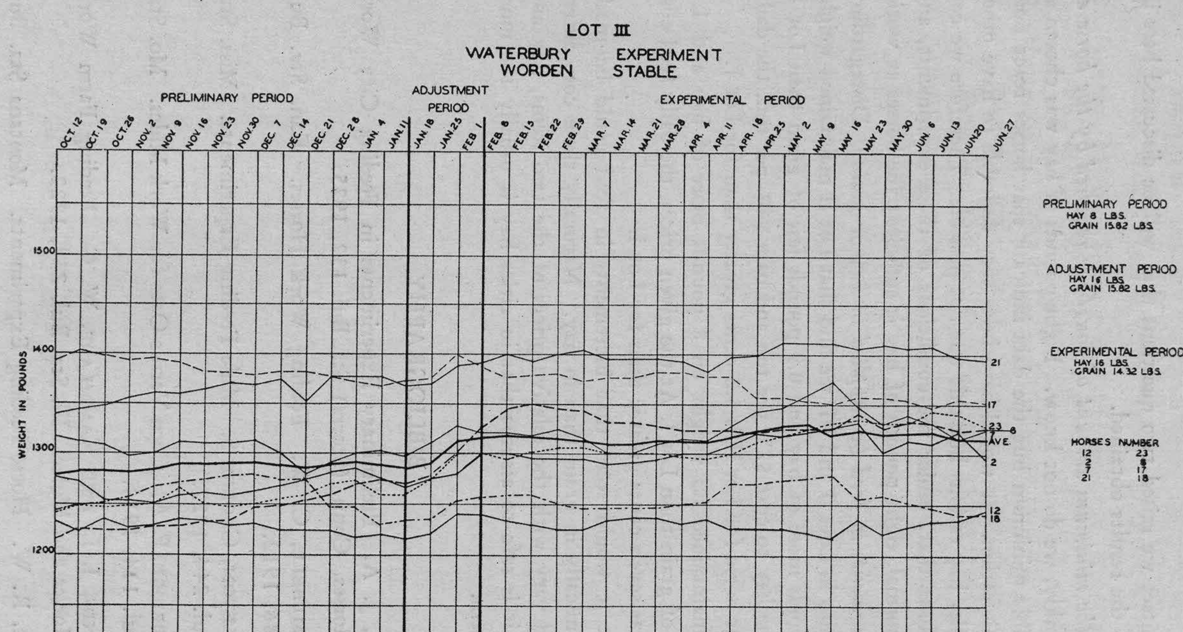

FIGURE 14

Conclusions

At the outset we raised two questions that will be discussed here in the light of the results obtained.

What is the minimum amount of roughage required by the horse at work? Frankly, we do not know. Eight pounds of hay was chosen as the irreducible minimum but the data indicate that horses react normally on this ration. It would have been very desirable to have other lots on smaller hay rations but this was not possible. Therefore we can safely conclude that, under the conditions of these experiments, and they were normal, eight pounds of hay is sufficient for horses at work.

Shall increments in feed be supplied in hay or grain? Disregarding the small gains in Lots II and III, we find that Lot II maintained weight on four pounds more of hay and 0.9 pounds less of grain than Lot I. If we assume hay to cost $25. per ton and oats $40. per ton, the daily feed cost per horse for Lot II is 3.2 cents greater than for Lot I.

Lot III maintained its weight on 8 pounds more of hay and 1.5 pounds less of grain than Lot I. At the given prices, the daily feed cost per horse was seven cents greater than for Lot I.

Therefore it would seem that increments in feed could be made more economically in grain than in hay. Naturally these cost differences would vary with the relative prices of the two items, hay and grain; but it is safe to assume that in cities hay is usually the more expensive item.

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Agricultural Experiment Station

An Economic Study of the Agriculture of the Connecticut Valley.

4. A History of Tobacco Production in New England.

Clarence Irving Hendrickson

CONNECTICUT AGRICULTURAL COLLEGE
STORRS, CONNECTICUT

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The complete manuscript of which this is an abridgement, has been submitted to the Faculty of the University of Wisconsin, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

TABLE OF CONTENTS

This bulletin is the fourth of a series dealing with the agriculture of the Connecticut Valley. The titles of previous studies follow:

1. Production, Supply, and Consumption of Connecticut Valley Tobacco. (Bulletin No. 134.)
2. Connecticut Market Demand for Vegetables. (Bulletin No. 138.)
3. Tobacco Farm Organization. (Bulletin No. 165.)

These may be obtained by addressing the Director, Storrs Agricultural Experiment Station, Storrs, Connecticut.

A History of Tobacco Production in New England

by

Clarence Irving Hendrickson[1]

TOBACCO PRODUCTION IN COLONIAL NEW ENGLAND

The commercial production of tobacco in what is now the United States began in Virginia a few years after the settlement of that colony. John Rolfe, the husband of Pocahontas, was the first white man to grow tobacco, having planted some in his garden in 1612.

As England offered a ready market commercial production in the colony followed and increased very rapidly. It is reported that by 1617 tobacco was grown even in the streets and market place at Jamestown. Production soon increased to such an extent that there was more than could be sold at a profit in England and some was taken to Holland. By 1640 so much was grown that the colony ordered all of the bad tobacco and half of the good tobacco destroyed in order to keep up the price. Low prices continued and attempts were made to prohibit the planting of any tobacco for one year.

Thus we see even in these early days tobacco farmers were troubled with overproduction and attempted schemes to adjust supply to demand. As other colonies were established they too took up the raising of tobacco, but Maryland was the only one besides Virginia where tobacco was an important product. In Virginia and Maryland it was the leading agricultural product—in fact those two colonies grew very little else. After the Revolutionary War tobacco raising expanded into the territory being opened up west of the Allegheny Mountains. By the time of the Civil War it had been introduced into all the states that are growing tobacco commercially today.

The early settlers of New England found the Indians growing tobacco and undoubtedly some of them imitated the Indians both in its production and its use. There is evidence that it was produced in Massachusetts, Rhode Island, and Connecticut. Tobacco was one of the commodities traded with the Dutch when the members of the Plymouth Colony first carried on commerce with the colonists at New Amsterdam. Also, there are records of tobacco entering the trade of the Connecticut Valley in the 17th century. It is not at all surprising that the early colonists of New England should have made these attempts at raising tobacco. They were influenced by the Mercantilist principles

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which prevailed in the Old World and were constantly seeking products which they could use to build up a trade. Knowing that Virginia was building its trade on tobacco they quite naturally attempted its production. During the 17th century it failed to prosper in New England. Many laws were enacted which prohibited or regulated its growth, sale, and consumption. Then too the climate was not favorable to the best qualities of tobacco for pipe, chewing, or snuff for which the tobacco was used by the English and other northern Europeans at that time. Trading with the Indians, fishing, ship-building and the carrying trade offered better opportunities than raising agricultural products for export. These were not so profitable, however that New England could, as Virginia did, neglect the production of food and clothing. Farming developed with this trading, shipbuilding and fishing, and during the 18th century gradually pushed its way inland, assuming the form of a nearly self-sufficient agricultural economy. In the meantime fishing and shipbuilding continued to develop and by the second quarter of the century a thriving trade between New England and the West Indies had developed. At this time farmers were growing tobacco for home and local consumption. In two localities a surplus was produced which entered into the West India trade, centering about Windsor and East Windsor, in Connecticut and in the Narragansett country of Rhode Island. In 1753 the Connecticut General Assembly prohibited the shipment of any tobacco not stamped and sealed by the official town packer, and after this date we find "packers" elected as regular officers of the Connecticut Valley towns. The first half of the eighteenth century was a period of commercial growth and expansion for the New England colonies. As a by-product of this development, tobacco became an export from Connecticut and Rhode Island and some of the Connecticut Valley towns in Massachusetts. However, from 1763 to the Revolution there was a period of depression in the colonies. While the causes of the depression are not exactly known, in the minds of the colonists the policies of the English government under George III, particularly the enforcement of the navigation laws, were responsible for the situation. Whatever the causes, the depression affected the tobacco trade adversely. The non-intercourse agreements among the colonists aggravated the situation and the American revolution practically eliminated the commercial trade.

New England's participation in this eighteenth century trade was based on her ability to supply cheap tobacco for the slaves on the sugar plantations, and it was on this basis that she was able to compete with Virginia for the West India trade. This advantage persisted even during the periods of low price and over-supply of tobacco on the European market. While the Virginia tobacco trader had to make tobacco pay its costs of shipment at all times, the New England shipper of mixed cargoes could add some tobacco without adding to the cost of his cargo. This gave the New England trader one advantage of importance.

Conditions After the Revolution

After the Revolution the economic and political conditions in the newly formed Confederation were very unstable because of the lack of a strong central government, the large public debt, the paper money, and the change back to a peace-time basis. Before the Revolution, trade with the West Indies was one of the mainstays of New England commerce and industry; following the Revolution, England denied the newly formed states the right to trade with her West India Colonies. This was an important factor in causing the depression in the New England states. However, conditions soon improved and adjustments were made to the changed situation. By the time the new government was established under the Federal Constitution, a period of prosperity had begun. The new country, particularly the New England states, benefitted by the wars in Europe. The British were compelled to permit the importation into the West Indies of American products. Purcell says: "Connecticut thrived under this stimulus; the Connecticut Valley and Sound towns became centers of a prosperous trade. Tonnage increased, agriculture was encouraged; and money became plentiful, for profits were large despite seizures and admiralty decisions."

The farmers of the Connecticut Valley were again producing tobacco. Purcell says concerning the period when prosperity returned: "Numerous small vessels plied their trade with the West Indies, bringing cargoes of grain, butter, meat, vegetables, tobacco, cattle, horses, and lumber from the northern states and returning with sugar and molasses to be made into rum." This is the same trade which was so flourishing during the middle of the previous century. Bull and King advertised in the *Connecticut Courant*, March 16, 1799: "Wanted (among other items) 1 Ton Windsor Tobacco." Enfield elected a packer of tobacco in 1786 and on various dates to 1813. Suffield, East Windsor and other towns also elected packers of tobacco at several meetings during this period. Tobacco was also grown in several of the Massachusetts towns in the Valley.

The period of prosperity extended through the last decade of the 18th century and well into the first decade of the 19th. The difficulties with the British over our shipping and commerce resulted in the non-intercourse and embargo acts by which the national government attempted to retaliate. These acts almost put an end to the commerce of the United States, especially the West India trade, which failed to revive in the peace following the War of 1812.

Introduction of Cigars

As the American colonies changed their political status to independent states, they later changed their economic status to a more independent one. The first two decades of the century saw the beginning of manufacturing in New England. The introduction of cigar manufacturing at this time not only saved the tobacco industry of New England but was the cause of its revival and development.

The Spaniards on their early voyages found the Indians of the West Indies smoking rolls of tobacco, and introduced the custom into Spain. It appears that cigars, if introduced into northern Europe, did not gain any popularity there until after 1800. Fairholt states that they were taken to Hamburg in 1796. Their use spread so rapidly that a cigar factory was established there soon after that date. Heavy duties and absolute prohibition tended to keep cigars out of England until about the same time. He states that in 1823 there were 23 pounds of cigars imported. The next year the duties were lowered and 15,380 pounds were imported and by 1830, 253,882 pounds.

Early Imports

Cigars seem hardly to have been known in the United States until nearly the end of the eighteenth century.* Since 1790 records have been kept of imports into the United States. Prior to the year ending September 30th, 1804, cigars were not reported separately from other manufactured tobacco. In that year four million are listed as being imported. The next year 22 million were imported. From a study of imports of tobacco it appears that cigars were separated from other forms of tobacco for only a part of the year ending September 30, 1804. For the previous year ending September 30, 1803, there were 81,518 pounds of tobacco imported from the Spanish West Indies; in 1804 there were 73,918 pounds; while in 1805 there were only 312 pounds; and in 1806, none. In place of the manufactured tobacco, cigars are reported from the Spanish West Indies. A further study of the import of manufactured tobacco from Cuba (Spanish West Indies) would indicate that cigars were first imported from Cuba in any considerable quantity about 1795. In 1790 only 473 pounds of manufactured tobacco was imported from that island; in the next year, 1791, the amount fell to 170 pounds. In 1795 it had risen to 32, 335 pounds, and increased to over 100,000 pounds by 1800.

American Cigars

The common account is that the cigar industry began in the United States in 1801 when a Mrs. Prout of South Windsor, Connecticut, began making cigars. However there is evidence they were sold in Hartford at an earlier date. In a number of issues of the *Connecticut Courant*, Hartford merchants advertised Spanish and American cigars. The first advertisement of American cigars noted was in1799, in the issue of July 22. The first advertisement of cigars noted was in 1791, in the issue of April 25, when Asa and Daniel Hopkins listed cigars among items for sale.

The importation of cigars, or "segars" as the word was spelled then, fluctuated around 20 million until 1811; then with the War it fell off and did not come back to that amount until 1822. The increase in importations became more rapid after 1830 and increased very rapidly from then on to the Civil War.

*Among the stories of the introduction of cigars into the United States is one which gives the credit to General Israel Putnam. He is said to have brought some cigars on his return from the military expedition to Cuba in 1762 and to have sold them in his inn at Pomfret.

Early Cigar Prices

In Wright's collection of prices and wages in the Annual Reports of the Massachusetts Statistics of Labor, the first price quoted for cigars was in 1806, when they sold for 25c a dozen. The price for several years was around two cents each. They dropped in 1817 to less than a cent apiece.

It has been noted that American-made cigars were sold in 1799. Most writers agree that cigars were first made in the homes about 1800. Women and children manufactured the cigars and bartered them at the stores for articles they desired. This method continued until the enactment of the revenue laws during the Civil War put a tax on cigars and the establishments producing them. The first cigar factories in New England were established in East Windsor and Suffield, Connecticut about 1810. They were established even earlier in Pennsylvania. The census of 1810 reports a production of 29,061,000 American cigars valued at $44,253 and 3,898,990 Spanish cigars valued at $26,-650, the latter from imported Cuban tobacco. The largest production was in the city of Philadelphia which is today the largest producer of cigars. Niles and Pease, in their *Gazetteer*, published in 1819, state that tobacco was grown in East Hartford, East Windsor, and Windsor, also that "one segar manufactory on an extensive scale" was established in East Windsor. There is no mention of a cigar factory in Suffield. A large part of the fillers used in the manufacture of the cigars of these early factories was imported from the West Indies. The binders and wrappers were from native tobacco. Not all of the binders and wrappers used in the United States were from the Connecticut Valley. In 1830 three factories in Boston reporting the source of the tobacco they used report only tobacco from Virginia, Kentucky and Maryland, and from Cuba and St. Domingo.

At an early date tobacco produced in this area was shipped to other markets to be made into cigars. According to Niles and Pease, part of the tobacco grown in East Windsor was shipped from the town. This would establish the shipment of tobacco for cigars earlier than the commonly stated first shipment from Warehouse Point in 1825.

Introduction of Broadleaf

After the introduction of cigar manufacturing the next important development in the New England tobacco industry was the introduction of Broadleaf tobacco. The tobacco grown during the first three decades of the century was a narrow leafed type called "shoe string" tobacco. This probably was the type that had been grown for export during colonial days and prior to its use in cigar manufacture. About 1833 a Mr. Barbour of East Windsor is said to have introduced a broad leafed variety from Maryland. From this have developed the present seedleaf, now more generally called broadleaf, varieties.

The new variety produced even better wrappers and binders than the "shoe string" tobacco, and soon displaced it.

Increase in Tobacco Production

The introduction of this new variety together with the increased demand for cigars was responsible for the increase in tobacco production which began about 1835. It was about this time that its production in the Connecticut Valley began to attract attention outside of its immediate neighborhood.

Prior to 1840 there are no data available as to the total amount of tobacco raised and only a limited idea of its relative importance can be obtained from the written material available. That it was relatively unimportant as an agricultural product before 1835 may be gathered from various comments in current publications. After that date mention of it in agricultural publications is much more frequent. The production in 1839 according to the Federal Census of 1840 was 538,000 pounds. This may be an underestimate, as it is believed that the early agricultural census was not complete. For the next few years estimates of its production in the Valley vary from one to five million pounds. The government estimate for 1845 gives a production of almost three and a half million pounds, but since the crop in 1849 was only 1,400,000 pounds, this latter estimate seems very much too high. Prices were higher during the first part of the decade and went lower towards the end, so that the production of tobacco around 1845 may have been larger than in 1849; but the data available do not appear reliable enough to justify any definite statement as to the total production. It may have been as much as three million pounds in 1844, but the changes in price would hardly have caused so large a drop in production by 1849. Massachusetts compiled its first census in 1845 from reports of the assessors; Connecticut also compiled the returns of the assessors in that year into a census. Both of these report the production of tobacco for 1844. In Massachusetts the crop reported was 266,000 pounds and in Connecticut 3,467,000 pounds. Study of the available data and information make it doubtful whether the

Connecticut crop was much over two million pounds at the outside, with a total production of two and one half million for New England. Even a reduction from two and one half million pounds to less than one and one half million in 1849 appears rather large when compared with the price changes during this period.

Localization of Production

Before 1835 the production of tobacco except in small garden patches for local consumption was limited to East Windsor and the adjoining towns on the Connecticut River. Even by 1840 the production was centered largely in Hartford County, which raised 471,000 pounds of the total of 538,000 pounds reported in the census. In March 1841 a grower in Warehouse Point estimated that 400,000 pounds were grown in the vicinity of that village. This estimate would indicate that the production of Hartford County was quite localized. A reason frequently given for the importance of tobacco around Warehouse Point was the large number of distilleries there. These distilleries kept many steers and hogs to fatten on the distillers' grain and had large quantities of manure available for the tobacco fields in the neighborhood. The next in production in 1839 was Hampden County, Massachusetts, which had a crop of only 41,000 pounds, which would have required about twenty-five acres for its production. During the forties the tobacco acreage was extended up the Valley into Franklin County, Massachusetts, and to the edge of the Valley into Litchfield and Tolland Counties, Connecticut, and into the Housatonic Valley in the towns of Kent and New Milford, Connecticut. A correspondent of the *Brooklyn Gazette* said in 1845: "Tobacco is getting to be a great article in agriculture all along the valley of the Connecticut, and it is said there is no land in the world that will produce so good, and so much per acre, as our own land will. We do not work as the Virginians do; here we manure high, and do our work ourselves—all free labor. I have about three acres growing for the first trial, and if it proves a good crop, I shall continue the cultivation of it."

Method of Production

The following method of production was given in 1841 by a farmer of Warehouse Point. He had grown tobacco for ten years and, as he says, his methods were nearly the same as his neighbors'.

> I raise from two to three acres of it annually, this being as much as I can attend to well and cultivate properly the variety of other crops of my farm. In giving a full account of the process I will commence with what the tobacco grower calls the bed, which consists of a few rods of rich moist ground, as well

prepared as the most productive garden; on this sow the seed about the 1st of April; as for the quantity of seed, I have no particular rule, probably a spoonful of good seed would be sufficient for one square rod of ground; in about three weeks after it is sown, it will make its appearance. The bed must be kept clean from weeds until the plants are of a suitable size to transplant which will be generally about the tenth of June. The best method of preparing the land on which the crop is to be grown, is to dress the ground in the autumn with a coat of manure, and then another in the spring; in all about thirty loads of good manure to an acre. The land should be frequently plowed in the spring, that the manure may be well mixed with the soil. When the plants are of a suitable size to transplant, the land on which the crop is to be grown should be well harrowed, then rowed, which is performed by attaching chains to a pole about three and a half feet apart, which will be the distance between rows and drawn across the field, which is usually done by two men. On these rows, with a hoe, the hills are made, two and a half feet apart, in which on some rainy day the plants are set, one plant in a hill. If the season is dry, the plants must be watered immediately after they are set out. If any of the plants wither and die, or if the worms destroy them, as they usually do more or less, other plants must be set in the place. The plow or cultivator should be used between the rows to loosen the ground and destroy the weeds, and the plants be frequently and carefully hoed. The worms should be destroyed or they will destroy or very much injure the plants. When the plant puts forth its blossom, so much of the top of the stock should be broken off as has not leaves of sufficient size to remain; also the shoots that spring out between the leaves should all be broken off. When the plants are sufficiently ripe, as they are generally about the 1st of September, they must be carefully cut and laid upon the ground to wilt for a few hours, then be carted to the barn and hung upon poles to cure. The plants fastened to the poles with twine wound around the stock across the pole, top downward, spreading them sufficiently for the free circulation of the air, the poles about one foot apart. The barn should be sufficiently ventilated, but not so much open as to expose the tobacco to wind and storms. Two months of mild weather will generally cure it. When the stem in the leaf is cured hard, it is taken down from the poles in damp weather, when the leaf will not crumble, the leaves stripped from the stock, bound in bundles called hands, and packed for further use. Most of the tobacco in this place is packed in boxes of 300 to 400 pounds each, and sent to the New York or Philadelphia market.

When a barn is built expressly to house tobacco in, as most of them thus used here are, it should be with ten or fifteen foot posts, twenty feet in width, and length as is wanted. A barn of ten foot posts, twenty-four feet wide and sixty feet in length, will usually be large enough to hold the produce of an acre of land.

The produce of an acre of land, well cured, will average about a ton, or from 1500 to 2500 pounds. The quantity depending upon the fertility of the soil, season, cultivation and curing. The comparative amount of labor required in growing this crop is about four to one of corn, that is it requires as much labor to raise one acre of tobacco as it does four of corn.

There are a number of differences to be noted in the raising of tobacco at that date as compared with methods of today. Transplanting was begun a week or two later than is usual at present; setting was done by hand; manure was the only fertilizer used; and instead of putting the plants on lath in the field they were hauled from the field loose on two-wheeled ox-carts, then fastened with twine wound around the butt of the stalk and criss-crossed around the pole.

Manure remained practically the only source of fertilizer for some time. About 1845 a preparation called "poudrette" began to be used on the beds, but manure was the only fertilizer used on the fields.

Cost of Production

The following statement of the cost of producing an acre of tobacco also throws light on the methods. These figures were reported to the Commissioner of Patents in 1845 by an East Windsor farmer. They are evidently estimates made by this farmer and a friend.

Use of one acre of land			$15.00
10 carts of manure at $2.50	$25.00	½	15.00
Carting and spreading	5.00		
Plowing twice			3.00
Harrowing and marking			1.00
7000 plants at 50 cents per thousand			3.50
Holding and setting plants			3.00
Hoeing four times			5.00
Extra attendance to secure and kill worms			2.00
Topping and securing			4.00
Cutting and hanging up to dry			4.00
Stripping from stalk and packing			5.00
Rent of shed to dry in			4.00
Freighting to Warehouse Point			3.00
			$67.50

The average production on which this estimate was based was 2,000 pounds per acre. Common estimates place the cost of raising an acre of tobacco at two to four times the cost of producing an acre of corn. Instead of using the disk harrow, farmers plowed the ground twice. A comparison of these figures with present costs shows that the increased costs today are the result of increases in cost per unit of the items rather than of increased intensity of culture. There may be a slight increase in the amount of labor applied to the acre for cultivation, and there is a very considerable increase in the application of fertilizer and the use of machinery. If the amounts given here are at all representative, there is at least a doubling of the amount of fertilizer. In fact there is probably much more, for then the application was made when the tobacco was raised and a large part went to the production of the succeeding crops of grain and hay. Today, however, when used alone, double that quantity of manure is applied each year. Then tobacco was produced in rotation, but now it is produced on the same field year after year.

Introduction of Sweating

In colonial and early national times the tobacco exported was shipped in hogsheads, as was all tobacco packed in the United States. With the revival of shipping after 1810 it is said to have been packed in boxes of various sizes and descriptions, mostly dry goods and other merchandise boxes, then in bales of about 100 pounds with boards on the four sides held together with hoops. Soon it was packed in cases of 300 to 400 pounds and put through the sweating process. Sorting of tobacco began about 1840. At that time two grades were made, fillers and wrappers. All but the very poorest was put in the wrapper grade. About the same time tobacco buyers began visiting the farmers to purchase the crop to be delivered at the warehouse of the buyers.

Increase in Prices

One reason for the development of the tobacco industry in New England during the first half of the nineteenth century was the gradual increase in tobacco prices during that period. This increase is shown in Table 1, which shows also the increase in purchasing power, which was even greater, because the trend of the general price level after the War of 1812 was downward. Tobacco prices reached a high point in 1841; after that there was a very slight decrease to the end of the decade. However, when compared with the general price level, they were about 50 percent higher than they had been before 1840. Prior to 1845 the price of New England tobacco seems to have been very close to the wholesale price of other tobacco, but from then on it became higher. The increase in the price for New England tobacco was due to the increased demand for cigars. Importation of cigars increased from an average of 23 million annually in 1805 - 1809 to 81 million in 1845 - 1849. This increase in importation could be accounted for by the growth in population. More important was the increase in domestic cigar manufacture. In their *Gazetteer,* Niles and Pease mention only one cigar factory in Connecticut; but by 1850 the census reported 2,029 male employees engaged in manufacturing cigars, and a Mr. Sheldon of Suffield states that by 1850, 152 men and 80 women were engaged in manufacturing cigars in that town alone. Besides those engaged in cigar factories, there were women and children who made "supes"* at home to be traded at the local store. It was this increase in domestic production which caused the increased demand for New England tobacco and in turn stimulated tobacco production.

Decline in other Agricultural Prices Relative to Tobacco

At the same time that tobacco prices were rising, the prices of some of the agricultural products of New England were declining. This was particularly true of corn, rye and cheese. These products were meeting competition from the products of the new land being opened up in the west. Rye and corn were the two crops which, next to hay, were most important in the Connecticut Valley. Broom corn was also important, especially in the vicinity of Hadley, Massachusetts. This product also felt the effect of western competition and gave way to the cheaper product from the future cornbelt. Beef cattle raised in the hill towns or purchased from farmers in nearby states were fattened on the farms

*"Supes" is the name given to the cigars made in the homes by women and children.

of the Valley. This enterprise was more important from Enfield north than in the lower part of the Valley, although it was carried on there too. Butter and cheese were also produced, although relatively not so important to the farmer of the Valley as to the farmer back in the hills. The following table pictures the relative trend of tobacco, corn and rye prices by decades:

TABLE 1

Price Relatives and Purchasing Power of Tobacco, Corn, Rye.

By Decades, 1801 - 1850

Decade	Price Relatives: Tobacco	Price Relatives: Corn	Price Relatives: Rye	General Price Level	Purchasing Power: Tobacco	Purchasing Power: Corn	Purchasing Power: Rye
1801 - 1810	100	100	100	100	100	100	100
1811 - 1820	123	126	113	108	114	117	105
1821 - 1830	101	79	69	69	146	115	100
1831 - 1840	94	75	81	74	127	101	109
1841 - 1850	111	69	79	57	195	121	139

The purchasing power of the agricultural products of New England tended upward during this period when compared with the general price level, but none increased so rapidly as tobacco. The purchasing power of tobacco was practically two times what it had been at the beginning of the period, while that of corn was about one-fifth greater, and of rye only a little more than one-third greater. The purchasing power of the more important agricultural products of New England, other than tobacco, was slightly more than fifty percent greater. There was no very material change in the relative cost of production, yet tobacco became much more profitable than other agricultural products, especially when compared with the two major tilled crops, corn and rye. Tobacco became profitable for many farmers who had not been able to make a profit at the lower prices prevailing in the earlier decades.

THE EXPANSION OF TOBACCO PRODUCTION

Since 1850 there are more data available for studying a particular agricultural enterprise or the agriculture of any region, in the Federal Census, the work of the Department of Agriculture, state experiment stations and other state agencies, and the agricultural and trade papers.

Rapid Increase in Production at Time of Civil War

In 1849 the production of tobacco in New England was small as compared with that of later years or with the production in the southern states. The million four hundred pounds reported by the census, however, was double the production reported ten years previous. It was during the next decade that tobacco production increased most rapidly, an expansion which appears like the recent expansion of tobacco in the Province of Ontario, Canada. The production in 1859 amounted to nine million pounds and was six times that of 1849. The Massachusetts state census shows that the gain in production was greatest during the last half of the decade. Expansion of the tobacco industry continued during the Civil War. The crop in Massachusetts in 1864, according to the state census, was nine million pounds. After the Civil War there was a slight decline for both states until 1869. During the next decade the trend of production for Massachusetts continued downward, while that for Connecticut was upward. The output of tobacco in Massachusetts declined nearly a million and a half pounds from 1869 to 1874 and another half million to 1879. The Census of 1880 shows an increase of nearly six million pounds for Connecticut over the production of 1869. The total for New England in 1879 was nineteen million seven hundred thousand pounds, which was practically the same as the production at the end of the Civil War. The loss in Massachusetts was offset by the increase in Connecticut. This difference in trends for the two states, together with differences shown by towns within the states, will be discussed in another section.

The trend of acreage follows production during this time, but with less fluctuations from year to year. It was steadily upward from 1849 to the end of the Civil War, then declined to 1869; in Massachusetts it continued downward, while in Connecticut there was an upward trend between 1869 and 1879.

Increase in Prices

For this study the factors causing the changes in production are of much more importance than the changes themselves. Changes in price were no doubt important in effecting the changes in production which have just been described. However, price does not account for the conflicting changes referred to in the preceding section which occurred

TABLE 2

Price per Pound of Connecticut Valley Tobacco in Cents.

1850 - 1865

Year	Farm	Wholesale*	Year	Farm	Wholesale
1850	13		1858	16	30
1851	6	20	1859	11	31
1852	14	15	1860	11	25
1853	8	17	1861		20
1854	8	18	1862	14	30
1855	11	15	1863	25	45
1856	21	29	1864	25	65
1857	13	40	1865	27	43

*Wholesale prices from Aldrich Report.

in the production of Massachusetts and Connecticut. The first important expansion of tobacco, which occurred between 1850 and 1865, was caused by the advance in price between those dates. Around 1850 the average price received by the Connecticut farmer was ten cents a pound. In 1856 it had advanced to an average of twenty-one cents, with a high price of over thirty cents. There was a decline the next year and the prices remained somewhat lower until 1863. Wholesale prices of Connecticut wrappers, and such farm prices as are available, show that prices advanced in 1863, 1864, and the beginning of 1865. This increase was due partly to inflation, but even on a deflated basis there was a fifty percent increase in the wholesale price of tobacco during the Civil War. Inflation itself, with no increase in a deflated price, would tend to increase production.

Factors Tending to Increase Price

This increase in price was a response to the increased demand for cigars. There are no figures on the production of cigars in the United States before 1862, but the trend of importations will show the large increase in the demand for cigars.

TABLE 3

Value of Cigars Imported into the United States by Decades

1820 - 1860

Decade	Value
1820 - 1829	$1,766,955
1830 - 1839	7,295,763
1840 - 1849	10,873,880
1850 - 1859	33,777,490

(1880 Census Report on Agriculture, Tobacco Manufactures)

Even the fact that imports trebled in the decade prior to the Civil War does not show the total increase in the consumption of cigars. There was a substantial increase in the production of cigars in this country during the same decade. The evidence on this point is indirect but indicates that the increase was 50 percent or more. In Connecticut there was an increase of 71 percent in the number of male employees in cigar factories, in Massachusetts an increase of 58 percent. Cigar makers were not listed separately from other workers in tobacco factories for most states in 1850. However, the total number of male workers in all tobacco factories in the United States more than doubled between 1850 and 1860. The data for 1850 may not be as complete as those for 1860, but even allowing for that, the increase must have been substantial. Then during the Civil War little tobacco was received from the Southern states. Although the tobacco from those states did not enter into the production of cigars it did have some effect on prices for cigar leaf. Manufacturers of chewing and smoking tobaccos, being unable to get their supplies from their usual source, turned to the northern cigar leaf areas and so increased the demand for that type of tobacco.

Another factor which, like inflation, would affect the attitude of the farmer to a greater extent than it would his financial returns was the increased variation in price received for tobacco in any one year. At the beginning of the decade under consideration, tobacco was sold in two grades, wrappers and fillers. The wrappers made up the greater part of the sales. At this time the price of wrappers was not very different from the price received for the whole crop. Towards the end of the decade, however, the farmer was selling three grades, wrappers, seconds and fillers. The spread between wrappers and fillers had increased very considerably, and the proportion of fillers and seconds was large enough to influence the average price. That which influenced the farmer most was the price of the wrappers rather than the average price for his crop. The larger part of the increase in acreage between 1850 and 1860 was due to farmers who took up the cultivation of tobacco. These new growers were influenced more by the price for wrappers received by some of the best growers than by the average price of tobacco.

Prices Following the Civil War

The close of the Civil War was followed by a sharp break in prices, the highest quotation for Connecticut wrappers being 65 cents at the beginning of the year and 40 cents at the end. The farm price as reported by the Department of Agriculture did not decline until the following year. This decline in prices was undoubtedly the cause of the severe decline which took place in the production for Massachusetts during the last years of the sixties. There was some decline in the production of Connecticut wrappers from 1864 to 1869, although the production reported by the census for the latter year was much greater than that reported for 1859. The rising prices for cigar leaf tobacco prior to and during the Civil War had the effect which has been seen a number of times in speculative markets in real estate and stocks. The expectation that prices will advance encourages many people to come into the market. Many farmers who began the cultivation of tobacco could not produce at a profit even with the higher prices and after a year or two of experimenting were forced out, and others who had been able to make a profit at the high war prices could not do so at the lower prices.

After 1866 a recovery in prices took place which continued until 1874, when the farm price was reported even higher than at the end of the Civil War. In 1875 came a definite decline, and from then on to the nineties tobacco prices fluctuated at about half the level of the war and immediate post-war period.

As was shown, Connecticut increased its acreage and production in 1879 over that of 1869. The recovery of prices after the Civil War to 1874 may have encouraged farmers to expect that a recovery would occur again and to keep on producing in the hope of a higher price. But this movement of production contrary to that expected from the movement of prices raises the question whether there were factors other than price which had some influence on increasing production. These factors will be considered later. The lower prices did result in a reduction of the amount of tobacco grown in Connecticut during the decade of the eighties.

Competition of Wisconsin and Pennsylvania Tobacco

The increasing consumption of cigars since 1830 had resulted in increasing prices for Connecticut Valley tobacco. Cigar consumption increased even more rapidly after the Civil War than before, but Connecticut Valley tobacco decreased in price after 1875 in the face of this increased consumption. One of the reasons offered for this decline is particularly interesting because it has been offered as a reason for the decline in the price of Connecticut tobacco since the World War. It was said that the quality of the tobacco had deteriorated because of the change from the use of manure to the use of commercial fertilizer. However, this was not the important factor; rather it was a case of competition. Cigar leaf tobacco produced in Pennsylvania and Wisconsin was of a darker color than that of the Connecticut Valley. When the demand was for a light cigar, this darker tobacco did not compete with the New England product for use as wrappers. But during the early seventies the preference of the cigar consumer changed to a dark cigar. This change in consumer attitude changed the preference of the manufacturer from the leaf of the Connecticut Valley tobacco to that of Wisconsin and Pennsylvania for wrappers. As a result, the price which the Pennsylvania and Wisconsin farmer received was relatively higher during the last half of the decade than during the first half when compared with the price received by the Connecticut and Massachusetts farmers. This relatively increased price for the Pennsylvania and Wisconsin leaf caused a much larger increase in the production of 1879 over that of 1869 for those two states than occurred in Connecticut, and as has been stated, the production of Massachusetts declined.

Prices of Other Agricultural Products

It is not enough in considering the factors influencing changes in the acreage of a particular crop to consider the changes in price for that product only. Other products which compete for the use of the land and labor of the farmer also must be considered. In the Valley during the period 1850-1880 the principal crops were hay, corn, rye, and oats. Some beef cattle were produced and fattened, and some butter and cheese made. Corn, rye and oats were the ones which competed most directly with tobacco for the use of the land, and are the ones which will be considered. Taking Hartford County as representative of the tobacco section, corn declined somewhat from 1850 to 1860, but in 1880 it was practically the same as in 1860; this would indicate that the increase in tobacco acreage had not been at the expense of corn. Rye declined very markedly from 1850 to 1880, and oats even more.

TABLE 4

Production and Estimated Acreage of Cereals, Hartford County

1850 and 1880

(U. S. Census 1850 and 1880)

	Corn		Rye		Oats	
	Bushels	Acres	Bushels	Acres	Bushels	Acres
1850	381,741	10,900	150,031	11,500	210,954	8,400
1880	337,109	11,526	86,578	7,620	83,261	3,566

The decline in price due to competition from the Middle West is usually given as the cause of the decline in the acreage of cereals which occurred in New England. The decline in price was an important factor in rendering those products unprofitable for the New England farmer. The increase in wages also tended to make these products unprofitable. Because of the rise of manufactures and the migration to the West, wages rose relative to prices. Wages did decline after the Civil War but not to the same extent. With relatively higher wages the cost of producing agricultural products increased and under many conditions their production became unprofitable. The question is: Why was tobacco in some New England towns more profitable than other agricultural products after the fall in prices? The relative increase in wages affected tobacco as well as other products; in fact tobacco required more labor per acre than cereals. The farm price of tobacco as

TABLE 5

Relative Farm Prices of Cereals and Tobacco and Relative Wages

Connecticut 1869 and 1879

	Corn	Oats	Rye	Tobacco	Wages*
1869	100	100	100	100	100
1879	53	62	57	44	72

(*Average of three years preceding each census year, except for wages which are reported for only one year. Wages equal arithmetical average of relatives of monthly and daily wage, both without board.)

reported by the United States Department of Agriculture declined more than the farm price of cereals. This might lead to the conclusion that tobacco should have become less profitable than the cereals.

The fact that the tobacco acreage was greater in many towns in Connecticut in 1879 than in 1869 is evidence that for those towns it must have been more profitable, relative to other enterprises.

Decline in Price of Cost Items

For cereals, labor and land were practically the only items of cost. Tobacco on the other hand required large amounts of fertilizer and a large investment of capital in sheds. Fertilizer declined in price also. Peruvian guano, a common form of commercial fertilizer, sold for $69 per ton in 1869 and declined to $53 per ton in 1880. The cost of fertilizer elements, as calculated by Dr. Johnson in his reports to the Connecticut Board of Agriculture, declined 24 percent for nitrogen, 23 percent for phosphoric acid, and 36 percent for potash. These figures may not indicate the full extent of the decline in the cost to the farmer of fertilizing; by this time inspection of fertilizer had begun and no doubt the quality of fertilizer had been improved. The experience of the farmer in the use of fertilizer increased his knowledge of the proper methods and the proper mixtures to apply so that he would get better results from it. One farmer stated that by 1880 an acre of tobacco could be fertilized as well for $50 as it could have been in 1868 for $100. This would indicate a decline of 50 percent in the cost of fertilizer, which would help in making tobacco more profitable relative to other farm products. However, the rapid expansion of tobacco acreage during the period of increasing prices just prior to and during the Civil War indicates that tobacco was much more profitable when compared with the other common agricultural products. With this in mind it is not difficult to see that even if the farm price of tobacco declined relatively more than the farm price of other agricultural products and more than costs, it was still profitable to produce it in 1880 and more profitable than other farm products.

Wrappers Decline Less Than Other Grades

A comparison of the wholesale price of Connecticut wrappers shows that wrappers declined less than the average of other grades. Farmers who could produce a large proportion of wrappers found the profit of producing tobacco declined less than that of the farmer producing average tobacco. During this whole period from 1850 to 1880 farmers were trying out tobacco. Up to 1880 more and more New England farmers found tobacco culture profitable and therefore increased the acreage.

Introduction of Havana Seed

Tobacco had been imported from Cuba into the Connecticut Valley almost if not quite as early as cigars were manufactured, to be used as fillers for the better grades of cigars. It is perfectly natural that many attempts should have been made to grow this tobacco in the Valley to supply the demand. The early attempts were not successful. The tobacco grown from Cuban seed did not have the peculiar qualities of flavor which made Cuban tobacco so desirable for fillers, while the leaf was too small to be used as wrappers. There are reports of a few farmers growing tobacco successfully from Cuban seed before the Civil War, but its general cultivation was not successful until about 1875. At this time it was discovered that, grown for several years, it became acclimated and produced a wrapper leaf that was profitable. The seed used for field production was taken from plants of the fourth or fifth generation grown in the Valley. The plant of this variety is smaller, with a narrower, more pointed leaf than the Connecticut seedleaf, or that which is now generally called broadleaf. More plants of the former variety can be set to the acre than of the latter. The Havana seed, as this Cuban variety is called, at that time commanded a somewhat higher price and the production of it spread quite rapidly.

Other Changes in Production

There were a number of other changes in the methods of production in this period. Increased use of commercial fertilizer was a very important one. This fertilizer, as well as the barnyard manure, still was applied by hand although manure spreaders and fertilizer sowers had been invented. A common method of applying fertilizer was to mark off a square of ground and spread a bag of fertilizer over it. The size of the square was varied according to the rate of application. Fertilizer was sometimes applied by plowing furrows three or three and a half feet apart, the distance the rows of tobacco were to be placed, sowing the fertilizer in these furrows and then covering with two or more furrows. Although the disc harrow was being manufactured it was not in general use and many farmers were plowing their land twice instead of using the disc. The plants were still set out by hand. The Prout hoe was in use with some of the larger growers but the common method of cultivation was with a one-horse cultivator. The use of lath for hanging the plants in the shed became quite common although many farmers still tied the plants to poles, as they do today around Hadley, Massachusetts. In putting the plants on the lath a spear was used as at present. The present tobacco wagon with a rack for hauling loaded laths to the sheds took the place of the ordinary farm cart used at first. In the early production of tobacco it was put in the barns or sheds used to house the cattle and general farm crops, but with increased production special tobacco sheds were constructed.

Cost of Production

The following statement of the cost of producing an acre of tobacco in 1880 is typical:

Making seedbed	$ 2.50
Seed	.25
Weeding and attention to plant bed	1.50
Rent of land (interest on value)	12.00
Stable manure, six cords, at $8	48.00
300 pounds guano at $56 per ton	8.40
Cost of applying manure	4.00
Plowing land twice	4.00
Harrowing and ridging	3.00
Making hills	1.50
Drawing and setting plants	4.00
Cultivating, hoeing three times ea. $3.00	9.00
Topping, worming, and suckering	15.00
Harvesting	12.00
Taking down, assorting, and stripping	20.00
Bulking	1.00
Use of barns, laths, wagons, etc.	12.00
Delivering to market	3.00
Total	$161.15

Other estimates give very nearly the same results. Some farmers hired the labor to grow the tobacco at three cents a pound. The farmer furnished the fertilizer, tools, etc. An estimate of the cost of growing an acre yielding 2000 pounds under those conditions was as follows:

Labor	$60.00
Use of team and implements	20.00
Manure, 6 cords at $8.00	48.00
300 pounds guano at $56 per ton	8.40
Use of shed and lath	12.00
Rent of land	12.00
Delivering crop to market	3.00
Total	$163.40

The results are practically the same as in the first estimate. It will be seen that the labor cost only $4.60 more than the fertilizer. These two items made up 71 percent of the total cost. If we compare this cost with that thirty-five years earlier, we find that the cost of fertilizer had more than doubled. It is difficult to compare the quantities of manure, but it is evident that a large part of the increase is due to the increased amount applied. Labor cost had also increased through an increase in amount required to produce an acre and in the rate of wages.

Type of Tobacco Farming Carried On

Even as late as 1880 tobacco was raised in connection with general farming. This was true of those towns where tobacco was produced in the largest amounts as well as in those producing only a small amount. The following description of a farm in Ellington is typical of most of the farms on which tobacco was grown, except that it was slightly larger. On this farm there were 9 acres of corn, 10 of oats, 1½ of potatoes, 2¾ of rye, 2¾ of tobacco, hay land producing 70 tons of hay and pasture for summer feed for the livestock. The products sold from this farm were tobacco, butter, beef, veal, pork, poultry, eggs and fruit. An idea of the variety of products sold on the tobacco farms is given by the products listed on two other farms. On the first, hay, butter, milk, pork, poultry, and tobacco were sold; while on the other the products were hay, corn, oats, onions, potatoes, tobacco, orchard products, pork and poultry.

The census figures for Hartford County in 1880 give a picture of the typical farm in the tobacco area. There were 68 acres of land in the farm, of which 48 were improved. There were 21 acres of crops of which 15 were in hay, 2 in corn, 1½ in rye, nearly an acre in tobacco, and nearly an acre in potatoes. The rest of the cropland was made up of small amounts of other crops, the most important being oats and buckwheat. Although many of the farms which entered into the averages quoted above did not produce tobacco, yet the average represents fairly well the typical farm of the tobacco area. The average acreage of tobacco per farm on all farms producing tobacco was 1.7 acres as compared with .9 acres, the average for all farms in Hartford County.

Size of Tobacco Enterprise

Most farmers had one or two acres of tobacco which they tended besides doing their other farm work. There were some towns where the farmers were engaged in its production more extensively, yet only eight towns in Hartford County had an average of two or more acres of tobacco per farm. East Hartford, with four acres per farm, had the largest average, and South Windsor the next with three acres per farm. The following frequency table of the acres per farm in East Windsor shows that it was grown mostly in small acreages.

TABLE 6

Distribution of Farms by Acres of Tobacco per Farm

East Windsor 1880. (U. S. Census 1880)

Acres Tobacco	Numbers of Farms*
Under 1	14
1-2	76
2-3	66
3-4	46
4-5	18
5 and over	10
Total	230

*The ten with 5 acres or more were distributed as follows: 4 at 6 acres, 2 at 8 acres, 1 at 5, 10, 36, and 47 acres.

During the period from 1850 to 1880 there was an increase of only one acre in the area of tobacco per farm.

TABLE 7

Acres of Tobacco per Farm in Connecticut

1850 - 1880.

Year	Acres per Farm
1850	1.2
1860	1.3
1870	1.4
1880	1.7

Variation in Type of Tobacco Farming

During this time, however, there was a tendency for the type of farming to vary in the different towns. There was a tendency towards adaptation and specialization. This is shown by the changes which occurred in the two towns of East Hartford and East Windsor between 1860 and 1880. In East Hartford there was a very significant decrease in the relative amount of cereals produced and a corresponding increase in tobacco. In East Windsor, on the other hand, there was a considerable increase in the proportion of hay and cereals produced but not as great an increase in tobacco as in East Hartford. The increase in the number of cattle was relatively less in East Hartford than in East Windsor. This is shown in the table below.

TABLE 8

Acres of Cereals, Hay, Tobacco and Number of Cattle per 100 Acres of Improved Land, East Hartford and East Windsor

1860 and 1880 (U. S. Census 1860-1880)

Town	Cereals		Hay		Tobacco		Cattle*	
	1860	1880	1860	1880	1860	1880	1860	1880
East Hartford	13	6	35	25	2	15	10	14
East Windsor	14	25	28	35	3	6	14	20

East Hartford was tending to specialize more in tobacco while East Windsor was tending to specialize in beef and dairy production. By 1880 there were a few specialized tobacco farms, farms where the cultivated area was mostly in tobacco and there was little other source of income from the farm. There are statements of Professor Stockbridge of Massachusetts Agricultural College and others pointing out

*Not including working oxen.

that due to heavy fertilization of the tobacco land and better tillage methods, including drainage, the yields of hay and grain per acre greatly increased. The table above, showing a considerable increase in cattle relative to the amount of improved land and the amount of hay, supports that conclusion.

Variation in the Production in Different Towns

Increase in the production of any commodity may be brought about by an increase in the production per farm, by an increase in the number of farmers growing it, or by both. Production may also increase in an area or on certain farms while decreasing in another area or on other farms. In the period of 1850 to 1880 all these changes took place in New England's tobacco industry and affected the total production. These changes are of particular interest because New England is practically one market so far as tobacco is concerned. The price of any one grade varies but little from one part to another. The farm population, too, during this period was quite homogeneous, being practically all of native New England stock. The difference in the response of the farmers in the various parts of New England was not due, then, to differences in the farmers nor to any great differences in the economic forces acting upon the farmer in the form of prices for his products or for the products he purchased. It was the physical environment of the farmers which made them respond differently to the outside economic forces.

Various factors which affected the total output will now be considered. The increased production between 1849 and 1859 was not due in any great extent to an increase in production per farm. The average output per farm in Connecticut was 1735 pounds in 1849 and 1922 pounds in 1859. There were some towns where the production per farm increased materially, particularly Suffield, Manchester, Glastonbury, Enfield, and East Hartford. On the other hand the number of farmers raising tobacco increased from 749 to 3198, or more than fourfold. The success of the farmers already growing it and the stimulation of the rise in price encouraged not only many other farmers in the same towns but many farmers in more distant towns to take up its cultivation. Even up to 1880 the increase in the quantity raised was due much more to the increase in the number of farmers growing tobacco than to the increase in production per farm.

In 1850 the production of tobacco was quite localized. The towns bordering on both sides of the Connecticut River from Hartford on the west and Glastonbury on the east to the Massachusetts line raised 79 percent of the total for Connecticut and 71 percent of the total for New England. Table 11 shows the proportion of the Connecticut and New England production grown in those towns for the crop reported by the census of 1850, 1860, 1870 and 1880. The proportion of both the Connecticut and the New England crop grown in those towns was very much smaller in 1859 than in 1849, showing that there had been a very great expansion in the tobacco area in that decade. During the next decade the expansion continued, particularly in Massachusetts, for the output of the towns along the Connecticut River, which may be called the heart of the New England tobacco section, was only 22 percent of the total New England crop as compared with 29 percent ten years previous. Of the Connecticut crop, however, those towns produced as large a proportion in 1869 as in 1859. During the next decade when prices were lower the towns in the heart of the tobacco section raised nearly half the Connecticut crop and one-third of the total New England crop. Half of the increased production of Connecticut occurred in those towns, while the output of Massachusetts decreased between 1869 and 1879.

TABLE 9

The Proportion of the Connecticut and New England Tobacco Crop Produced in the Heart of the Tobacco Section.

1849-1879

Year	Percent of Connecticut	Percent of New England
1849	79	71
1859	44	29
1869	44	22
1879	46	33

The maps showing the production of tobacco as reported by the census present the same picture, a very large expansion in the tobacco area from 1850, more particularly 1855, to the end of the Civil War, then decreases in some towns and increases in others. Maps 2 (1869) and 3 (1879) also show a very large increase in production in the towns of the Housatonic Valley. The increase there was 180 percent as compared with 69 percent for Connecticut as a whole, 79 percent for the heart of the tobacco section, and a decrease of 27 percent in Massachusetts. This very large increase in the Housatonic is to be accounted for in the same way as the large increase in Wisconsin. It was due to the change in the habits or preference of the cigar smoker. As has been mentioned earlier, the fancy of the smoker, or at least enough of the smokers, had changed from the light cigars that were wrapped by the leaf grown in the Connecticut Valley to the darker cigars wrapped by leaf grown in Wisconsin, Pennsylvania and the Housatonic Valley, so that the darker leaf was in greater demand than the light. Many of the towns in this valley raised more tobacco during this time than at any other before or since. In no other areas in Connecticut were there any important increases in production between 1870 and 1880, and in a number of towns there was a decrease.

TABLE 10

Showing the Production and Percentage Increase in Several of the New England Tobacco Areas. (In thousands of pounds.)

1869 and 1879

	Heart of Tobacco section	Housatonic Valley	Other Connecticut	Massachusetts
1869	3,612	1,109	3,582	7,313
1879	6,457	3,108	4,242	5,369
Percentage Increase	+79	+180	+18	—27
Increase in pounds	2,845	1,999	660	—1,944

Even in a period of low prices and change in demand to darker tobacco the towns in the heart of the tobacco section continued to increase their production while the decrease took place in areas at a distance which were not so well adapted to tobacco raising. The towns of East Hartford and Glastonbury in the heart of the tobacco section are particularly interesting because of the great increase shown in the output there.

TABLE 11

Production of Tobacco in East Hartford and Glastonbury and Proportion of Farmers Producing Tobacco.

1849 - 1879

		1849	1859	1869	1879
East Hartford					
	Pounds	87,130	205,040	493,578	1,339,709
	Percent Increase		135	140	170
	Proportion Farmers	39	45	82	93
Glastonbury					
	Pounds	7,850	91,400	204,975	630,270
	Percent Increase		1,060*	125	208
	Proportion Farmers	9	31	55	50

The increase in production was greater both relatively* and actually in each succeeding decade. The absolute increase in each decade was one-half as great for Glastonbury as for East Hartford.

This large increase of tobacco in East Hartford and the tendency for the farmers of that town to specialize in tobacco to a greater extent than the farmers of other towns can be accounted for by the large proportion of Merrimac sandy loam which is found in that town. This soil is not so favorable for the production of hay or pasture as the heavier textured soils. With heavy applications of fertilizer it is an excellent soil for the production of tobacco for use as binders and wrappers for cigars. In the northwest section of the town of Glastonbury, adjoining East Hartford, there is an extensive area of Merrimac sandy loam. It is in this area that the large increase in tobacco production in that town took place.

THE CONCENTRATION OF TOBACCO ACREAGE IN THE CONNECTICUT VALLEY

The Depression in the New England Tobacco Industry

From 1880 to 1887 there was a steady decline in the acreage and production of tobacco in both Connecticut and Massachusetts. Then for several years the acreage remained about steady at just over forty-five hundred acres for Connecticut and twenty-five hundred acres for Massachusetts. In 1891 there began a recovery from the depression which had affected the New England tobacco industry since the business depression following 1873. By 1899 the census reported the acreage and production to be greater than any previously reported for the census year. The recovery during this decade was somewhat erratic; during the first two years there was a large increase, then for the next few years there was a decrease to 1898. In 1899 there was a substantial increase nearly equal to the acreage of 1892 and 1893. From 1900 the acreage increased almost steadily to 1910. In 1909 the census reported a production of thirty-eight million pounds, nearly double the output of 1879 which was the greatest amount grown previous to the depression of the '80's.

In studying the factors responsible for the changes in acreage and production just given, it is natural to look at the trend of prices to see if changes in price account for the changes in production. As noted in the previous chapter, the price of New England tobacco declined drastically in 1875 and 1876 but the production in Connecticut did not decline until after 1880. The price of tobacco remained low until 1888. The average farm price for any of these years was never over 16 cents nor below 12 cents. For the ten-year period 1879 to 1888 the average price was 13.5 cents. This low price was an important factor in

*The increase of 1060 percent was of course due to the very small production in 1849.

the decrease in tobacco production during this decade. In 1890, 1891 and 1892 there was a rapid increase in price which explains the large production of 1891, 1892 and 1893. In 1893 the price declined to 14 cents and remained low to the end of the decade. This accounts for the decline in production following 1893. There was a slight recovery at the end of the decade. From 1900 on the price was around 15 cents a pound, except for 1904 when it was 22½ cents and 1907 when it was only 11 cents. The average price for the period 1899 to 1908 was 15.1 cents. When an average price of 13.5 cents during the decade of the '80's resulted in a decline in production, it shows that there must have been some other factor than an increase in price of a cent and a half to account for the trend of increasing production during the decade 1899-1908. When the price for the two decades is adjusted to changes in the purchasing power of money, the average price for the ten years 1899 to 1908 is four cents a pound higher than for 1879 to 1888. The price of tobacco was somewhat higher in comparison with the price of other important farm products of New England from 1899 to 1908 than it was twenty years earlier. Agricultural products as a group were in a more favorable price position when compared with the general price level than they had been previously. Changes in price and particularly the changes in the relative price of tobacco as compared with the general price level and with other farm products undoubtedly did influence changes in tobacco acreage. There were other factors which were important in accounting for the upward trend in acreage. These will be discussed later.

Continued Competition from Wisconsin

The demand for New England tobacco comes from its use as cigar wrappers and binders. The extent of this demand naturally effects the price of New England tobacco. From 1880 to 1890 the number of cigars produced in the United States practically doubled, yet during this period the price of New England tobacco remained very low. For the price of tobacco to remain at such a low level the supply of cigar tobacco must have increased as fast as the production of cigars. Since the production of tobacco in New England decreased the increased supply came from elsewhere. It was noted that Pennsylvania and Wisconsin increased their output very greatly between 1870 and 1880. While Pennsylvania showed no large increase during the next decade—in fact the Department of Agriculture and the census reports show some decline in acreage during the last two years—Wisconsin's production continued to increase and the census reported acreage and production in 1889 nearly twice that of 1879. New York and Ohio also increased their production somewhat. The demand during this decade was for dark cigars, which had begun about 1875. It is stated that the buyers of tobacco preferred Wisconsin leaf, and the large increase in production shows the result of this preference.

Introduction of Sumatra

Another source of supply that became important during this decade and one to which protectionist New England was particularly alert was the importation of Sumatra wrappers from the Dutch East Indies. Tobacco for use in the manufacture of cigars had been imported into the United States almost from the establishment of the Constitution, but prior to 1880 this had been Cuban tobacco which was used as fillers. The New England tobacco grower never felt that this Cuban tobacco was a competitor for his market, in fact he thought that it was a benefit, for the desirable quality of Cuban tobacco for fillers increased the demand for cigars, which in turn increased the demand for New England tobacco for binders and wrappers. Sumatra tobacco, however, is used for wrappers, and the extent to which it displaced New England tobacco took away his highest priced market. The manufacturer of cigars preferred the Sumatra, for the New England leaf had certain defects as a wrapper when compared to the Sumatra. Doctor E. H. Jenkins, Director of the Connecticut Experiment Station, listed the defects as follows:

1. Being sorted before sweating, the colors of the finished leaf are not even and uniform.
2. The sweat is not even all through the case; the leaf next the case is less perfectly sweated than the middle.
3. The sorted leaves while of one length differ both in width and shape.
4. The leaf is too large, and in consequence "unprofitable" to the cigar maker. It cuts so as to leave much waste-binder, cuttings and trash.
5. The strains of tobacco grown are numerous; the plantations small; soil, fertilizers, handling vary a good deal—all of which make the small packings differ too much in quality.

Sumatra was also thinner and more elastic and would wrap many more cigars pound per pound than the New England tobacco. The imports of Sumatra leaf were practically insignificant up to 1880, when they reached 130 thousand pounds and gradually increased to four million pounds by 1886.

The Tariff

The New England tobacco grower soon became very much interested in the tariff, and in 1883 a tariff of 75 cents a pound was levied on all leaf tobacco imported for wrappers. This was the first time any distinction had been made in classifying unmanufactured tobacco imported into the United States. The tariff of 75 cents had no effect in decreasing the importation of Sumatra tobacco. Sumatra tobacco being thinner and more elastic produces more wrappers per pound than New England tobacco, and the manufacturer could still pay the duty and wrap his cigars at a lower cost than when he used native grown wrappers. Agitation for increased duties continued which resulted in raising the duty on unstemmed wrappers to $2.00 per pound in the McKinley tariff act of 1890. In anticipation of this increased duty and also because of a low price for Sumatra tobacco caused by a large crop on the island, nearly double the usual amount of this tobacco was imported that year.

The imports for the four years following the passage of the McKinley Act averaged four million pounds as compared with six million in the four years just prior to the act. Although the increased duty may have been partially responsible, other conditions were influential in causing reduced imports. In 1892 a short crop in Sumatra caused high prices for that tobacco and tended to reduce imports. The fact that such a large quantity was imported in 1890 in anticipation of the tariff also provided a supply which undoubtedly tended to cause less importation in the following years. In 1893, as a result of the high prices of the previous year, a large acreage was planted in the island and a large production and low price resulted. This low price stimulated importation into the United States. In 1894 the Wilson tariff act reduced the duty to $1.50 per pound on unstemmed wrappers. This tariff was in effect until 1897. For the three years in which this lower tariff was in effect less Sumatra tobacco was imported than the average for the four years of the McKinley tariff. This however does not prove that the higher duty was ineffective because the years the Wilson act was in force were the years of depression following the panic of 1893. In 1897 the Dingley tariff increased the duty 35 cents a pound to $1.85 for the unstemmed wrappers. The next year there was a slight increase in imports followed by a decrease in 1899. They increased in 1900 to six million pounds and have fluctuated around six million pounds annually since then, regardless of tariff changes. At the present time there is agitation for an increase in tariff on Sumatra tobacco. A study of the effect of the previous tariff changes shows that a duty of $1.50 to $2.00 a pound did not have any marked effect on imports.

Change to Light Cigars

About 1890 the preference of the cigar smoker turned again to a light cigar and New England tobacco was in a better price position when compared with Wisconsin and Pennsylvania tobacco. From 1890 to 1893 cigar production increased from four billion to four and eight-tenths billion. With the general business depression there was a decrease again to just over four billion cigars for the next few years, then with improved business conditions there was a steady and rapid increase from 1898 to 1907. In the first year four and one-half billion cigars were produced and by the latter year, seven and one-half billion. This increased demand helped to bring a better price for New England tobacco and thus aided in stimulating increased production.

Shade Grown Experiments

Another development which was of considerable concern to the New England tobacco grower was the growing of tobacco under shade in Florida. The Department of Agriculture believed that the importation of Sumatra offered a challenge to the American tobacco farmer to raise a product which could compete with it. The Department turned to Florida as having soil and climate most like that of the Dutch East Indies. Seed was obtained from the Islands and distributed to tobacco growers in Florida. President Duval of the Florida Central and Peninsula Railroad sent a man to Sumatra who obtained some of the finest strains of Sumatra tobacco. This seed was distributed to growers in Florida. Among the growers who experimented with various types of tobacco including this Sumatra were cigar manufacturers and dealers who operated large tobacco plantations in Florida. This work was not successful until it was noticed that the plants growing under trees were much better than those elsewhere in the field. Then in 1896 experiments were begun growing tobacco under artificial shade. At first slats 1x3 inches were placed on posts but soon cheese cloth was tried and has since been used. The tobacco grown in Florida in this manner from seed from Sumatra was said to be so much like the imported article that it could not be distinguished from it.

News of the success of this work in Florida caused more worry to the New England grower. This competition could not be checked by a tariff. However, at this time the Department of Agriculture was conducting its first work in mapping soils, and the soils of the tobacco sections were among those first studied. In this study the Department found that some of the soil in the Connecticut Valley was quite similar to the soil on which the tobacco had been grown so successfully under cover in Florida. In 1900, as a direct result of this study of the soil, the Connecticut Experiment Station in cooperation with the Bureau of Soils made the first trial of growing "shade" tobacco in the Valley. It was carried on under the direction of M. L. Floyd at Poquonock in Connecticut on about one-third of an acre. Part of this was set out to plants from Sumatra seed grown in Florida, the remainder to Havana seed. This first trial proved very successful. The tobacco was sent to various tobacco buyers and manufacturers for their opinion as to its merits. All were quite enthusiastic, saying that it was as good as the leaf imported from Sumatra. This encouraged a number of farmers of the Valley to try it out in 1901, and 41 acres were planted to tobacco under artificial shade. This was purchased at good prices by the manufacturers and caused a real boom in "shade" tobacco. Dealers and manufacturers became interested in the production of "shade" grown tobacco. So many had visions of the large profits that could be made from growing tobacco in this manner that 720 acres were planted in 1902. This did not prove so successful. The year was not particularly favorable and it was found that the Sumatra seed used had a tendency to break up into a large number of varieties so that the product was far from uniform. In spite of rather disappointing results in 1902 there were 445 acres planted in 1903. Again this year the results turned out much as they had in 1902. In the next year there were but 33 acres planted and up until 1910 only small acreages were planted. There were some growers who persisted and the government continued the experiment. The efforts of the government experts were directed particularly towards overcoming the lack of uniformity in the leaf and producing a leaf as nearly perfect for use as wrappers as possible. The Bureau of Plant Industry of the United States Department of Agriculture did this work making many selections of seed from individual plants and also many cross fertilizations. Out of the hundreds of plants which resulted they finally selected four types as suitable for production of wrappers under shade. These four varieties were (1) Uncle Sam Sumatra, (2) Hazelwood Cuban, these two secured by selection of seed from self-fertilized plants, (3) Brewer hybrid, and (4) Cooley hybrid, these two being secured by means of cross fertilization. The Hazelwood Cuban was the one which finally proved economically profitable for the growers.

Spotted Tobacco

Another attempt was made to meet the demand for a wrapper like the Sumatra by growing a spotted leaf. At first they tried to produce this spotted leaf by fertilization but were not successful. A liquid was then sprayed on the leaf to produce the spots. This was quite successful and seemed likely to prove very profitable. The craze for this particular type of spotted leaf was short lived. The spotting of tobacco was carried on during the latter part of the decade of the '90's. In 1897 one company of tobacco jobbers purchased considerable tobacco in the field and had it spotted by a man who had invented a machine for spraying the liquid on the plants. This seems to have been the largest attempt to produce the spotted leaf.

Research on Tobacco

Prior to 1890 little research work had been done by any experiment station or the Department of Agriculture on the problems of the tobacco grower. During the following decade these organizations turned their attention to these problems. Prior to that date some analysis had been made of the various parts of the tobacco plant and many analyses had been made of fertilizers. Much of this early work of considerable value to the tobacco grower had been done by Professor S. W. Johnson, first as chemist for the Connecticut State Agricultural Society, then as chemist for the Connecticut State Board of Agriculture, and finally as chemist and director of the Connecticut Agricultural Experiment Station.

The competition of the Sumatra tobacco and the depression in the New England tobacco industry of the 80's no doubt were largely responsible for the interest of research organizations in the problems of tobacco growers. Also these organizations had become fairly well established and were enlarging their scope of activity.

Some of the first work done on tobacco by any research agency was a study of pole sweat of tobacco conducted by W. C. Sturgis of the Connecticut Station and a study of curing of cigar leaf tobacco by heat, conducted by Doctor E. H. Jenkins, also of the Connecticut Station. In 1892 Doctor Jenkins began the first trials with fertilizer on tobacco at Poquonock, Connecticut. This work was carried on for five years through 1896. The work at Poquonock was carried on in cooperation with the Connecticut Tobacco Experiment Company, organized in the winter of 1891-92. The organization of this company shows that some of the progressive tobacco growers had faith in the value of research work to aid in the solution of their problems. Doctor C. A. Goessman of the Massachusetts Station carried on some field experiments on fertilizers from 1893 to 1896. At about the same time the Department of Agriculture began work on tobacco, in 1894 Professor Whitney made a study of the tobacco soils of Connecticut and Pennsylvania. In 1899 one of the first soil surveys in the United States was made in the tobacco district of the Connecticut Valley from Wethersfield and Glastonbury, Connecticut, to South Hadley, Massachusetts. These organizations increased the number of workers and the scope of the work so that they were soon doing research work on tobacco diseases, on the curing of tobacco by artificial heat, on fermentation in bulk, on fertilization, and on breeding new varieties.

Invention of the Tobacco Planter or Setter

During the period under consideration, 1880-1910, some of the most important changes in methods of production occurred. The tobacco setter was invented and came into general use. The records of the Patent Office indicate that many attempts were made to invent a machine to aid in transplanting such plants as tobacco and cabbage. As early as 1873 a C. E. Bates of South Deerfield, Massachusetts, took out a patent on a hand tobacco transplanter. From that date on a large number of patents were taken out on machines for transplanting tobacco and similar plants. A horse-drawn tobacco planter was patented February 9, 1886, by M. Smith of Janesville, Wisconsin. The one which proved the most successful and which has become practically universal in tobacco regions was invented by Frank A. Bemis of Dane, Wisconsin, a patent for which was granted in March 1890. This machine became very popular almost immediately. By 1904 it was estimated that two-thirds of the tobacco acreage of the Connecticut Valley was set by machine. This invention was one of the important causes back of the large increase in acreage which occurred in the Valley from 1890 to 1910. The machine permitted the farmer to plant a much larger acreage in the planting season. It also reduced the time necessary to plant an acre, one of the peak loads of labor, thus reducing the cost of production. There was the added cost of the machine, but on a large acreage this was not a large item.

Increase in Machinery

There was also increased use of machinery on the farms of the tobacco areas when fertilizer sowers, prout hoes, two horse cultivators, and disc harrows came into quite general use. The table below showing the value of machinery per farm in Hartford County, Connecticut, is evidence of the increasing importance of machinery on tobacco farms after 1890. The value of machinery per farm increased less than $10 from 1880 to 1890, while in the next decade it increased over $50 and in the succeeding decade, over $100.

TABLE 12

Value of Farm Machinery per Farm, Hartford County, Connecticut.

1880 - 1910

1880	$134
1890	142
1900	216
1910	325

Chemical Fertilizers

Another important change in cultural methods was the continued increase in the use of commercial fertilizer. As stated in the previous chapter commercial fertilizer was used quite early in tobacco production but to a very limited extent, for barnyard manure was the main source of fertilizer. During the period of 1880 to 1910 commercial fertilizer became a very important source of plant food applied in the tobacco area. In 1880 there was an average of $35 worth of fertilizer purchased per farm in Hartford County; by 1910 this figure had risen to $211. Tobacco and market garden farms have been the heaviest purchasers of fertilizer. The number of tobacco farms increased very little, so change in the proportion of tobacco farmers would not account for the increased purchases of fertilizers. Much of the increase, however, is due to increased acreage of tobacco, yet the increase in fertilizer was greater than the increased acreage of tobacco, so either a larger proportion of the tobacco acreage must have received applications of commercial fertilizer or more must have been applied per acre. The increase was due to both causes. A large quantity of this fertilizer was manure from the stables of New York. There was, however, an increasing quantity of cottonseed meal, castor pomace, and chemical fertilizers such as nitrate of soda, acid phosphate, etc., being used.

Marketing

Before 1880 the farmers delivered their tobacco loose in the wagons after sorting it into wrappers, fillers, and seconds and tying it into hands. Soon after that date, one account makes it 1883, they began to pack it in bundles which they wrapped with paper. It was delivered in this form to the dealer without stripping into grades. The grading was done by the dealer, who made 15 to 20 grades in place of the three made by the farmer.

Increase in the Number of Acres of Tobacco per Farm

In contrast to the small increase in average acreage of tobacco per farm from 1850 to 1880 was the marked increase in acreage cultivated by the average farmer in 1910. Use of the tobacco setter and other machinery was much more economical on the larger acreages than on the smaller. The introduction of these machines and their increased use was responsible to a very large extent for the increased acreage of tobacco per farm.

TABLE 13

Average Acreage of Tobacco per Farm and the Number of Farmers Reporting Tobacco.

Connecticut 1880 - 1910 U. S. Census.

Year	Number of Farmers	Acres	Year	Number of Farmers	Acres
1879	5,279	1.7	1899	2,909	3.5
1889	2,448*	2.8*	1909	2,869	5.6

It was pointed out in the preceding chapter that the increase in tobacco production was largely a matter of the increase in the number of

*The number of farmers who produced tobacco is not given in the Census Report. The figure quoted is the average of a survey by the New England Homestead in 1891. There probably was not an increase of an acre in the average size of the tobacco enterprise per farm during the decade preceding. The Homestead survey omitted the small plots of tobacco which they regarded as non-commercial which are included in the census average. There was probably some increase in acreage per farm due to the fact that less tobacco was produced in the hill towns in 1891 than in 1879. The more intensive tobacco towns had larger acreages per farm than did the towns having less tobacco.

farmers raising tobacco and not of increased output per farm. As the table above shows, the increased acreage per farm in 1909 over 1879 would, with the same number of farms, give an acreage more than three times as large. The total acreage in tobacco actually increased less than three times because of the decrease in the number of farmers producing tobacco. The greatest increase in the size of the tobacco enterprise occurred between 1900 and 1910. The decrease in the number of farms between 1880 and 1890 occurred because many farmers who had been producing a small amount of tobacco gave it up and tobacco production became concentrated on the farms better suited to it. The use of more machinery, particularly the tobacco setter and fertilizer sower, enabled the more favorably situated farmers to increase their production. This is what occurred after 1890, making it possible for not much more than half the number of farmers to increase the acreage almost three fold.

Continued Concentration of Acreage

In the preceding chapter it was shown that from 1850 to 1880 a very large part of the tobacco production of Connecticut and of New England as well was concentrated in a few towns bordering the Connecticut River, which were designated as the heart of the tobacco section. It was shown that there had been an expansion of the tobacco area so that those towns produced less of the Connecticut and New England crops than they had in 1850. It was also shown that during the decade 1870-1880 there was a reversal of the expansion and more of the production was concentrated in those towns. The data for the two decades following show that the concentration continued. A much greater proportion of the tobacco acreage of Connecticut and New England was in the heart of the tobacco section than previously except for the years around 1850.

The table below (Table 14) shows some interesting changes in the distribution of tobacco acreage in New England. There was a concentration of tobacco acreage in the heart of the tobacco section between 1880 and 1890. With the increase in acreage in 1891, 1892, and 1893

TABLE 14

The Proportion of the Connecticut and New England Tobacco Acreage in the Heart of the Tobacco Section.

Year	Connecticut Percent	New England Percent
1879	46	29
1890	67	50
1893	60	43
1899	67	51

there was an expansion in the towns outside of this more specialized tobacco area. As a result the towns in the heart of the tobacco section had a lower proportion of the total acreage. With the decrease in price after 1893 the acreage did not decrease in the towns in the heart of the tobacco section nearly as much as in the towns outside of that area, and in 1899 the towns in the heart of the tobacco section had as large a proportion of the acreage as in 1890.

Although the tobacco acreage for Connecticut and New England as a whole decreased nearly 50 percent between 1879 and 1889 there was practically no decrease in the heart of the tobacco section. The increase in acreage from 1890 to 1893 was also much less in those towns than in the rest of Connecticut and New England. In 1899 the acreage in the heart of the tobacco section was practically the same as in 1893, if anything slightly larger. In the Housatonic Valley and in other Connecticut towns there was a considerable decrease. In Massachusetts the acreage was practically the same in 1899 as in 1893. This was because of a considerable increase in acreage in the towns of Hadley, Hatfield and Whately which counterbalanced the considerable decrease in other towns of the state. Those three towns and Deerfield are the most important tobacco towns of Massachusetts, producing over half the total tobacco. Those towns with Sunderland occupy much the same relation to the tobacco acreage and production of Massachusetts as the towns in the heart of the tobacco section do to that of Connecticut. In 1890 they produced a larger proportion of the Massachusetts crop than they had previously. With the increase in production from 1890 to 1893 the proportion in those towns decreased somewhat, and in 1899 it was practically the same as in 1890. Although the acreage of tobacco in these towns decreased from 1880 to 1890 it did not decrease as much as the acreage of the other tobacco towns of Massachusetts. They did not increase their acreage in proportion to the general increase of 1893; and as has been stated, they had a larger acreage of tobacco in 1899 when most of the tobacco towns in Massachusetts decreased from what they had in 1893. What happened during this period was that with low prices tobacco production was concentrated on the lands most suitable for it in both Connecticut and Massachusetts. This land was largely confined to a few towns on the Connecticut River. Increased prices and expectation of yet higher prices caused expansion on less suitable land, land which was submarginal for tobacco production under lower prices. With the decrease in price these lands went out of tobacco production, and its cultivation was again concentrated on the more favorable land. In 1897 and 1898 there was a slight recovery in prices and tobacco acreage increased considerably in 1899. This increase, however, was in the towns which had the more favorable tobacco land. New Milford was the only town not bordering on the Connecticut River to show a large increase in acreage in 1899 over that of 1893.

An important factor bringing about the increase in production in the towns bordering on the Connecticut River was the introduction of tobacco setters and the increased use of machinery. On the farms of the Valley towns the fields were large enough and level enough to make the use of this machinery profitable, while on the farms of the hill towns the fields were too small and too rough. Another important factor in bringing about the concentration of tobacco in these towns was the increased use of commercial fertilizers. These towns have large areas of Merrimac sandy loam, Enfield very fine sandy loam, and similar light soils which when fertilized heavily produced excellent crops of tobacco—tobacco light in color and having qualities that made it a desirable wrapper—although not as thin and elastic as Sumatra and cutting to more waste. Mr. Gold, Secretary of the Connecticut State Board of Agriculture, states, "When a town or a neighborhood can take land that is not worth much in ordinary agriculture and, by applying $100 worth of fertilizer and $100 worth more of labor and get $500 in return why that land is going up in value. Some of this worthless, valueless land for ordinary agriculture is producing the highest return of any land in the country." Dr. E. H. Jenkins, Director of the Connecticut Experiment Station, made the following statement: "Light cinnamon-brown leaf, as a rule can only be raised on sandy light lands, which are nearly free from loam or clay." These light soils properly fertilized produced the quality of tobacco which at this time brought a price above the average, so that tobacco production on these soils was profitable when it was not on soils which did not produce as good quality tobacco.

The invention of the tobacco setter and the use of commercial fertilizer gave these soils an added advantage so that tobacco production was concentrated in the towns of the Connecticut Valley where these soils are found.

THE WORLD WAR AND THE DECREASE IN CIGAR CONSUMPTION

The course of the New England tobacco industry from 1910 to 1914 was quite similar to that from 1900 to 1910—a steady increase in acreage and production, with increasing use of machinery and fertilizer. After 1914 it was influenced to a considerable extent, as were all lines of industry, by the World War.

Continued Increase in Acreage

The trend of tobacco acreage in New England continued upward from 1910 to 1921; since that date it has been downward, with a slight tendency upward again from 1927 to 1930. The largest acreage ever reported for Connecticut was in 1921 when 31,000 acres were in tobacco. The largest acreage for Massachusetts was 10,000 acres

reported for the four years 1918-1921. For both states the acreage in 1921 was nearly double what it had been 10 years earlier; for Connecticut it was nearly three times the acreage of twenty years earlier, and for Massachusetts it was two and a quarter times as large as that of 1900. This increase was at a more rapid rate than that of any other cigar leaf producing area in the United States. In Connecticut, every year from 1910 to 1921 saw an increase in acreage over the preceding year, except 1917; and in Massachusetts there was an increase each year except 1916 up to the maximum of 10,000 acres in 1918.

Expansion of "Shade" Acreage

A part of this increased acreage was due to the expansion which occurred in "shade" grown tobacco. As discussed in the previous chapter the "shade" grown tobacco industry was in the experimental stage from 1900 to 1910. After that it became established and had a remarkable development. In 1910 there were 1,000 acres of tobacco grown under shade in the Valley, by 1915 the amount had increased to 3,600 acres, in 1918 there were 6,000 acres, in 1919 it fell off somewhat but increased the following year, and in 1923 it reached 8,700 acres.

Reaction of "Shade" and Stalk Tobacco Growers to Price Changes

From 1921 the acreage of stalk tobacco declined slightly to 1925. In that year there was a substantial decline of 10,000 acres, or nearly one-third of the acreage of the year before; in 1927 and 1928 there was a slight recovery in Havana acreage. This, however, was practically balanced by an equal decrease in the Broadleaf acreage. The decrease in "shade" came in 1924 and 1925. There was a decline in the two years of 4,000 acres or nearly one-half of the high production of 1923. The acreage of "shade" has increased since 1926 and in 1928 was nearly as large as the high production of 1923, and this year, 1929, will exceed that figure.

It is interesting to note that the decline in "shade" preceded the decline in outdoor tobacco. "Shade" decreased in 1919, Broadleaf in 1925, and Havana seed in 1924. "Shade" again decreased substantially in 1924 and 1925, Havana seed and Broadleaf followed in 1926. It seems very probable that one of the reasons for the quicker adjustment of "shade" acreage to the change in the price situation is the fact that the "shade" producers are larger growers and are also dealers in leaf tobacco and better informed concerning market conditions than the average small grower of outdoor tobacco. By reducing their acreage in 1924 and 1925 the "shade" producers aided in bringing about a better market situation and a recovery in the prices for their product.

Increased Price

The tremendous increase in production during and immediately following the World War was a response to higher prices which were obtained for New England tobacco. The simple average price per pound for the six years 1910-1915 was two and a half cents higher than for the six years 1904-1909. The first years of the World War did not see any increase in the price of tobacco, in fact the price for 1914 and 1915 was less than for the three preceding years. In 1916 there was a very substantial increase in price. The average price reported by the Department of Agriculture increased from 17 cents to 27 cents. By this time there was a considerable acreage of "shade" grown tobacco and the higher price received for it would have some weight in the average price. However, the average price received by a group of farmers producing Broadleaf increased from 18.5 cents to 24.5 cents from 1915 to 1916. The five years 1916-1920 saw a repetition of the high prices the growers had received during the Civil War period. The average December first price reported by the Department of Agriculture for those years was 38 cents and the average price for Broadleaf was 35 cents.

Decreased Production of Cigars

In the two preceding chapters was shown the tremendous increase in cigar production from 1862 to 1910. The increase in production continued to 1920 when 8.1 billion cigars were produced. From 1907 to 1920, however, the trend in cigar production did not increase at nearly so rapid a rate as previously and since 1920 the trend has been downward. The last few years it has been somewhat stable at 6.5 billion. The average production from 1904 to 1909 was 6.8 billion cigars. It increased to 7.0 billion in 1910-1915, to 7.3 in 1916-1920 and decreased to 6.8 billion for 1921-1926. The decrease in consumption of cigars since the World War is not confined to the United States but is general throughout the world. The enormous increase in cigarette smoking is generally accepted as accounting for the decrease in the use of cigars.

War Time Inflation

The increase of three percent in production of cigars for the period 1910-1915 over the period 1904-1909 was accompanied by an increase of 14 percent in price of tobacco. The increase of four percent in the production of cigars for the period 1916-1920 over the preceding period was accompanied by an increase of 70 percent in the price of tobacco. A decrease in the supply of cigar leaf tobacco would result in an increased price as well as would an increase in demand for tobacco. But the increased price during the period was not due to a decrease in the supply in comparison with the demand. There was a somewhat larger increase in the amount of cigar leaf consumed in the manufacture of cigars than in the number of cigars produced; that is, the number of pounds used in the manufacture of a thousand cigars increased. Yet the increase in the amount of cigar leaf tobacco grown was over three times the increase in the consumption of tobacco for cigar purposes. The export of cigar leaf tobacco during this time was not large enough either absolutely or relatively to have any marked effect on the price. Of course a very large part of the increase in price, particularly during this last period, was due to the increase in the general price level. The price of tobacco from 1904-1909 when adjusted by the general index of prices averaged 16.8 cents; for 1910-1915 the average was 19.5 cents; and for 1916-1929 it was 21.6 cents. It was shown in the previous chapter that an increase of two or three cents in the deflated price resulted in increased acreage. The fact that the price of tobacco increased faster than the general price level is an important factor in accounting for the increased acreage.

Decline in Price

After 1920 there was a severe decline in the price of tobacco to below the general price level. This decline in price accounts for the decline in acreage. In 1921 the price received by Broadleaf growers declined to 21.5 cents from the 41.0 cents of the year before, and the average price for Broadleaf since 1925 has been 21 cents and for Havana seed 22 cents.[1] There has been a tendency for a slight increase in prices of Havana seed the last few years resulting in increased acreage of that type, while Broadleaf prices and acreage have tended down. Prices of "shade" also declined after 1920 but there was a recovery in 1925 which has resulted in an increase in shade acreage in the last three years.[1]

Increase in Stocks of Tobacco on Hand

The decline in price after 1920 cannot all be explained by the decline in the general price level, for tobacco prices, particularly Broadleaf prices, declined more than the general level of prices and went back to pre-war levels. This decline was a result of the decline in cigar production. With the smaller consumption of leaf in the manufacture of cigars, stocks of cigar leaf tobacco accumulated. The doubling of the acreage in New England between 1910 and 1920, with a very large increase in other cigar leaf areas, while there was but a small increase in the production of cigars, resulted in an increase in stocks on hand from 1.3 years' supply for the period 1918-1920 to 2.8 years' supply in 1924. While there has been in recent years a reduction of stocks there has been no indication of a trend towards increased consumption of cigars.

[1]Through 1928.

Chronology

Below are listed some of the more important events which have influenced the development of New England tobacco industry:

1620-1640 1. Tobacco production was taken up by the colonists of New England soon after they established the several settlements. It was grown in Plymouth Colony, Massachusetts Bay, Connecticut, and Rhode Island for local consumption.

1700-1775, 1790-1810 2. The development of the carrying trade to the West Indies during the first quarter of the 18th century gave an export market for New England tobacco. This was lost during the Revolutionary War. It was revived for a short period following that war and was permanently lost with the War of 1812.

1790-1820 3. The general use of cigars and their manufacture in the United States began after 1790.

1833-1845 4. The Broadleaf variety of tobacco was introduced into the Connecticut Valley in 1833 and had completely replaced the narrow "shoe string" variety by 1845.

1845-1865 5. There was a very large expansion in cigar production during the middle of the nineteenth century.

1860-1870 6. There was a very rapid increase in cigar leaf production in New England, Pennsylvania, and Wisconsin during and following the Civil War.

1870-1880 7. The first successful growing of Havana Seed type of tobacco was made during the seventies. Seed was taken from plants which had been acclimated for three or four years.

1875-1890 8. A vogue for dark cigars began in the latter part of the decade of the seventies and ended about 1890.

1880-1886 9. The importation of Sumatra was insignificant prior to 1880; by 1886 it had increased to four million pounds.

1890 10. The Bemis tobacco setter, the one which has been generally adopted, was patented in 1890.

1900 11. Tobacco was first grown under shade in New England at Poquonock, Connecticut, in 1900. The production of "shade" was in the experimental stage until 1910.

1914-1923 12. During the World War there was a much more rapid increase in the production of cigar leaf tobacco than in production of cigars in all sections of the United States raising those types of tobacco.

1920 and after 13. There was a general decline in cigar consumption after 1920.

SUMMARY

I. Market Factors

A. Changes that affected the demand for New England tobacco.

1. Tobacco was first produced by New England colonists in small garden patches for local consumption. The development of the West India trade in the early eighteenth century opened a market for the production of tobacco for export. This stimulated production around Windsor and East Windsor, Connecticut, and in the Narragansett county of Rhode Island. This market was lost during the Revolutionary War, was regained to some extent, but was lost permanently with the War of 1812.

2. The next market which developed for New England tobacco was based on the introduction of cigar smoking after 1790. The discovery that the tobacco grown in New England had qualities which made it particularly desirable for cigar wrappers and binders gave rise to the demand which established the production of cigar leaf tobacco in New England. The production of cigars in the United States and with it the demand for New England tobacco developed gradually but slowly until 1850. Then it became quite rapid until after the Civil War. The New England farmers responded to this demand with steadily increasing production, especially from 1830 to the end of the Civil War. This was the most important factor influencing production during this period.

3. A temporary falling off of the demand for Connecticut Valley tobacco occurred when smokers shifted to the use of darker cigars wrapped with Pennsylvania, Wisconsin and Housatonic leaf. This brought a decrease in Connecticut production during the eighties.

4. The demand for Connecticut Valley tobacco increased again when the smokers again preferred the lighter cigars, about 1890. The demand again declined with the depression in 1893. Recovery came about 1900, and the demand steadily increased until after the World War. This was one, although not the only factor, causing the tremendous increase in tobacco production in New England which occurred during this period.

5. The trend of demand for cigars and cigar leaf tobacco has been downward since 1920, resulting in lower prices and lessened production of New England tobacco.

B. Changes that affected the supply and the competition of New England tobacco.

1. New England tobacco had no serious competition for the cigar wrapper and binder market until the Civil War. From the Civil War to 1890 the tremendous increase in tobacco production in Pennsylvania and Wisconsin greatly increased the supply of wrappers and binders. The shift of smokers to dark cigars made this competition

even more effective. This competition caused production in New England to decline.

2. The importation of Sumatra tobacco increased the competition, in fact offered even more serious competition than the Wisconsin or Pennsylvania leaf when the preference of the smoker was for a light cigar. Because of the thinness and elasticity of the leaf, Sumatra tobacco wraps a larger number of cigars per pound than New England tobacco. Sumatra tobacco took a large share of the wrapper market, so that an increasing share of New England tobacco had to be sold as binders. This occurred at the time that cigar production was increasing; and although New England tobacco production increased, the importation of Sumatra tobacco tended to keep the price and production of New England tobacco from rising as high as they would have without this competition.

3. The competition of the middle west lowered the relative price of wool, beef, cheese, butter, rye, oats, and corn more than milk, eggs, fruits, vegetables, and tobacco. In the towns of the Connecticut Valley, tobacco was the most important of these products. Farm abandonment in the Valley towns is almost negligible as compared with the hill towns. It was tobacco which made it possible for most of the farmers to secure as great or greater rewards there than they could by going into the factories or migrating to the West.

4. During the Civil War and the World War the general price level rose very rapidly. The price of tobacco rose faster than the cost of production. This was an important factor in the great increase in production during those periods.

II. Agricultural Science and Technique

A. The introduction of the Broadleaf type of tobacco was the first important improvement in the cultivation of tobacco in New England. That this was a much more desirable leaf for cigar use and yielded a larger profit to the grower is shown by the fact that in ten years it displaced the narrow leafed "shoe string" variety. The introduction of this variety was a contributing factor in the development of tobacco production during the middle of the nineteenth century.

The development of the Havana Seed varieties displaced the Broadleaf varieties in a large area after 1870. Although these new varieties were found more profitable over a considerable area, they were never important in the heart of the tobacco section in Glastonbury, East Hartford, South Windsor, and East Windsor. The area where these varieties were grown was the area where tobacco production declined the most during the eighties. It is probable that the introduction of these new varieties tended to retard the trend since they proved more profitable than the Broadleaf varieties in those areas.

B. The use of commercial fertilizer was one of the most important changes in methods of production which the tobacco farmers made. It made possible the production of tobacco year after year on the same land. It thus did away with crop rotation on each farm and allowed specialization in the production of tobacco.

Organic fertilizers were first used—dried fish, cottonseed meal, bone meal, and manure from the stables in the cities. After 1906 mineral fertilizers became a more important source of fertilizer elements. In recent years nitrogen from chemical sources has become important.

C. Another factor in bringing about specialized production and increased production was the invention of the setter and the increased use of machinery. The increase in tobacco production from 1900 to the World War was to a very considerable extent due to the lowering of the cost of production by the use of the tobacco setter and other machinery. It tended to increase specialization as the reduction in costs was greater on the larger acreages. Before the invention of the setter, the farmer growing ten acres of tobacco had much less advantage over the farmer growing two or three acres than he did after. Commercial fertilizer and machinery complemented each other in bringing about specialization. Commercial fertilizer enabled a farmer with a small acreage to put his whole farm in tobacco so that he had acreage enough to use machinery advantageously.

D. The introduction of growing tobacco under "shade" had a very great effect upon the tobacco industry. This method produced a thinner leaf, a pound of which will wrap more cigars than a pound of Broadleaf or Havana Seed. As stated previously the introduction of Sumatra had taken part of the market for cigar wrappers. At present only a small number of cigars are wrapped with Broadleaf.

The cost of production of "shade" is so high and the losses from a failure are so great that it is produced by large corporations rather than by individual farmers.

Many other changes in methods of production influenced the profitableness of tobacco raising. Those listed are the ones which have had the greatest influence to date. There has been much experimentation in the control of disease and the use of fertilizer on tobacco. These experiments have been very valuable in lowering costs.

III. Natural Environment

An increase or decrease in the price of a product does not cause all farmers producing it to increase or decrease their production in the same proportion. Some farmers will increase or decrease production with a small change in prices, others will not change at all. Some will make much greater changes than others in response to price changes. The same is true of changes in methods of production. All farmers do not respond to new methods in the same degree. Variations in soil and topography have largely determined the kind and the extent of changes which tobacco farmers have made because of changes in price and methods of production.

A. Soil

1. The production of tobacco has been limited almost exclusively to the light sandy soils. In periods of high prices, as during the Civil War and World War, some tobacco is grown on soils of heavier texture. During the period when dark cigars were in demand, some of the heavier soils were also used for tobacco.

2. The increase in production resulting from the use of commercial fertilizer was much greater on some soils than on others. The use of fertilizer caused a much greater increase in tobacco production on Merrimac sandy loam than on any other soil.

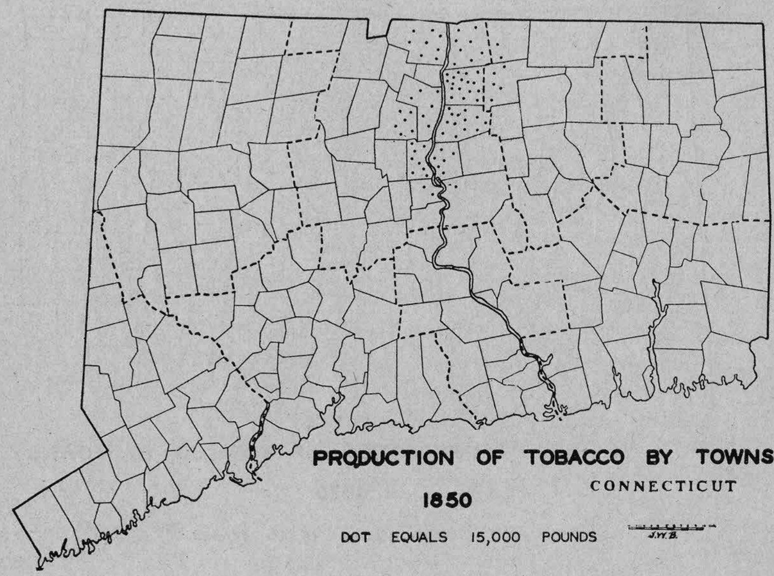
3. The use of fertilizer and the production of "shade" made it possible to produce tobacco at a profit on certain areas of Merrimac sand. "Shade" tobacco is practically the only tobacco grown on this soil type. This kind of soil is practically useless for any other type of farming.

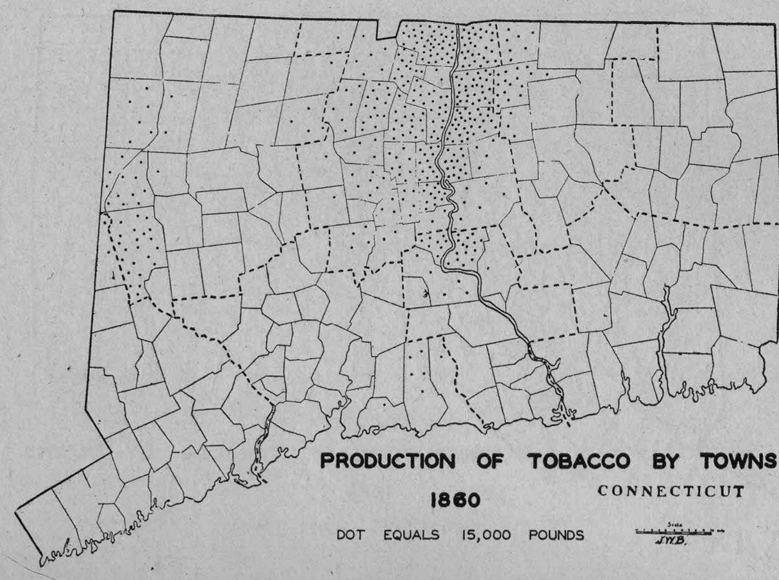
B. Topography

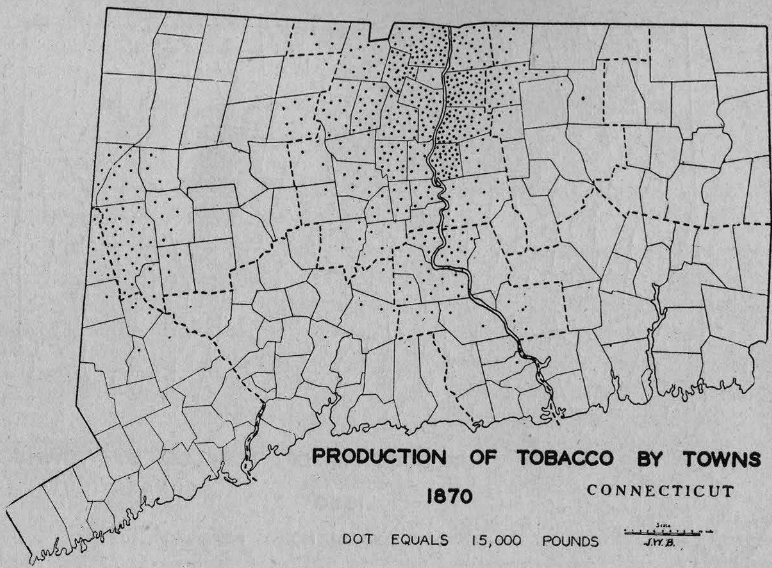
The influence of topography on tobacco production is through the limitations which a rolling or rough topography places on the use of machinery. The expansion that was stimulated by the use of machinery was on the level land of the Connecticut Valley. Some of the rougher areas which had produced tobacco previous to this were forced out of production after 1890.

C. Effect of Price Changes on the Geography of Tobacco Production.

A rapid increase in price, during the Civil War, from 1890 to 1892, and the World War, stimulated tobacco production on soils and topography that are less favorable to its production. Then with the decline in price those areas made the greatest reduction in acreage. Production in the heart of the tobacco section has been more stable. The changes which have occurred in the areas of more favorable soil and topography have been due more to changes in methods of production than to changes in price or the use of fertilizer and machinery.



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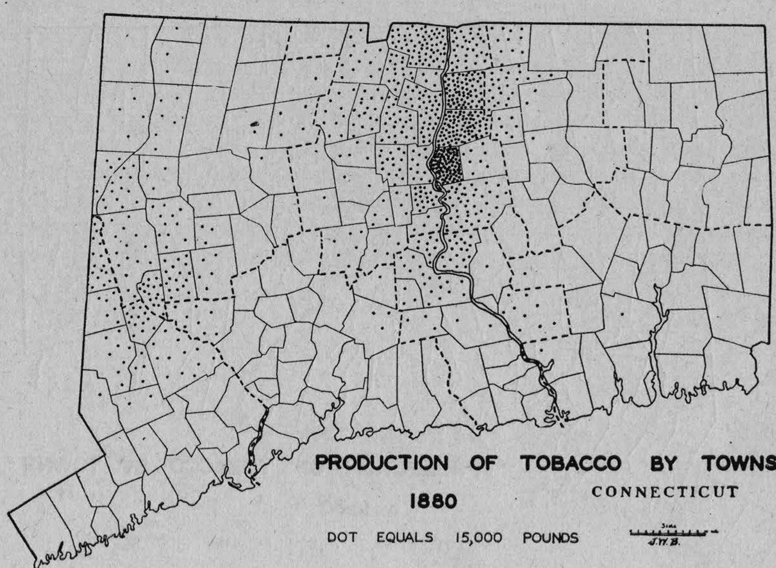
1870
CONNECTICUT
DOT EQUALS 15,000 POUNDS
J.W.B.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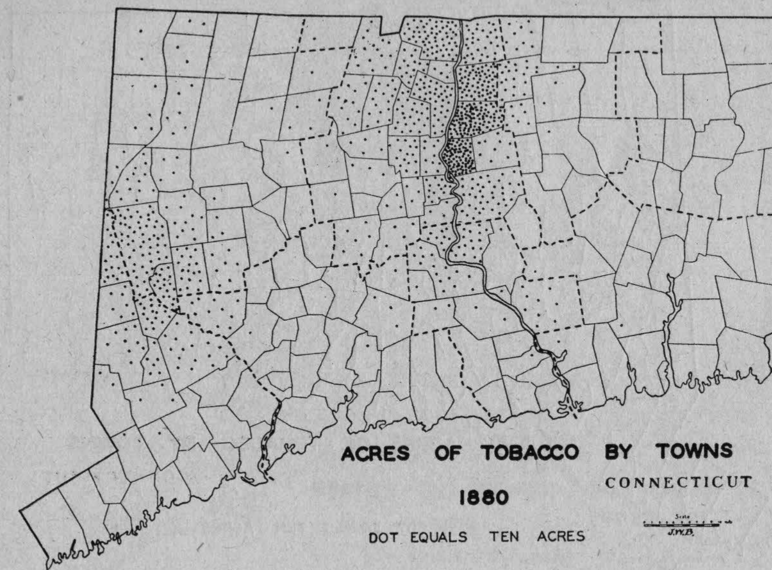
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CONNECTICUT
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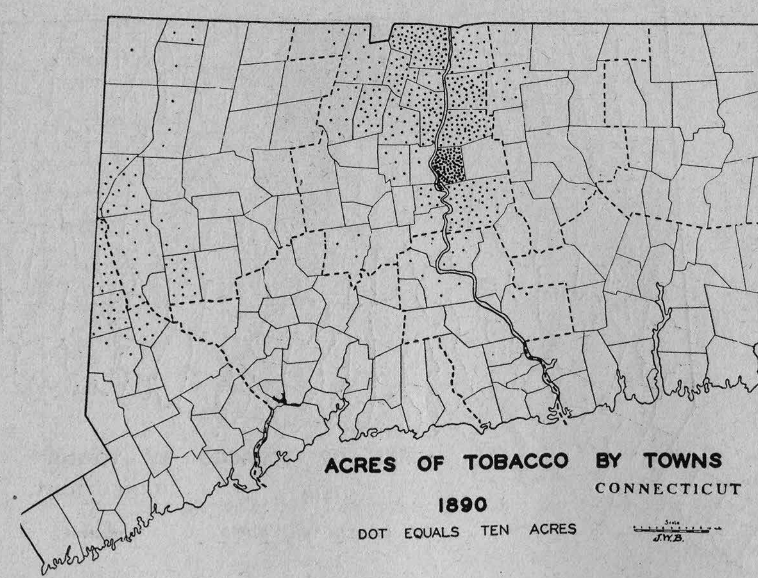
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1890
CONNECTICUT
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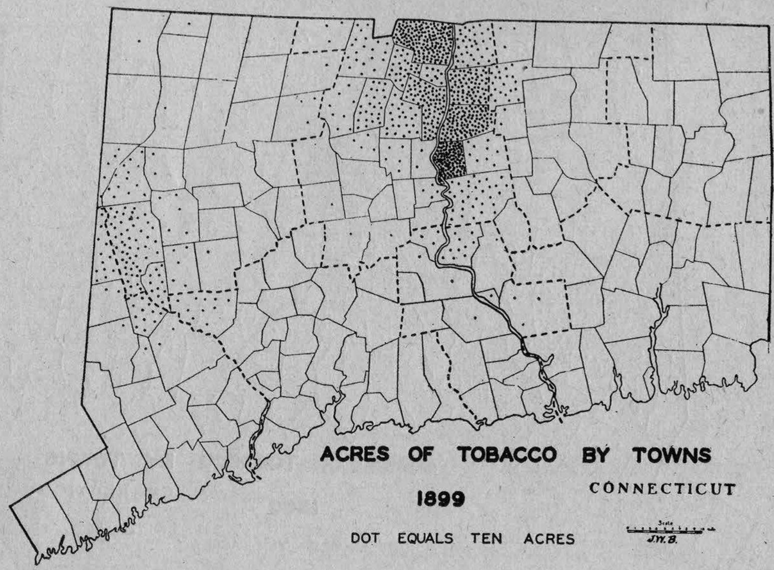
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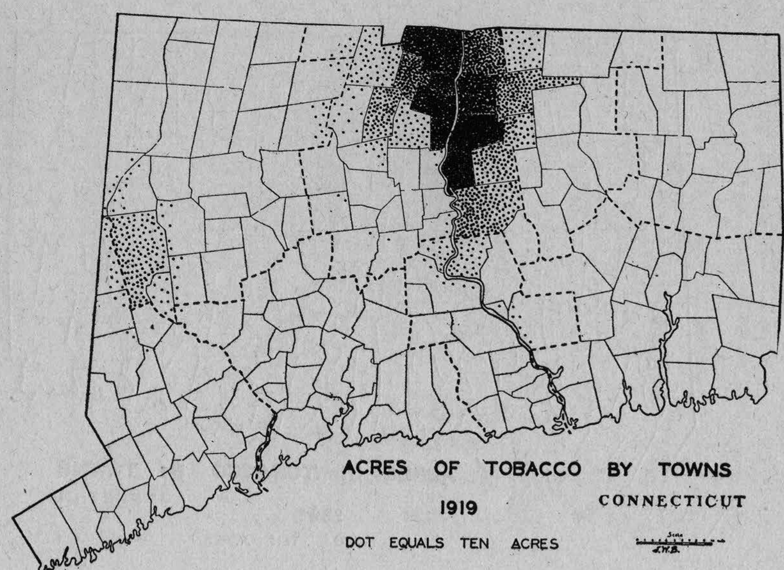
1899
CONNECTICUT
DOT EQUALS TEN ACRES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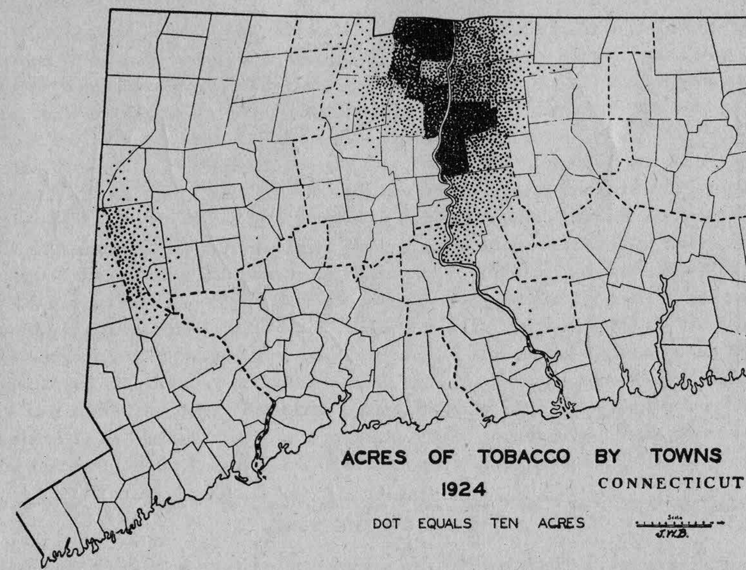
1919
CONNECTICUT
DOT EQUALS TEN ACRES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1924
CONNECTICUT
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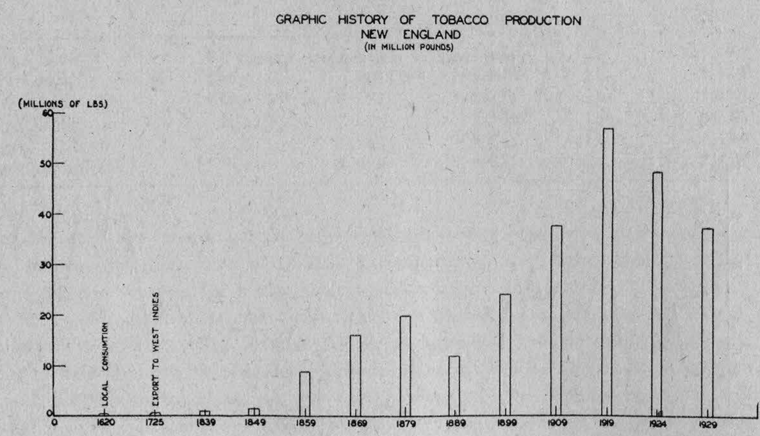
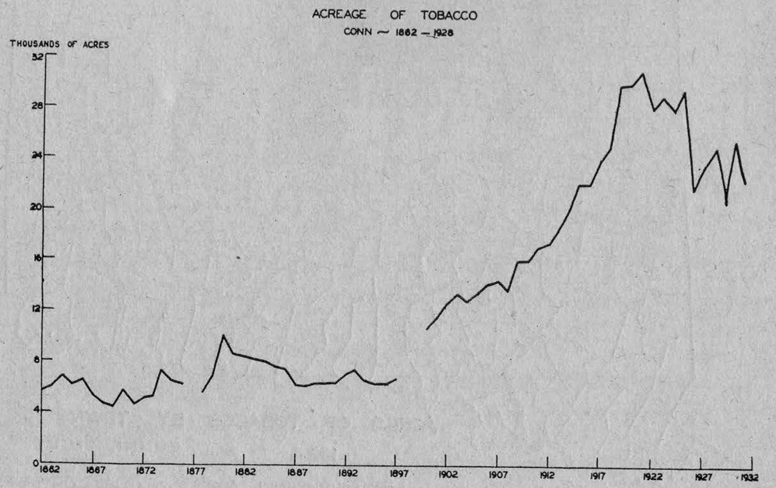
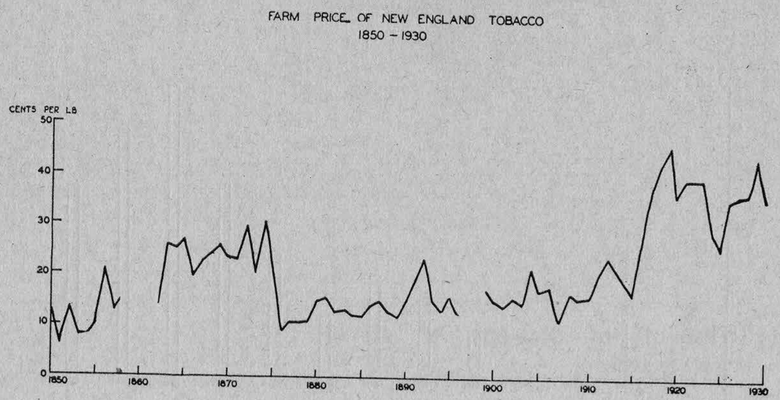

GRAPHIC HISTORY OF TOBACCO PRODUCTION
NEW ENGLAND
(IN MILLION POUNDS)
(MILLIONS OF LBS)
60
50
40
30
20
10
0
LOCAL CONSUMPTION
EXPORT TO WEST INDIES
1620
1725
1839
1849
1859
1869
1879
1889
1899
1909
1919
1924
1929





APPENDIX

Status of Tobacco Production in the United States

While it is possible to grow tobacco in any state in the Union it is of commercial importance in only twenty-five. The tobacco produced in the different parts of the United States has different characteristics due to differences in variety, soil, climate, and methods of growing and curing. Because of these differences in the leaf produced, the tobacco of the United States is classified into different types. The United States Department of Agriculture recognizes twenty-nine distinct types. These are grouped into six classes. Each class has qualities which make it preferred for particular uses but all the tobacco of a given class is not used solely for any one purpose. The six classes recognized by the Department of Agriculture are as follows: flue-cured, air-cured, fire-cured, cigar filler, cigar binder, cigar wrappers. The first three classes are named according to the method of curing the leaf, the last three are named according to the principal use to which the leaf is put. The cigar types are raised in the northern states except for a small quantity in Florida and Georgia, while the other types are raised in the southern states. The chief uses of the different classes are as follows: the bright flue-cured is used for cigarettes; the dark fire-cured is exported to Europe where it is used for cheap cigars, for smoking, chewing tobacco, and for snuff. In the United States it is also used as pipe tobacco. Of the air-cured

Appendix Table 1

Average Annual Acreage, Production, Yield per Acre, Price per Pound and Farm Value of Tobacco by Classes. United States 1925-1928.

(United States Department of Agriculture Yearbooks 1926-1928)

Class	Acres	Yield per Acre pounds	Production 1,000 pounds	Price per pound cents	Farm Value $1,000
Flue-Cured	947,675	681	645,031	21	$135,496
Fire-Cured	210,425	767	161,348	11	17,880
Air-Cured	434,450	798	346,578	19	65,836
Cigar Fillers	64,337	1,155	74,285	12	9,050
Cigar Binders	60,473	1,287	77,843	18	14,344
Cigar Wrappers	9,315	1,017	9,473	84	7,938

class Burley is the most important. It was formerly used mainly for sweetened plug but recently has been used extensively for cigarettes. The cigar classes, as their names indicate, are used for fillers, binders, and wrappers of cigars.

The importance of these various classes in the United States is shown in Table 2. There are more than twice as many acres of flue-cured tobacco raised as of any other class, and nearly twice as many pounds produced. The air-cured class is next in importance. These two classes, as was stated above, are the main source of the tobacco used in cigarettes. The fire-cured class is third in acreage and amount produced. Cigar fillers rank fourth in acreage but only slightly higher than cigar binders, and in pounds produced are exceeded by the latter. The smallest acreage is devoted to cigar wrappers, but the price received for these types is considerably higher than that for other types of tobacco. Flue-cured, air-cured, and cigar binders are next in value per pound. There is not much variation in the average price of those three classes. There is more variation in the price of the different types within these classes than between the classes themselves. There is also considerable difference between the classes in yield per acre. The cigar binder classes have the highest average yield, with cigar fillers second, cigar wrappers third, air-cured fourth, fire-cured fifth, and flue-cured last. The average yield per acre of the cigar binder class is nearly double that of the flue-cured class.

Cigar Tobacco

Table 2 shows the relative importance of the cigar classes and types, and the regions where they are grown. Pennsylvania produces the largest amount of cigar fillers, with the Miami Valley in Ohio and Indiana second. A very small amount is produced in Florida and Georgia. There are two regions producing cigar binders, the

Appendix Table 2

Average Annual Acreage, Production, Yield per Acre, Price per Pound, and Farm Value of the Cigar Types, United States 1925-1928.

Types and Region	Type No.	Acreage	Yield per acre lbs.	Production 1000 lbs.	Price per lbs. cents	Farm Value $1000
Filler						
Pennsylvania						
Seedleaf	41	35,363	1,359	48,073	12	5,647
Miami Valley						
Gebhart						
Spanish						
Dutch	42-44	27,475	892	24,517	12	3,064
Georgia, Florida						
Sun Sumatra	45	1,500	1,128	1,691	20	338
Binders						
Connecticut Valley						
Broadleaf	51	13,193	1,363	17,986	21	3,819
Havana Seed	52	12,693	1,363	17,173	22	3,781
New York						
Havana Seed	53	1,200	1,146	1,375	19	260
Pennsylvania						
Havana Seed	53	887	1,265	1,123	20	221
Wisconsin						
Southern	54	19,325	1,250	24,160	14	3,481
Northern	55	12,925	1,217	15,726	17	2,747
Wrappers						
Connecticut Valley						
Shade	61	6,223	917	5,844	1.03	5,893
Georgia, Florida						
Shade	62	2,700	1,128	3,045	61	1,873
Connecticut Valley						
Primed Havana	65	393	1,489	584	29	171

Connecticut Valley, including a small area in the Housatonic Valley, and Wisconsin. Wisconsin has the larger acreage and production of binder tobacco but the yield per acre and the value per pound is less than in the Connecticut Valley. The Connecticut Valley is the largest producer of cigar wrappers, raising twice as much as Florida and Georgia, the only other regions that grow cigar wrappers in the United States. The New England wrapper is also the highest priced and yields the most per acre.

All of the tobacco grown in New England is cigar leaf. Four types are grown, Broadleaf and Havana, also called U. S. types numbers 51 and 52 respectively, of the cigar binder class, and shade and primed Havana, U. S. types 61 and 65, of the cigar wrapper class. The differences between the Havana and primed Havana types are due to methods of harvesting and curing. The table shows that primed Havana is not very important and that it brings much less per pound than the other wrapper types although more than the binder type of Havana.

Appendix Table 3

Acreage, Production, Yield per Acre, and Price of New England Tobacco

By Types

1925-1929

U. S. D. A. Yearbooks

Year	Acreage	Yield	Production (1,000 Pounds)	Price (Cents)	Acreage	Yield	Production (1,000 Pounds)	Price (Cents)
	Broadleaf				*Havana Seed*			
1925	18,070	1402	25,328	18.9	15,230	1318	20,067	16.1
1926	12,450	1403	17,462	25.0	10,390	1494	15,527	26.0
1927	11,450	1309	14,993	21.0	11,800	1324	15,622	23.4
1928	10,800	1311	14,162	21.0	13,350	1309	17,474	24.0
1929	8,300	1453	12,058	27.4	11,600	1509	17,505	31.4
	Shade				*Havana Primed*			
1925	4,580	1052	4,818	100.0	320	1550	496	21.0
1926	5,210	1004	5,231	97.7	350	1537	538	35.0
1927	7,100	900	6,390	105.0	450	1473	663	30.0
1928	8,000	867	6,936	100.0	450	1422	640	30.0
1929	8,700	1174	10,218	95.0	200	1575	315	35.0

Appendix Table 4

Acreage, Yield, Production, and Price of Tobacco Connecticut and Massachusetts

1862 - 1929

(U. S. Department of Agriculture Annual Reports and Yearbooks.)

Year	Connecticut Acres	Yield	Production	Price	Massachusetts Acres	Yield	Production	Price
1862	5,769	1300	7,500,166	14.0	3,533	1144	4,041,497	14.0
1863	6,000	1250	7,500,166	25.0	4,333	1200	5,200,000	26.5
1864	6,828	1450	9,900,218	25.0	4,097	1650	6,760,000	25.0

Appendix Table 4 *(Continued)*

Acreage, Yield, Production, and Price of Tobacco
Connecticut and Massachusetts

Year	Connecticut Acres	Connecticut Yield	Connecticut Production	Connecticut Price	Massachusetts Acres	Massachusetts Yield	Massachusetts Production	Massachusetts Price
1865	6,050	1350	8,167,681	30.0	4,788⅓	1200	5,746,000	22.5
1866	6,534	1200	7,840,974	19.5			5,171,400	20.0
1867	5,263	1266	6,664,000	23.0	3,290	1100	3,619,000	22.0
1868	4,871	1450	7,063,000	25.0	3,200	1300	4,161,000	23.0
1869	4,482	1450	6,500,000	27.0	4,333	1200	5,200,000	26.0
1870	5,996	1250	7,495,000	22.6	4,658	1350	6,289,000	24.0
1871	4,761	1700	8,094,000	25.0	4,770	1450	6,917,000	20.5
1872	5,052	1650	8,336,000	30.0	4,821	1750	8,438,000	29.5
1873	5,220	1647	8,600,000	23.0	5,620	1459	8,200,000	17.0
1874	7,224	1250	9,030,000	32.0	3,393	1450	4,920,000	28.0
1875	6,600	1500	9,900,000	22.0	6,296	1350	8,500,000	19.0
1876	6,203	1220	7,568,000	9.1	2,835	1640	4,650,000	9.4
1877				11.0				11.0
1878	5,800	1400	8,120,000	11.0	2,700	1600	4,320,000	11.0
1879	6,900	1400	9,660,000	12.0	2,900	1500	4,350,000	11.0
1880	10,070	1538	15,487,660	15.0	3,242	1520	4,927,840	15.0
1881	8,753	1572	13,763,759	16.0	3,291	1520	5,000,964	15.0
1882	8,665	1128	9,772,269	13.0	2,962	1435	4,250,819	12.5
1883	8,145	1176	9,576,824	13.5	2,814	1435	4,038,278	13.2
1884	8,064	1176	9,481,000	12.4	2,730	1361	3,715,000	12.2
1885	7,661	1575	12,066,000	12.4	2,594	1464	3,798,000	12.0
1886	7,292	1600	11,667,000	14.0	2,594	1631	4,231,000	14.0
1887	6,198	1480	9,173,000	14.3	2,464	1425	3,511,000	17.0
1888	6,136	1565	9,603,000	13.0	2,464	1580	3,893,000	13.0
1889	6,259			12.5				12.0
1890	6,394			16.0				15.0
1891	6,458			19.5				19.5
1892	7,104			21.0				26.0
1893	7,459	1429	10,658,911	14.0	2,640	1650	4,356,000	16.0
1894	6,713			16.0				10.0
1895	6,579	1509	9,928,000	16.5	1,975	1600	3,160,000	14.0
1896	6,579	1550	10,197,450	13.0	1,975	1620	3,199,500	12.0
1897	6,908							
1898								
1899				18.0				18.0
1900	10,948	1684	18,435,765	15.0	4,041	1823	7,367,363	15.0
1901	11,782	1586	18,682,319	15.0	4,284	1810	7,752,200	12.0
1902	12,725	1712	21,785,200	16.0	4,755	1560	7,417,800	15.0
1903	13,234	1600	21,174,000	15.5	4,993	1400	6,990,200	12.0
1904	12,705	1685	21,407,925	22.6	4,444	1690	7,510,360	18.6
1905	13,340	1725	23,011,500	17.0	4,488	1850	8,302,800	16.9
1906	14,140	1735	24,532,900	18.0	4,712	1750	8,246,000	18.5
1907	14,400	1510	21,744,000	11.5	4,700	1525	7,167,500	11.0
1908	13,824	1680	23,224,320	17.0	4,512	1650	7,444,800	15.5
1909	16,000	1752	28,110,000	16.5	5,500	1730	9,549,000	14.0
1910	16,000	1730	27,680,000	16.5	5,500	1730	9,515,000	15.0
1911	17,000	1625	27,625,000	20.5	5,600	1650	9,240,000	20.0
1912	17,500	1700	29,750,000	24.1	5,800	1700	9,860,000	23.9
1913	18,400	1550	28,520,000	21.0	6,100	1550	9,455,000	21.0
1914	20,200	1770	35,754,000	18.5	6,600	1750	11,550,000	17.7
1915	22,200	1350	29,970,000	17.0	8,800	1100	9,680,000	14.5
1916	22,200	1630	36,186,000	27.0	8,900	1660	14,774,000	25.0

Appendix Table 4 *(Continued)*

Acreage, Yield, Production, and Price of Tobacco
Connecticut and Massachusetts

Year	Connecticut Acres	Connecticut Yield	Connecticut Production	Connecticut Price	Massachusetts Acres	Massachusetts Yield	Massachusetts Production	Massachusetts Price
1917	24,000	1400	33,600,000	38.4	9,000	1400	12,600,000	38.4
1918	25,000	1500	37,500,000	44.0	10,000	1500	15,000,000	40.0
1919	30,000	1565	46,950,000	46.3	10,000	1540	15,400,000	46.3
1920	30,000	1480	44,400,000	35.0	10,000	1550	15,500,000	40.6
1921	31,000	1454	45,074,000	41.0	10,000	1370	13,700,000	36.0
1922	28,000	1045	29,260,000	40.3	9,000	1068	9,612,000	37.8
1923	29,000	1388	40,252,000	40.3	9,000	1410	12,690,000	34.9
1924	28,800	1370	39,456,000	29.3	9,000	1340	12,060,000	29.8
1925	29,600	1352	40,019,000	26.5	8,600	1243	10,690,000	21.8
1926	21,900	1340	29,346,000	35.6	6,500	1448	9,412,000	35.0
1927	23,700	1223	28,985,000	36.6	7,100	1223	8,683,000	35.7
1928	25,000	1190	29,750,000	37.2	7,600	1245	9,462,000	34.1
1929	20,800	1370	28,496,000	48.0	8,000	1450	11,600,000	42.6

Appendix Table 5

Acreage and Production of Cigar Leaf Tobacco
New England, Pennsylvania, and Wisconsin

1849 - 1929 U. S. Census

Year	New England Acreage	New England Production (Pounds)	Pennsylvania Acreage	Pennsylvania Production (Pounds)	Wisconsin Acreage	Wisconsin Production (Pounds)
1849		1,405,920		912,651		1,268
1859		9,266,448		3,181,586		87,340
1869		15,870,499		3,467,539		960,813
1879	12,199	19,717,398	27,556	36,943,272	8,810	10,608,423
1889	8,451	11,827,083	26,955	28,956,247	17,241	19,389,166
1899	14,212	23,810,524	27,760	41,502,620	33,830	45,500,480
1909	21,745	37,961,893	41,742	46,164,800	40,458	46,909,182
1919	36,225	56,732,177	42,799	55,965,851	41,465	52,454,246
1924	36,379	49,277,445	44,780	56,353,741	35,027	35,522,305
1929	27,326	37,973,289	40,040	50,584,276	36,602	43,289,644

Appendix Table 6

Prices of Leading Agricultural Products and Agricultural Labor
in Massachusetts by Ten Year Periods

1761-1860
(From 16th Annual Report of Massachusetts Statistics of Labor
p. 431 ff, converted into United States standard dollar.)

Years	Tobacco per lb.	Corn per bu.	Oats per bu.	Potatoes per bu.	Rye per bu.	Butter per lb.	Cheese per lb.	Beef per lb.	Agric. Labor per day
1761-1770	.060	.558	.333	.354	.663	.167	.087	.039	.330
1771-1780	.164	.703	.333	.300	1.000	.110	.133	.074	.315
1781-1790	.91	.725	.494	.279	.967	.114	.081	.044	.396
1791-1800	.150	.900	.451	.302	1.140	.185	.096	.047	.478

Appendix Table 6 (*Continued*)

Prices of Leading Agricultural Products and Agricultural Labor in Massachusetts by Ten Year Periods

Years	Tobacco per lb.	Corn per bu.	Oats per bu.	Potatoes per bu.	Rye per bu.	Butter per lb.	Cheese per lb.	Beef per lb.	Agric. Labor per day
1801-1810	.125	1.040	.554	.501	1.270	.213	.140	.084	.779
1811-1820	.304	1.310	.737	.485	1.440	.240	.123	.089	.782
1821-1830	.200	.817	.426	.369	.882	.186	.089	.076	.803
1831-1840	.181	.782	.544	.492	1.030	.220	.096	.081	.875
1841-1850	.226	.721	.545	.783	1.000	.196	.096	.090	.950
1851-1860	.285	.992		.860	1.500	.262	.117	.126	1.010

Appendix Table 7

Wholesale Price of Leaf Tobacco

Boston 1795-1844

(Hayward's Gazeteer p. 392 ff, Tobacco listed as fair. Price per cwt.)

Year	Price	Year	Price	Year	Price	Year	Price	Year	Price
1795	6.87	1805	8.00	1815	7.00	1825	10.00	1835	7.50
1796	7.00	1806	7.50	1816	20.00	1826	9.00	1836	8.00
1797	9.00	1807	8.50	1817	13.00	1827	9.00	1837	7.50
1798	12.00	1808	8.00	1818	12.00	1828	6.50	1838	8.00
1799	10.50	1809	7.00	1819	12.00	1829	4.50	1839	10.00
1800	5.00	1810	8.00	1820	7.00	1830	6.00	1840	
1801	6.50	1811	6.00	1821	6.00	1831	6.12	1841	11.00
1802	7.50	1812	6.00	1822	6.50	1832	5.50	1842	9.00
1803	7.25	1813	5.00	1823	10.00	1833	5.00	1843	8.00
1804	8.50	1814	6.50	1824	10.00	1834	7.00	1844	8.00
Average 10 yrs.	7.96	Average 10 yrs.	7.05	Average 10 yrs.	10.35	Average 10 yrs.	6.86	Average 10 yrs.	8.75

Average 50 years 8.19

Appendix Table 8

Index Number and Wholesale Prices of Connecticut Wrapper Tobacco

NEW YORK 1851 - 1891

(Aldrich Report, Senate Report No. 1394—52 Congress 2nd Session.)

Year	Index Number	Price January	April	July	October
1851	116.1	16-20	16-20	16-20	16-20
1852	64.5	16-20	5-10	3½-8	5-15
1853	64.5	5-15	5-15	5-15	5-15
1854	74.2	6-20	6-20	5-18	5-18
1855	69.4	5-18	5-18	5-18	6½-15
1856	95.2	6½-15	6½-15	6½-15	7-22½
1857	187.1	11½-35	11½-35	13-45	13-45
1858	141.9	10-35	9-35	9-35	9-35
1859	116.1	6-25	6-25	6-35	6-30
1860	100.0	10-35	6-25	6-25	6-25
1861	80.6	6-25	6-25	5-20	5-20

Appendix Table 8 (*Continued*)

Index Number and Wholesale Prices of Connecticut Wrapper Tobacco

Year	Index Number	Price January	April	July	October
1862	129.0	5-20	7-25	7-25	10-30
1863	209.7	10-30	20-45	20-45	20-45
1864	290.3	20-45	20-60	25-65	25-65
1865	177.4	25-65	20-40	16-30	15-40
1866	185.5	12½-45	12½-45	12½-45	12½-45
1867	209.7	30-40	25-55	45-65	20-45
1868	258.1	25-55		15-70	25-55
1869	258.1	35-75	49	35-45	35-45
1870	290.3	36-50	50-75	35-65	40-50
1871	193.5	35-40	35-40	41-45	25-35
1872	161.3	25-35	25-40	20-40	20-30
1873	216.1	20-30	40-55	40-55	22-45
1874	145.2	22-45	22-45	18-30	15-30
1875	112.2	15-30	15-30	15-30	15-20
1876	145.2	15-20	15-22	15-25	15-30
1877	138.7	15-30	14-25	20-30	18-25
1878	153.2	18-25	18-22	18-22	20-27½
1879			18-25	18-25	
1880	153.2	20-27½	20-27½	20-27½	20-27½
1881	193.5	25-35	25-35	25-35	25-35
1882	141.9	22½	22½	22½	22
1883	193.5	20-42½	20-42½	20-40	20-40
1884	193.5	20-40	20-35	20-35	25-35
1885	161.3	20-30	20-30	20-30	20-30
1886	161.3	20-30	20-30	20-30	20-30
1887	162.9	18-28	18-28	18-32½	18-32½
1888	162.9	18-32½	18-32½	18-32½	18-32½
1889	162.9	18-32½	18-32½	18-32½	18-32½
1890	162.9	18-32½	18-32½	18-32½	18-32½
1891		18-32½			

Appendix Table 9

Price of Connecticut Tobacco in Cents

1845 - 1859*

1910 - 1925**

Year	*Price*	*Year*	*Price*	*Year*	*Price*	*Year*	*Price*
1845	8.0	1853	8.0	1910	20.5	1918	40.5
1846	7.0	1854	8.0	1911	21.5	1919	38.5
1847	9.0	1855	10.5	1912	21.0	1920	41.0
1848	7.5	1856	21.0	1913	21.0	1921	21.5
1849	9.5	1857	13.0	1914	21.5	1922	28.0
1850		1858	16.0	1915	18.5	1923	29.0
1851		1859	11.0	1916	24.5	1924	16.5
1852				1917	30.5	1925	19.0

*For the years 1845-1859 the prices are averages from prices given in the pages of Anson Bates the property of A. C. Bates the Secretary of the Connecticut Historical Society.

**For the years 1910-1925 the prices are from an unpublished manuscript by A. E. Waugh "A Basis for the Computation of Index Numbers of Farm Products in Connecticut." They are prices obtained from a group of Broadleaf growers on actual sales.

Appendix Table 10

*Percent of Area in Important Soil Groups in the Towns of Hartford County**

Towns	*Stony Soils*	*Hinckley*	*Holyoke Stony*	*Wethersfield Cheshire*	*Manchester*	*Enfield*	*Suffield*	*Merrimac Sandy Loam*	*Merrimac Sand*
Avon	10.2	8.5	29.1	14.2	16.4			14.7	
Berlin			18.4	38.6	21.2		19.8		
Bloomfield			5.6	41.7		6.1	10.8	27.4	8.4
Bristol	21.9			26.5	15.6			1.7	
Burlington	48.3	4.8		1.3					
Canton	72.2	16.4		9.6					
East Granby			17.1	38.9	9.7	8.1	3.3	3.0	16.1
East Hartford				3.6	1.8	27.8	44.5		
East Windsor				6.0	13.7	16.3	31.9	27.9	
Enfield				18.8	1.5	12.7	17.5	36.3	7.5
Farmington		3.2	9.2	49.6				15.5	
Glastonbury	52.5	12.5		.9	15.5	5.7		4.3	
Granby	42.5	11.2	8.6	7.3	19.9		49.4	10.3	
Hartford				19.2		.8		2.9	
Hartland	82.2	6.9							
Manchester	14.7			11.5	65.4	8.4			
Marlborough	81.6	6.9							
New Britain			.6	57.3	38.0		4.1		
Newington			12.4	15.4	54.9	.6	16.7		
Plainsville			17.6	19.1				55.8	
Rocky Hill				46.8	31.3		2.4		
Simsbury			19.3	19.8	27.2			27.2	
Southington	8.1		10.1	30.7	19.5			5.1	
South Windsor				13.4	16.9	22.4	2.0	39.4	
Suffield			4.1	21.9	3.4	19.2	35.4	12.5	1.4
West Hartford			8.9	62.7	7.0	15.8	5.0		
Wethersfield			1.0	59.5	11.7		3.1		
Windsor				20.4			19.5	24.6	23.3
Windsor Locks							21.6	14.9	60.2

*This table is through the courtesy of Mr. M. F. Morgan, in charge of the Soils Division of the Connecticut Agricultural Experiment Station, New Haven.

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STORRS
Agricultural Experiment Station

The Drawing and Handling of Blood Samples for the Serological Diagnosis of Bang's Abortion Disease

Departments of Animal Diseases and Dairy Husbandry

CONNECTICUT AGRICULTURAL COLLEGE
STORRS, CONNECTICUT

THE DRAWING AND HANDLING OF BLOOD SAMPLES FOR THE SEROLOGICAL DIAGNOSIS OF ABORTION DISEASE

During the past two or three years dairymen of the state have shown considerable interest in the Connecticut Plan for the control of Bang's abortion disease, as is indicated by the increase in the number of samples submitted for examination. With the increase in the amount of blood testing, the control of the movement of reacting animals has become an important problem. Consequently, on July first, 1931, a cooperative plan was adopted by the Commissioner on Domestic Animals, in which the Storrs Agricultural Experiment Station actively participates. Under this plan, which is described in a recent pamphlet issued by the Commissioner's office, entitled "The Connecticut Plan for the Establishment and Maintenance of Cattle Herds free from Bang's Abortion Disease, as Determined by the Serological Tests", equipment for the collecting of blood samples may be secured by licensed veterinarians from the Storrs Station upon request. Official record sheets are supplied by the Commissioner's office. For the making of satisfactory tests it is necessary that the samples arrive at the laboratory properly identified and in a fresh condition. The following suggestions are offered to facilitate the bleeding and the handling of the blood tubes.

Drawing of Blood Samples

The animal is placed in a stanchion*, a small rope halter fitted over the head as a slip noose, and the rope drawn over the horizontal bar above the stanchion. In this manner the animal's head may be drawn either to the right or to the left. The jugular vein is distended by applying pressure with the thumb of the left hand. As soon as the vein is distended noticeably, a sterile veterinary needle held in such a position as to form an angle of about 30 degrees with the surface of the skin, with the needle pointing toward the head, is inserted and the sample of blood collected in a sterile test tube. With animals having a large neck, particularly bulls, it is sometimes necessary to place a rope around the neck close to the shoulders and to draw the loop tight

*For those who have had experience in collecting blood for the test the stanchion is not necessary.

in order to distend the vein. An illustration of the method described here is shown in the accompanying figure.

As the needles provided have been sterilized, they should not be removed from the package until they are to be used.

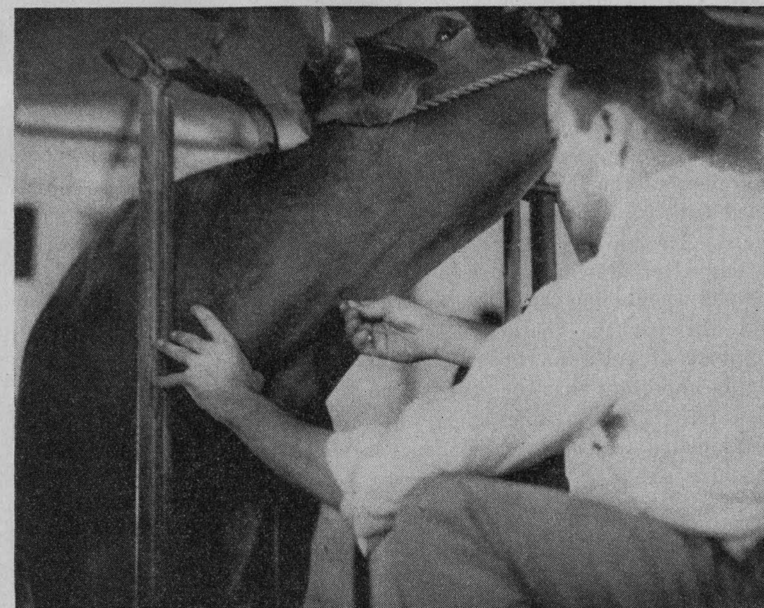

FIG. 1—SHOWING MANNER OF DRAWING BLOOD SAMPLE.

Labeling of Tubes

A number corresponding to the one placed on the identification sheet must be placed on the etched area of the tube. This should be done with an ordinary lead pencil.

Care of Samples

As soon as the blood is drawn the tubes should be tightly stoppered, labeled and placed in an almost horizontal position until the blood is thoroughly clotted. This requires about 30 minutes.

After the clot has formed the tubes containing the blood should be packed tightly together (upright) in the small sections of the shipping container. Cotton or paper should be placed in partially filled compartments.

Care of Needles

After drawing a sample the wire plunger should be placed in the used needle and the needle returned to the shipping container without washing. Unless the needles can be thoroughly cleansed and rinsed with alcohol it is best to return them without attempting to remove the clotted blood.

Shipment of Samples

During warm weather ice should be placed around the tall copper container of the shipping pail. In cold weather this space should be filled with paper or excelsior. Small lots of samples, where the use of our regular shipping container is not feasible, should be chilled immediately after drawing and left on ice until ready for mailing. Such samples should be carefully packed (each tube wrapped in paper) and the package marked "*perishable*" and "*fragile*". For small numbers of tubes an ordinary cigar box serves the purpose. It is highly important that the packages be sent to the laboratory by Special Mail Delivery or by messenger. In order to avoid delay or possible loss, all packages and correspondence intended for the laboratory should be addressed—

DEPARTMENT OF ANIMAL DISEASES

ATWATER LABORATORY, STORRS, CONNECTICUT.

Fees

At the present time it is necessary to make a charge of thirty-five cents for each sample tested, in order to finance the laboratory work involved in conducting the official test. This is to be paid directly to the Commissioner of Domestic Animals, Hartford.

Information on the Blood Test

Questions regarding the method of conducting the tests and the interpretation of results will be answered gladly.

Bulletin 175 December, 1931

STORRS
Agricultural Experiment Station

A Record of the Guernsey Herd at the Connecticut Agricultural College

GEORGE C. WHITE
AND
CHARLES OLIVER

CONNECTICUT AGRICULTURAL COLLEGE
STORRS, CONNECTICUT

A Record of the Guernsey Herd at the Connecticut Agricultural College

GEORGE C. WHITE AND CHARLES OLIVER*

Introduction

It is always of interest to breeders of cattle to observe the efforts and results of other breeders, with a view to applying in their own herds the practices that are most likely to bring success. It is not often that herd records covering a third of a century are available to the public, as it is human nature to forget or stress lightly the factors that have not brought satisfaction and to make public only those that are most pleasant to dwell upon. Moreover, in the few herds where appropriate records are available the task of presenting a complete analysis of them is seldom undertaken.

This paper aims to present much of the production data of the College Guernsey herd covering a period of thirty-five years**. It is made possible by systematic herd records that have steadily accumulated year after year, and is the result of a study of this breed recently made by the junior author. Frankly, the study has been the means of correcting certain misconceptions that we have held with reference to some of the animals, and it is hoped that this contribution may give definite stimulus to others to undertake a similar analysis of their own herds. Probably in no other manner may one properly evaluate the influence of individuals, a matter of great importance as one considers the future. Our present knowledge of genetics and Mendelian inheritance compels us to recognize the dominant role of the progeny test in animal breeding.

Brief Historical Account of the Herd

No effort has been made to assess the influence of the environmental factors during this period. It goes without saying that some changes have been made in management practices. Dairymen have effected considerable improvement in environmental conditions of stabling, feeding, and watering, but such advance has probably been less marked

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**The records on this and the other breeds have been of inestimable value in other ways also, particularly in abortion studies and studies on variations in fat and solid tests.

in College herds where practices were more ahead of the times twenty to thirty years ago than now.

Up to 1913 the herd was housed in a wooden barn built against a dirt bank on one end and on one side, and consequently it was not too well lighted and ventilated. This barn provided very limited quarters for box stalls. In 1913 a modern well lighted stable with a capacity of 48 stanchion stalls was added and four box stalls and young stock pens were placed in the old barn. In 1919 the old barn was burned, and while a large storage barn was promptly erected at the end of the stable built in 1913, the young stock quarters and box stalls were again very limited for five years. In 1924 a young stock and maternity stable was erected at the end of the storage barn opposite the 1913 stable.

Tuberculosis eradication was early undertaken but losses occurred from this disease with varying severity until 1910. Between 1910 and 1921, during which time there were untested cattle on the farm, an occasional animal reacted and once a purchased animal reacted. No reactor to this disease has appeared since 1921.

Bang's abortion disease took its toll in the herd for many years, as reported in other studies (1), until the reactors were removed in 1925. Since then the herd has had a continuous record free from this disease.

Animals have been sold from time to time for various reasons and at various ages. In general it has not been the practice to dispose of heifers until after they have come into milk. However, for one reason or another this history does not constitute a complete progeny record. The herd has never been large, as it shares the barns with herds of three other breeds, and moreover it seems that fate has been rather more severe at critical times with this Guernsey herd than with the others in respect to proportion of female calves, etc. Perhaps also we have unwittingly been rather severe in culling our Guernsey and Jersey milking females with respect to performance in milk yield compared with the Holsteins and Ayrshires in the herd, with insufficient emphasis given to the total food value of the product. Since 1927 the total herd, all breeds, has numbered about 115. For fifteen years before that the total herd averaged about 75 in number. The Guernsey herd approximates in size many milking and breeding herds in Connecticut. An inventory of the herd will be found in Table 1. Comparatively few purebred herds anywhere in this country have been in continuous existence as long as this one.

The original animals were purchased by Dr. C. L. Beach, at the time head of the department. Since Mr. Beach's resignation in 1906 the department has had two heads, Professor J. M. Trueman from 1906 to 1913, and the present incumbent since 1913.

Although the foundation of the present Guernsey herd was laid in 1896, Guernseys were not unknown in the college barns before that.

In 1885 Charles M. Beach* of Elmwood, Connecticut, one of the pioneer dairymen of the state, presented to the Storrs Agricultural School a purebred Guernsey bull registered as Marion 706. About the same time the school purchased a purebred Guernsey heifer, Ethel of Mystic 2289, from Roswell Brown of Mystic, Connecticut. Marion's granddam, Imp. Bridget 311, had been imported by Charles M. Beach in 1877. The paternal great granddam of Marion, Imp. Gypsy of Brockton 969, had been imported in 1874 for the Massachusetts Society for the Promotion of Agriculture. Neither Marion nor Ethel of Mystic were more than four generations removed from imported Guernseys.

In the report of Professor L. P. Chamberlain (2) for the year ending November 30, 1888, is found the following statement. "We have now thirteen cows, and hope to increase our herd during the coming year by adding a number of animals that have been reared upon the farm. Nearly all are grades, and partially represent many of the various breeds. But little attention has been given to breeding, though we are now beginning to make the Guernsey our specialty. Of this class we have five thorough-bred animals and six half bloods. Of these, two are males and nine are females."

This small herd had been built up from the two original animals, Marion and Ethel of Mystic, except that another bull, Elmwood 1496, also from Mr. Beach's herd, had replaced Marion. Table 1 indicates the passing of the purebreds from this original foundation in 1892.

The report of Professor C. S. Phelps (3) dated December 1, 1896, contains the following statement. "During the past fall committees from the Ayrshire, the Guernsey and the Jersey Breeders' Associations, acting with the Professor of Agriculture (Professor Phelps) arranged to place thorough-bred animals in the college herd. Each association has selected from prominent herds four or five representative animals. These will doubtless become the foundation for a valuable herd of dairy stock, besides being of service to illustrate the characteristics of the leading dairy breeds. The products of these animals will be utilized in the practical instruction in dairying."

The Guernseys referred to were Francille 8,178, purchased from William H. Caldwell of Peterborough, New Hampshire, Secretary of the American Guernsey Cattle Club; Fairview Maid 3,810, and Eurotas 2,537, purchased from E. C. Freeman of Cornwall, Pennsylvania; and the bull Fill Pail's Star 4,295, purchased from Francis Shaw of Wayland, Massachusetts. Both Freeman and Shaw were leading breeders of that time.

Fairview Maid and Eurotas were sired by Imp. Pacific, one of the most noted Guernsey bulls of his day. Pacific was also the sire of Purity, the highest producing Guernsey cow and fifth high cow of all

*C. M. Beach was one of the founders of the American Guernsey Cattle Club in 1877. The office of the club was located at the home of Edward Norton, the first secretary, at Farmington, Connecticut.

breeds in the thirty-day butter test at the World's Columbian Exposition at Chicago in 1893. Purity won second prize in the aged cow class at that show, and received many first prizes and championships throughout the East and South over a period of four years.

Imp. Fillpail 4th 565, the dam of Fill Pail Star, was born on the Island of Guernsey in 1878 and was imported in 1880, dropping a heifer calf just a month after her arrival.

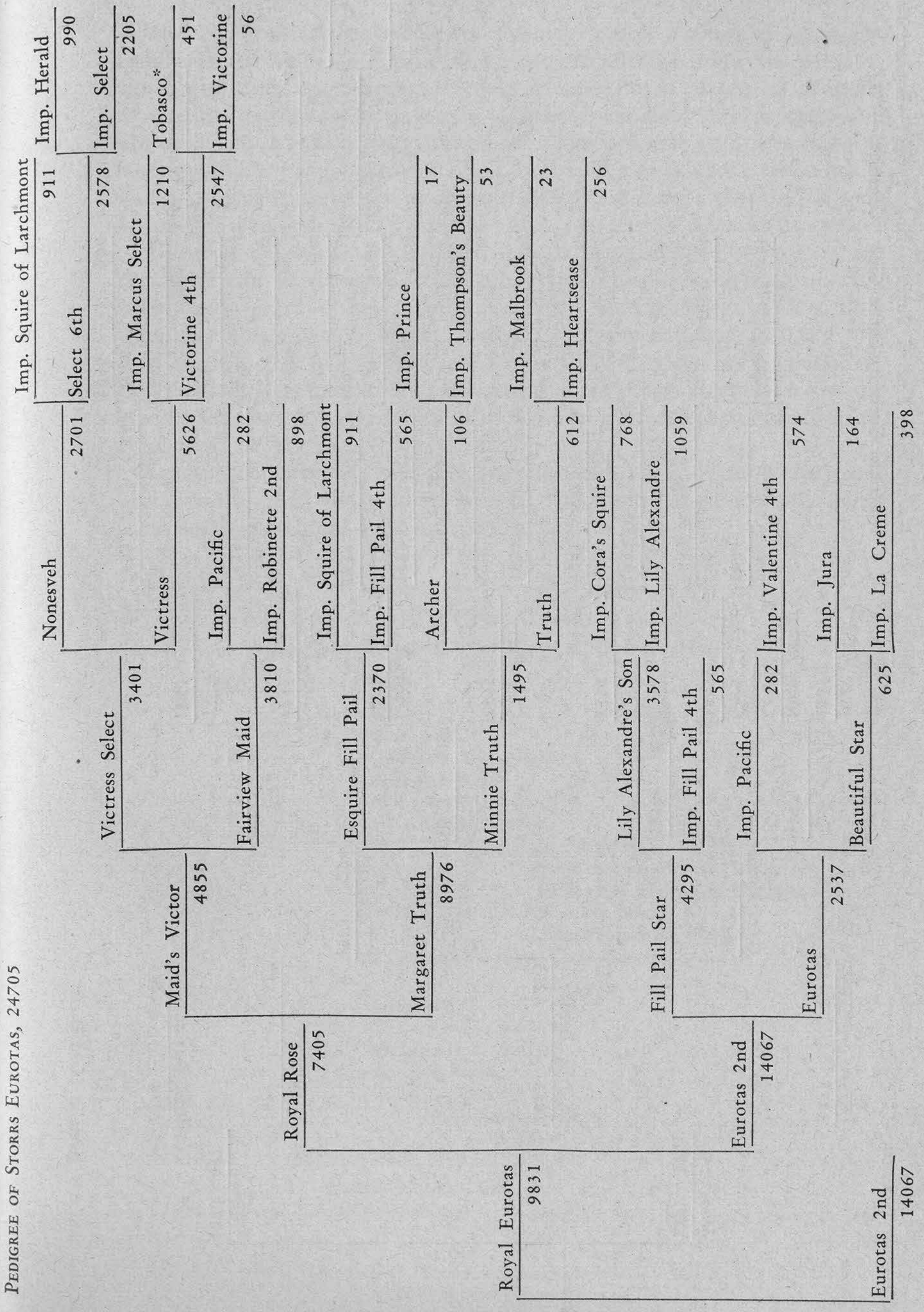
TABLE 1

Classification of the Herd by Years from Inventory Records

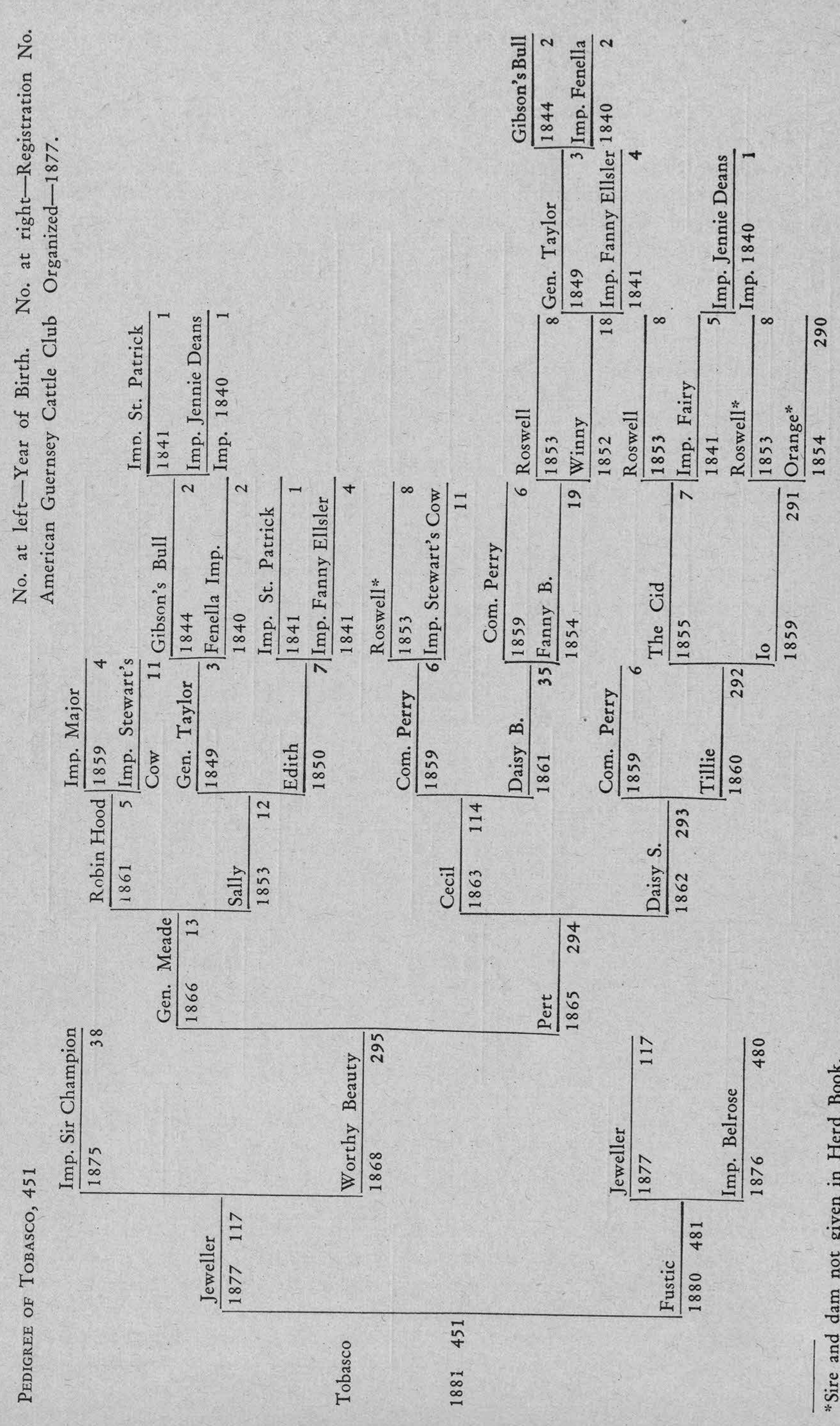
Year	Purebred Bulls	Purebred Cows	Purebred Heifers	Grades Cows	Grades Heifers	Year	Purebred Bulls	Purebred Cows	Purebred Heifers	Grades Cows	Grades Heifers
1885	1		1			1910	1	12	3		
1886	1	1	1			1911	1	9	2		
1887	1	1	4			1912	1	10	2		
1888	2	1	2		5	1913	1	7	1		
1889	1	3			15	1914	1	8	2		
1890	1	2			13	1915	5	8	4		
1891		2		6	6	1916	3	6	2		
1892					3	1917	2	6	1		
1893				6		1918	1	4	3		
1894				3		1919	3	5	6		
1895				4		1920	2	7	1		
1896	1	3		3	2	1921	1	6	3		
1897	1	3	2			1922	3	10	1		
1898	1	3	1			1923	1	10	2		
1899	1	6	1			1924	1	8	6		
1900	1	5	2			1925	1	15	2		
1901		7	2			1926	2	13	5		
1902 to 1907		Inventories not listed by breeds				1927	3	11	4		
						1928	1	10	8		
1908	1	9	2			1929	3	12	6		
1909	1	8	5			1930	1	13	8		
						1931	3	12	6		

Fill Pail Star was dropped in 1894 when his dam was in her seventeenth year. Lily Alexandre's Son, the sire of Fill Pail Star, was out of Imp. Lily Alexandre, a cow with a private record of 12,856 pounds of milk, a high record for that day. Fill Pail Star, with Imp. Fillpail 4th and Imp. Lily Alexandre as his two nearest dams, should have carried a great inheritance but the records of his daughters would indicate that he failed to measure up to what must have been expected of him. He was killed while yet a young bull as a reactor to the tuberculin test, a fate common to many animals in the early years of the herd.

PEDIGREE OF STORRS EUROTAS, 24705



*See continuation of pedigree on following page.



The pedigree charts of Storrs Eurotas which are typical for the family are of value in establishing the relationships involved, since in the earlier days of Guernsey breeding in the United States, on account of the small numbers of purebred Guernseys available, much close line breeding and inbreeding was practiced. The pedigree of Storrs Eurotas is easily made up in two parts since seven removes from the cow in question leads to imported animals in every case except that of Tobasco 451. The pedigree of Tobasco is most interesting because he traces to the first importations of Guernseys to be accepted for registry by the American Guernsey Cattle Club. Nicholas Biddle, who made this importation in 1840, kept accurate pedigree records of his herd, so that when the American Guernsey Cattle Club was founded in 1877 the animals in his herd were admitted to the Herd Register. This pedigree, together with that of animals descended from Storrs Eurotas or similar blood lines, reveals 23 generations of American bred Guernseys covering a period of 89 years.

Eurotas contributed two daughters to the herd, Eurotas 2nd and Lily Eurotas, full sisters sired by Fill Pail Star. These animals, with their descendants, are shown in Table 2.

Table 2

Pedigree Chart

Showing Descendants of Eurotas (Female Line)

EUROTAS
- Lily Eurotas
  - Lily Eurotas 2nd
    - Lily Eurotas 2nd's Rose
      - Eurotas Rose
      - Lily Rock
        - Lorin Masher
          - Lute Storrs Masher
            - Lighting Storrs Masher
              - Laureate Lightning Storrs
            - Lassie Lute Storrs
              - Buoyant Lassie Storrs
          - Carmine Lorin Storrs
- Eurotas 2nd
  - Eurotas Mansfield
    - Wolf Rock's Eurotas
      - Winifred of Storrs
    - Eurotas Mansfield 2nd
      - Emerald Joffre
        - Ellen Emerald Storrs
          - Julia Ellen Storrs
  - Storrs Eurotas
    - Storrs Eurotas 2nd
    - Simple Eurotas
      - Storrs Sunbeam
        - Salient Sunbeam Storrs
        - Sagacious Storrs Sunbeam
      - Genial Eurotas Storrs

An addition was made to the females of the herd in 1903 by the purchase from E. T. Gill of Haddonfield, New Jersey, veteran Guernsey breeder and famous for his Glenwood strain of Guernseys, of Naomi's Beauty 9,914, and Lady Naomi 9,913. These cows had been bred, however, by Alexander Warner of Baxter Springs, Kansas.

Royal Rose 7,405, a bull, was purchased from H. F. Dimock of South Coventry, Connecticut, in 1902. Mr. Dimock was the breeder of Miss Sharon, the granddam of Gerar Pearl, one of the great dams of the Guernsey breed for the number and quality of her sons and daughters. Royal Rose was by Maids Victor, a son of Fairview Maid and out of Margaret Truth, a daughter of Esquire Fill Pail, another son of Imp. Fill Pail 4th. It is interesting to note that Truth, the granddam of Margaret Truth, was by Imp. Malbrook, the maternal grandsire of Marion, the bull of the earlier, but extinct, herd. Wolf Rock 13,082, another bull of Mr. Dimock's breeding, was added to the herd in 1908 to follow Royal Eurotas, a son of Royal Rose and out of Eurotas 2nd, a daughter of Eurotas, one of the foundation cows. Simple Septimus, a son of Masher's Sequel was purchased in 1909 from Grassland's Farm, Taconic, Connecticut, to follow Wolf Rock. The bulls later used in the herd: Eva's Sequel, leased from Grassland's Farm; General Joffre of Greenway, purchased from Greenway Farm, South Manchester, Connecticut; Grassland's Comet, purchased from Grassland's Farm; Albamont Jupiter, leased from the University of New Hampshire; and Foremost's Excelsior, Foremost's Marshall, Princess' May Royal, Royal Supreme, and Caroline's May Royal, all leased from Emmadine Farms, Hopewell Junction, New York, have followed in succession. The present policy of the College of leasing outstanding bulls from large breeding establishments is illustrated by the last five service bulls mentioned.

Some of the bulls leased from Emmadine Farms have been used only a short period because in most instances they were returned for service or for the Emmadine Farm show herd. It is possible to report on the daughters of only one of the bulls, Foremost's Excelsior, and for him on only two daughters. This bull was in service for one year, but all except three of his progeny were males, and one heifer calf was lost. Six daughters of the next bull, Foremost's Marshall, were obtained from one year of service. One of these failed to conceive and one of the five aborted in the first gestation, so it is impossible to report on this bull at present. The daughters of Princess' May Royal, seven in number, are just now coming into milk. The next bull, Royal Supreme, became inactive shortly after reaching the College and this most promising bull was returned with great reluctance. Two heifers were born to this bull. The present sire, Caroline's May Royal, is of exceptionally fine type and is the Junior Champion of the 1929 National Dairy Show and Grand Champion of the 1931 Eastern States Exposition.

TABLE 3.
Vital Statistics and Production Data of the Guernsey Herd

Cow	Reg. No.	Dam	Sire	Year of Birth	Year of Death or Sale	No. of Lactations	Total Production while in herd: Milk	% Fat	Fat
1. Francille (P)	8,178	Minelle	M	1893	1899	2	9,207	5.00	460.7
2. Franconia	10,389	Francille	C	1897	1901	2	3,881	4.62	179.4
3. Fairview Maid (P)	3,810	Imp. Robinette 2nd	N	1888	1901	5	26,452	4.64	1227.4
4. Eurotas (P)	2,537	Beautiful Star	N	1885	1900	4	21,245	4.13	878.4
5. Lily Eurotas	10,388	Eurotas	C	1897	1901	2	5,692	4.81	273.7
6. Eurotas 2nd	14,067	Eurotas	C	1900	1909	5	44,893	4.50	2042.0
7. Lily Eurotas 2nd	14,131	Lily Eurotas	F	1900	1908	5	27,374	5.20	1425.0
8. Naomi's Beauty (P)	9,914	Peter's Naomi	O	1897	1910	6	36,984	4.23	1565.0
9. Lady Naomi (P)	9,913	Naomi H.	O	1897	1907	3	15,981	4.62	738.0
10. Lily Eurotas 2nd's Rose	18,211	Lily Eurotas 2nd	D	1903	1912	6	30,878	4.48	1385.2
11. Storrs Naomi	21,558	Lady Naomi	D	1905	1916	7	55,091	4.43	2444.1
12. Eurotas Mansfield	21,560	Eurotas 2nd	E	1906	1911	2	9,386	4.28	402.1
13. Eurotas Naomi	21,559	Naomi's Beauty	E	1906	1912	3	25,184	4.59	1157.6
14. Eurotas Rose	23,500	Lily Eurotas 2nd's Rose	E	1906	1911	2	8,312	4.68	389.5
15. Naomi's Beauty 2nd	23,501	Naomi's Beauty	E	1907	1912	1	9,756	4.61	450.1
16. Storrs Eurotas	24,705	Eurotas 2nd	E	1908	1914	2	8,842	4.67	412.9
17. Lily Rock	27,397	Lily Eurotas 2nd's Rose	G	1909	1915	4	28,655	4.66	1335.5
18. Wolf Rock's Eurotas	30,904	Eurotas Mansfield	G	1909	1916	4	25,299	4.48	1135.9
19. Eurotas Naomi 3rd	35,173	Eurotas Naomi	Q	1910	1916	2	11,402	4.91	559.7
20. Eurotas Mansfield 2nd	35,289	Eurotas Mansfield	G	1910	1920	6	46,601	4.06	1819.1
21. Storrs Naomi 2nd	35,290	Storrs Naomi	Q	1910	1915	3	15,931	4.25	678.0
22. Simple Eurotas	38,350	Storrs Eurotas	H	1911	1923	8	70,939	4.32	3064.6
23. Storrs Eurotas 2nd	44,708	Storrs Eurotas	H	1913	1917	2	11,805	4.62	545.7
24. Lorin Masher	61,496	Lily Rock	I	1914	1927	10	71,585	4.92	3523.1
25. Eva of Storrs	71,049	Storrs Naomi	I	1915	1920	2	12,641	4.75	600.1

TABLE 3. (Continued.)

Vital Statistics and Production Data of the Guernsey Herd

Cow	Reg. No.	Dam	Sire	Year of Birth	Year of Death or Sale	No. of Lactations	Total Production while in herd Milk	% Fat	Fat
26. Winifred of Storrs	61,497	Wolf Rock's Eurotas	I	1914	1918	1	6,009	4.55	273.9
27. Lute Storrs Masher	87,066	Lorin Masher	J	1916	1929	12	87,803	4.83	4242.4
28. Emerald Joffre	95,420	Eurotas Mansfield 2nd	J	1917	1921	2	7,091	4.20	298.4
29. Lola of Green Lodge (P)	78,025	Imp. Lizette III of the Bourg de Bas	R	1917	1926	2	10,263	5.72	587.0
30. Lighting Storrs Masher	95,422	Lute Storrs Masher	J	1918	1923	2	14,786	4.12	609.0
31. Storrs Sunbeam	95,421	Simple Eurotas	J	1918	1923	4	18,087	4.13	747.6
32. Ella of Green Lodge (P)	70,103	Eve of Green Lodge	S	1915	1928	4	18,954	4.64	880.2
33. Doris of Green Lodge (P)	92,834	Dorothy of Green Valley	R	1919	1925	2	4,610	4.98	229.8
34. Moorland Margaret (P)	136,275	Omega Margaret	T	1920	1926	4	18,309	4.64	849.6
35. Ellen Emerald Storrs	118,516	Emerald Joffre	K	1921	1925	2	6,365	4.76	303.1
36. Ernestine of Green Lodge (P)	119,016	Evelyn of Green Lodge 2nd	U	1921	1928	3	14,757	4.80	708.4
37. Salient Sunbeam Storrs	123,078	Storrs Sunbeam	K	1921	1928	4	30,721	4.60	1415.4
38. Genial Eurotas Storrs	145,552	Simple Eurotas	K	1922	1929	4	41,922	4.54	1902.2
39. Lassie Lute Storrs	134,118	Lute Storrs Masher	K	1922	1925	1	8,092	5.27	428.3
40. Doris of Green Lodge 3rd (P)	147,155	Doris of Green Lodge	U	1923	1927	2	9,366	4.27	400.8
41. Laureate Lightning Storrs	148,284	Lighting Storrs Masher	K	1923	1930	6	37,860	4.53	1713.2
42. Sagacious Storrs Sunbeam	156,775	Storrs Sunbeam	K	1923	*	6	50,697	4.54	2304.1
43. Buoyant Lassie Storrs	171,217	Lassie Lute Storrs	L	1924	*	5	37,548	5.55	2084.6
44. Amiable Lola Storrs	180,143	Lola of Green Lodge	U	1924	1930	5	28,046	4.80	1347.4
45. Julia Ellen Storrs	197,711	Ellen Emerald Storrs	L	1925	1931	3	24,102	5.03	1213.3
46. Carmine Lorin Storrs	208,607	Lorin Masher	L	1926	1929	2	13,215	4.90	648.0
47. Orchid Ella Storrs	211,838	Ella of Green Lodge	L	1926	1930	2	10,703	5.68	608.1
48. Melodant Margaret Storrs	220,172	Radiant Margaret Storrs	V	1926	*	2	10,396	5.27	548.5
49. Sprightly Lola Storrs	225,056	Lola of Green Lodge	V	1926	*	2	14,369	5.42	778.9

*Still in Herd.
(P) Purchased.

More recent purchases of females were made as follows: Imp. Green Meadow Peeress, of Mr. G. A. Cluett, Williamstown, Mass. and Moorland Margaret of Mr. E. A. Moore of Moorland Farms, Kensington, Conn., in 1922; Ella of Green Lodge, Lola of Green Lodge, Doris of Green Lodge, Doris of Green Lodge 3rd and Ernestine of Green Lodge, from Mr. E. D. Codman of Dedham, Massachusetts, in 1924.

It is interesting to observe that of the cows originally purchased the descendants of but one, Eurotas, are found in the herd today. Thirteen of the nineteen females in the present Guernsey herd (1931) are direct descendants of Eurotas, and it seems probable that this proportion will increase unless new females should again be introduced, as the more recent purchases have not yet made impressive contributions. Fairview Maid, the half sister of Eurotas, produced five bulls; but as none of these were retained for use in the herd she left no descendants.

The blood of Eurotas entered the Naomi family by the mating of Royal Eurotas, a son of Eurotas 2nd, to Lady Naomi and Naomi's Beauty, but the offspring from these matings extended in the herd through only two generations.

Presentation of Production Data

Table 3 gives a list of the lactating females of the herd since its foundation in 1896, with dam, sire, date of birth, date of death or sale, number of lactations while in the herd, total milk and butter fat production while in the herd, and average percentage of butter fat based on total production of milk and butter fat while in the herd. The butter fat percentage, derived as indicated in the preceding statement, and found in this table, is used throughout, in the belief that the average of the total production will be more exact than the percentage for any one year. No cow has been considered that has not milked 200 days or more. A key to the code letter for bulls is to be found in Table 4.

TABLE 4

Key to Bulls Represented by Daughters

Key	Name	Reg. No.	Key	Name	Reg. No.
C	Fill Pail Star	4,295	M	Preservers Fancy	3,028
D	Royal Rose	7,405	N	Imp. Pacific	282
E	Royal Eurotas	9,831	O	Lord Baxter	4,278
F	Maid's Victor	4,855	Q	Young Truth	11,631
G	Wolf Rock	13,082	R	Noble Merger	31,341
H	Simple Septimus	15,224	S	Jokastus	17,320
I	Eva's Sequel	21,588	T	Langwater Soldier	43,379
J	General Joffre of Greenway	31,313	U	St. Ita's Planet	54,954
K	Grassland's Comet	55,931	V	Foremost's Excelsior	113,350
L	Albamont Jupiter	79,919			

Table 5

Advanced Registry Records of the Guernsey Herd

No.	Name	Lbs. Milk	Lbs. Fat	Days	Year of Birth	Age	Sire	Generation removed from Eurotas through daughter indicated
6	Eurotas 2nd	8640	392.7	365	1901	Sr. 4	C	1st generation
11	Storrs Naomi	10557	475.2	"	1905	8	D	
	" "	10145	413.9	"	"	10		
13	Eurotas Naomi	9388	451.9	"	1906	Sr. 4	E	3rd, through son of Eurotas 2nd
17	Lily Rock	7694	356.6	"	1909	" "	G	4th, " Lily Eurotas
20	Eurotas Mansfield 2nd	6911	294.8	"	1910	Sr. 2	"	3rd, " Eurotas 2nd
	" " "	9225	359.5	"	"	Sr. 4		
22	Simple Eurotas	7499	327.1	"	1911	Jr. 2	H	3rd, " " "
	" "	10850	470.9	"	"	5		
	" "	12756	539.6	"	"	6		
24	Lorin Masher	10632	529.3	"	1914	Sr. 3	I	5th, " Lily Eurotas
	" "	11475	534.9	"	"	5		
	" "	11357	558.7	"	"	6		
25	Eva of Storrs	9781	476.4	"	1915	Sr. 3	I	
27	Lute Storrs Masher	7067	356.6	"	1916	Jr. 2	J	6th, " " "
	" " "	8030	433.3	358	"	Jr. 3		
	" " "	10328	492.7	365	"	5		
	" " "	10982	529.0	"	"	7		
	" " "	11318	557.4	"	"	9		
	" " "	10681	509.0	"	"	10		
	" " "	8913	417.4	"	"	11		
	" " "	8740	424.7	360	"	12		
29	Lola of Green Lodge	9339	530.5	365	1917	7	R	
31	Storrs Sunbeam	8655	370.8	"	1918	Jr. 3	J	4th, " Eurotas 2nd
30	Lighting Storrs Masher	10094	416.5	"	"	" "	"	7th, " Lily Eurotas
36	Ernestine of Green Lodge	7913	395.7	"	1921	" "	U	
37	Salient Sunbeam Storrs	12835	560.4	"	"	Jr. 2	K	5th, " Eurotas 2nd

Table 5 (Continued)

No.	Name	Lbs. Milk	Lbs. Fat	Days	Year of Birth	Age	Sire	Generation removed from Eurotas through daughter indicated
39	Lassie Lute Storrs	8093	448.0	365	1922	Jr. 2	U	7th, through Lily Eurotas
38	Genial Eurotas Storrs	11116	503.5	"	"	Sr. 2	U	4th, " Eurotas 2nd
	" " "	12587	565.5	"	"	Jr. 4		
	" " "	10451	470.1	263	"	5		
41	Laureate Lightning Storrs	8144	359.5	318	1923	Sr. 2	U	8th, " Lily Eurotas
	" " "	8678	400.0	290	"	Sr. 4		
42	Sagacious Storrs Sunbeam	10058	457.2	365	"	Jr. 2	U	5th, " Eurotas 2nd
	" " "	12086	565.9	"	"	Jr. 4		
	" " "	14098	640.4	"	"	6		
43	Buoyant Lassie Storrs	10568	596.8	"	1924	Sr. 2	L	8th, " Lily Eurotas
	" " "	12226	657.1	"	"	5		
45	Julia Ellen Storrs	9127	457.3	"	1925	Jr. 2	"	6th, " Eurotas 2nd
46	Carmine Lorin Storrs	6983	361.1	"	1926	" "	"	6th, " Lily Eurotas

Note: It will be noted that the second name of the cow is the first name of the dam for cows named in recent years.

Table 5 presents in addition the list of Advanced Registry records completed and accepted by the American Guernsey Cattle Club to July 1, 1931, for cows that have been admitted. The numbers at the left correspond to the serial numbers in Table 3.

Twenty-one of the 49 cows have been admitted to the Advanced Registry. Of this number all except three are direct descendants of Eurotas.

A record of 500 pounds of fat first appeared in the third generation; and a 600 pound fat record has been obtained from two cows, one in the fifth and the other in the eighth generation removed from Eurotas. The Advanced Registry records, it should be pointed out, are not corrected for age but are presented here just as they are recorded.

Daughter-dam Comparisons

The first lactation of a cow in the herd not affected by abortion or other accident is used to compute the records in Table 6. The conversion factors are the same as those used by White et al. (4). These corrective factors are for age as follows: under 2 years = 1.48; 2 to 2½ years = 1.4; 2½ to 3 years = 1.3; 3 to 3½ years = 1.2; 3½ to 4 years = 1.15; 4 to 4½ years = 1.1; 4½ to 5 years = 1.07; 5 to 5½ years = 1.05; 5½ to 6 years = 1.03; 6 to 6½ years = 1.02; 6½ to 7 years = 1.01; 7 to 10 years = 1.00; and 10 to 13 years = 1.05. The factor used to convert Advanced Registry tests to regular herd yield was .70. This factor was applied, however, only when the cows were milked more than twice daily. The three columns under "Cow's Record" of Table 6 show the milk and butter fat records of each cow corrected to standard conditions as explained above. The next three columns under "Dam's Record" show data similarly computed for the dam of each cow in the same horizontal line. The three columns under "Difference" show the difference between the production of daughters and dams. When the daughter's record is greater than the dam's record, it is indicated by a plus sign; when the daughter's record is less it is indicated by a minus sign.

Thus after thirty-one years of breeding (females born in the last four years not being listed) no claim can be made to great accomplishment. To be sure improvement has been made. The appearance of the animals is more pleasing. The heavy, winged shoulders, the weak loin, the drooping eyes and ears and the rough shaggy coat so common twenty years ago have disappeared. Also there is evidence of improved yield, and the appearance of low grade producers is less frequent than formerly in spite of the fact that the daughter-dam comparisons in Table 6 reveal 20 decreases against 21 increases in milk yield, the same number in fat yield, and 25 increases against 16 decreases in percentage of fat in the individual cases.

TABLE 6

Comparison of the Records of Guernsey Cows with the Records of Their Dams

	Cow's Record*			Dam's Record*			Difference		
	Milk	% Fat	Fat	Milk	% Fat	Fat	Milk	% Fat	Fat
1. Francille	6102	5.00	302.4						
2. Franconia	3750	4.62	181.0	6102	5.00	302.4	−2352	− .38	−121.4
3. Fairview Maid	6455	4.64	309.0						
4. Eurotas	6455	4.13	289.0						
5. Lily Eurotas	3675	4.81	182.0	6455	4.13	289.0	−2780	+ .68	−107.0
6. Eurotas 2nd	6705	4.50	295.0	6455	4.13	289.0	+ 250	+ .37	+ 6.0
7. Lily Eurotas 2nd	6511	5.20	293.0	3675	4.81	182.0	+2836	+ .39	+110.0
8. Naomi's Beauty	5565	4.23	239.0						
9. Lady Naomi	5090	4.62	234.0						
10. Lily Eurotas 2nd's Rose	6110	4.48	296.0	6511	5.20	293.0	− 401	− .72	+ 3.0
11. Storrs Naomi	7863	4.43	346.8	5090	4.62	234.0	+2773	− .19	+112.8
12. Eurotas Mansfield	6587	4.24	280.6	6705	4.50	295.0	− 118	− .26	− 14.4
13. Eurotas Naomi	6216	4.59	281.4	5565	4.23	239.0	+ 651	+ .36	+ 42.4
14. Eurotas Rose	5097	4.68	243.8	6110	4.48	296.0	−1013	+ .20	− 52.2
15. Naomi's Beauty 2nd	7540	4.61	347.2	5565	4.23	239.0	+1975	+ .38	+108.2
16. Storrs Eurotas	5887	4.67	268.3	6705	4.50	295.0	− 818	+ .17	− 26.7
17. Lily Rock	8331	4.66	372.0	6110	4.48	296.0	+2221	+ .18	+ 76.0
18. Wolf Rock's Eurotas	8638	4.48	390.2	6587	4.24	280.6	+2051	+ .24	+109.6
19. Eurotas Naomi 3rd	6448	4.91	320.1	6216	4.59	281.4	+ 232	+ .32	+ 38.7
20. Eurotas Mansfield 2nd	6488	4.06	265.3	6587	4.24	280.6	− 99	− .18	− 15.3
21. Storrs Naomi 2nd	5569	4.25	232.0	7863	4.43	346.8	−2294	− .18	−114.8
22. Simple Eurotas	7300	4.32	328.9	5887	4.67	268.3	+1413	− .35	+ 60.6
23. Storrs Eurotas 2nd	7561	4.62	349.3	5887	4.67	268.3	+1674	− .05	+ 81.0
24. Lorin Masher	7376	4.92	369.5	8331	4.66	372.0	− 955	+ .26	− 2.5
25. Eva of Storrs	7141	4.75	335.4	7863	4.43	346.8	− 722	+ .32	− 11.4

TABLE 6 (Continued)

	Cow's Record*			Dam's Record*			Difference		
	Milk	% Fat	Fat	Milk	% Fat	Fat	Milk	% Fat	Fat
26. Winifred of Storrs	7812	4.55	356.1	8638	4.48	390.2	— 826	+ .07	— 34.1
27. Lute Storrs Masher	9894	4.83	499.2	7376	4.92	369.5	+2518	— .09	+129.7
28. Emerald Joffre	6118	4.20	257.6	6488	4.06	265.3	— 370	+ .14	— 7.7
29. Lola of Green Lodge	6537	5.72	361.4	8170	4.71	393.1	—1633	+1.01	— 31.7
30. Lightning Storrs Masher	8479	4.12	349.9	9894	4.86	499.2	—1415	— .74	—149.3
31. Storrs Sunbeam	6492	4.13	296.2	7300	4.32	328.9	— 808	— .19	— 32.7
32. Ella of Green Lodge	7120	4.64	339.1	7032	4.87	342.5	+ 88	— .23	— 3.4
33. Doris of Green Lodge	4610	4.98	229.8						
34. Moorland Margaret	5578	4.64	267.4	9958	4.20	418.4	—4380	+ .44	—151.0
35. Ellen Emerald Storrs	6882	4.76	329.5	6118	4.20	257.6	+ 764	+ .56	+ 71.9
36. Ernestine of Green Lodge	6647	4.80	332.4						
37. Salient Sunbeam Storrs	10977	4.60	515.9	6492	4.13	296.2	+4485	+ .47	+219.7
38. Genial Eurotas Storrs	10116	4.54	458.2	7300	4.32	328.9	+2816	+ .22	+129.3
39. Lassie Lute Storrs	7931	5.27	439.0	9894	4.86	499.2	—1963	+ .41	— 60.2
40. Doris of Green Lodge	9324	4.27	405.7	4610	4.98	229.8	+4714	— .71	+175.9
41. Laureate Lightning Storrs	7411	4.53	327.2	8479	4.12	349.9	—1068	+ .41	— 22.7
42. Sagacious Storrs Sunbeam	9857	4.54	448.1	6492	4.13	296.2	+3365	+ .41	+151.9
43. Buoyant Lassie Storrs	9633	5.55	543.1	7931	5.27	439.0	+1702	+ .28	+104.1
44. Amiable Lola Storrs	5552	4.80	257.3	6537	5.72	361.4	— 985	— .92	—104.1
45. Julia Ellen Storrs	8945	5.03	448.2	6882	4.76	329.5	+2063	+ .27	+118.7
46. Carmine Lorin Storrs	6843	4.90	353.9	7376	4.92	369.5	— 533	— .02	— 15.6
47. Orchid Ella Storrs	7448	5.68	432.7	7120	4.68	339.1	+ 328	+1.00	+ 93.6
48. Melodant Margaret Storrs	5925	5.27	315.7						
49. Sprightly Lola Storrs	9412	5.42	497.5	6537	5.72	361.4	+2875	— .30	+136.1

*See explanation preceding this table for method used to convert records to mature equivalent. Fat percentage is based upon "Total Production" in Table 3 and not upon single record given in this table.

The accomplishments, or rather lack of rapid accomplishments over this long period, we fear are characteristic in the majority of herds. It is of extreme economic importance that breeders find some means for more rapid and definite improvement of herds, if such are to be had. In the first place it is possible today to start higher in the scale for certain desirable characteristics than the original foundation animals possessed thirty-five years ago. A few attempts have been made to bring about improvement by the introduction of females, but of the two introduced in 1903 no trace remains; and of seven females introduced since 1921 it is not at present evident that any one will leave a permanent imprint upon the herd.

It is realized that this fact in a measure constitutes an indictment against judgment in purchases, but it may be pointed out that the ordinary breeder has faced the same difficulties on account of the very high prices commanded by Guernsey breeders. This experience, common to those seeking a foundation in Guernseys, also presents an indictment against breeders who have been so reluctant to offer for this purpose animals that could lay claim to merit and who have been content to sell female discards at prices considerably above their value.

The ray of light is found in the fact that the herd has been developed from one original foundation cow introduced in 1897, through the introduction of sires. The sire therefore constitutes the second factor for improvement, and in the following pages we shall recount the contributions of these animals.

Analysis of the Influence of Bulls

Table 7 is compiled from Table 6 and is an arrangement of the daughters of the different herd sires according to sires. The plus figures in the column "Difference" of Table 6 are arranged in the column "Under Dam." The last column "Average Difference," is the average net difference of all the daughters of a sire and represents the average increase or decrease of all the daughters of a bull in the production of milk and butter fat and percentage of butter fat when compared with the records of their dams.

A study of Table 7 reveals the fact that Fill Pail Star with three daughters in the herd lowered the milk production an average of 1627 pounds under their dams, lowered the butter fat production an average of 74.1 pounds, but increased the butter fat percentage an average of 0.22. He got two daughters out of Eurotas, the foundation cow, one of which, Eurotas 2nd, showed a slight increase over her dam's production in milk, butter fat, and butter fat percentage. The other daughter, Lily Eurotas, full sister to Eurotas 2nd, gave 2780 pounds less milk and 107 pounds less butter fat than her dam but had a butter fat percentage 0.38 higher.

TABLE 7

Summary of Daughter-Dam Comparison Arranged According to Sires

	Over Dam			Under Dam			Average Difference of Sires' Daughters from Dams		
	Milk	%	Fat	Milk	%	Fat	Milk	%	Fat
Fill Pail Star									
1. Eurotas 2nd	250	.37	6.0						
2. Lily Eurotas		.67		2780		107.0			
3. Franconia				2352	.38	121.4			
	250	1.04	6.0	5132	.38	228.4	—1627	+ .22	—74.1
Royal Rose									
1. Storrs Naomi	2773		112.8		.19				
2. Lily Eurotas 2nd Rose			3.0	401	.72				
	2773		115.8	401	.91		+1186	— .45	+57.9
Royal Eurotas									
1. Eurotas Mansfield				118	.26	14.4			
2. Eurotas Naomi	651	.36	42.4						
3. Eurotas Rose		.20		1013		52.2			
4. Naomi's Beauty	1975	.38	108.2						
5. Storrs Eurotas		.17		818		26.7			
	2626	1.11	150.6	1949	.26	93.3	+ 135	+ .17	+11.5
Wolf Rock									
1. Lily Rock	2221	.18	76.0						
2. Wolf Rock's Eurotas	2054	.24	109.6						
3. Eurotas Mansfield 2nd				99	.18	15.3			
	4275	.42	185.6	99	.18	15.3	+1392	+ .08	+56.8
Simple Septimus									
1. Simple Eurotas	1413		60.6		.35				
2. Storrs Eurotas 2nd	1674		81.0		.05				
	3087		141.6		.40		+1544	— .20	+70.8

TABLE 7 (Continued)

	Over Dam			Under Dam			Average Difference of Sires' Daughters from Dams		
	Milk	%	Fat	Milk	%	Fat	Milk	%	Fat
Eva's Sequel									
1. Lorin Masher		.26		955		2.5			
2. Eva of Storrs		.32		722		11.4			
3. Winifred of Storrs		.07		826		34.1			
		.65		2503		48.0	— 834	+ .22	—16
General Joffre of Greenway									
1. Lute Storrs Masher	2518		129.7		.06				
2. Emerald Joffre		.14		370		7.7			
3. Lighting Storrs Masher				1415	.74	149.3			
4. Storrs Sunbeam				808	.19	32.7			
	2518	.14	129.7	2593	.99	189.7	— 19	— .21	—15.0
Grassland's Comet									
1. Ellen Emerald Storrs	764	.56	71.9						
2. Salient Sunbeam Storrs	4485	.47	219.7						
3. Genial Eurotas Storrs	2816	.24	129.3						
4. Lassie Lute Storrs		.41		1963		60.2			
5. Laureate Lightning Storrs		.37		1068		22.7			
6. Sagacious Storrs Sunbeam	3365	.36	151.9						
	11430	2.41	572.8	3031		82.9	+1400	+ .40	+81.7
Albamont Jupiter									
1. Buoyant Lassie Storrs	1702	.46	104.1						
2. Julia Ellen Storrs	2063	.22	118.7						
3. Carmine Lorin Storrs				533	.06	15.6			
4. Orchid Ella Storrs	328	1.13	93.6						
	4093	1.81	316.4	533	.06	15.6	+ 890	+ .45	+75.2
Foremost's Excelsior									
1. Melodant Margaret Storrs									
2. Sprightly Lola Storrs	2875		136.1		.30				

Royal Rose and his son Royal Eurotas, out of Eurotas 2nd, seem to have some characteristics in common. When bred to the Naomi family they increased the milk production but when bred to the Eurotas family they lowered it. Royal Eurotas raised the butter fat percentage on all but one daughter.

Wolf Rock raised the milk production, butter fat production and butter fat percentage very materially on Lily Rock and Wolf Rock's Eurotas over that of their dams, but lowered all three slightly in the case of Eurotas Mansfield 2nd, a full sister to Wolf Rock's Eurotas.

It is to be regretted that Simple Septimus got but two daughters to have records, as he increased the production of his two daughters by an average of 1544 pounds of milk and 70.8 pounds of butter fat. He lowered the butter fat test an average of 0.20%. Since he had but these two daughters, Simple Eurotas and Storrs Eurotas 2nd, both out of the same cow, Storrs Eurotas, a true measure of his ability is not shown.

Following the first bull, Fill Pail Star, the next bull, Royal Rose, contributed a marked increase. Then came Royal Eurotas to lower the production slightly, followed by another sharp increase through Wolf Rock, with Eva's Sequel and General Joffre of Greenway to offset partially the advance of their immediate predecessors.

Eva's Sequel with three daughters lowered the milk production of each of them an average of 834 pounds, lowered the butter fat production of each an average of 16 pounds, but increased the butter fat percentage of the three by an average of 0.22.

The influence of Gen. Joffre of Greenway on his daughters is interesting but is difficult to measure. He increased the milk production of Lute Storrs Masher 2518 pounds and the butter fat production 129.7 pounds over that of her dam, but lowered the butter fat percentage 0.06. Lighting Storrs Masher, the result of breeding Gen. Joffre of Greenway back to his own daughter, Lute Storrs Masher, produced 1415 pounds of milk and 149.3 pounds of butter fat less than her dam, while her butter fat percentage was 0.74 less than that of her dam. The effect from the use of General Joffre of Greenway was to increase the production of one daughter over the dam and to decrease the production in three other cases. The net result upon the four daughters seemingly was to effect a slight decrease in milk and test, although the values in the table perhaps do not measure fully the true adverse effects contributed by this bull, since the gain attributed to his daughter Lute Storrs Masher may be over-rated, as one may judge by comparing her Advanced Registry records with those of her dam, Lorin Masher, in Table 5.

Grassland's Comet increased the butter fat percentage of all his daughters an average of 0.40, the smallest increase being 0.24%. This bull increased the milk production of his daughters an average of 1400 pounds and the butter fat production an average of 81.7 pounds. He lowered the milk and butter fat production on Lassie Lute Storrs

TABLE 8

A Table Showing the Effect of Sires on the Herd Production

	Number of Daughters	Average of Production of Daughters of Herd Sires			Average Differences Between Daughters' Records and Records of Dams		
		Milk	% Fat	Fat	Milk	% Fat	Fat
Fill Pail Star	3	4710	4.64	219.3	—1627	+.22	—74.1
Royal Rose	2	6987	4.46	321.4	+1186	—.45	+57.9
Royal Eurotas	5	6265	4.56	284.5	+ 135	+.17	+11.5
Wolf Rock	3	7819	4.40	342.5	+1392	+.08	+56.8
Simple Septimus	2	7431	4.47	339.1	+1544	—.20	+70.8
Eva's Sequel	3	7443	4.74	353.7	— 834	+.22	—16
General Joffre of Greenway	4	7746	4.33	350.7	— 19	—.21	—15.0
Grassland's Comet	6	8862	4.70	419.7	+1400	+.40	+81.7
Albamont Jupiter	4	8217	5.35	444.5	+ 890	+.45	+75.2
Foremost's Excelsior*	2	7668	5.16	406.6	+1131	—.56	+45.2

*Only two daughters and record of one dam available.

and Laureate Lightning Storrs, the former a daughter of Lute Storrs Masher and the latter a daughter of Lighting Storrs Masher and granddaughter of Lute Storrs Masher. Ellen Emerald Storrs, a daughter of Grassland's Comet and out of Emerald Joffre, shows an increase of 764 pounds in milk production over that of her dam; and the increase in her butter fat percentage, 0.56, and butter fat production, 71.9 pounds, are particularly significant. Grassland's Comet got two daughters from Storrs Sunbeam, also a daughter of Gen. Joffre of Greenway. One of these, Salient Sunbeam Storrs, increased the milk production over her dam by 4485 pounds, the butter fat production by 219.7 pounds and the butter fat percentage by 0.47. The other, Sagacious Storrs Sunbeam, increased the milk production over her dam by 3365 pounds, the butter fat production by 151.9 pounds and the butter fat percentage by 0.36.

Albamont Jupiter has three daughters from the Eurotas family and one from a family more recently added to the herd. Carmine Lorin Storrs, a daughter of Lorin Masher, is lower in milk production by 53.3 pounds, lower in the production of butter fat by 15.6 pounds and lower in butter fat percentage by 0.06 than her dam. The other three daughters of Albamont Jupiter have enough increase over their dams so that the average increase for the four daughters is 890 pounds of milk, 75.2 pounds of butter fat and 0.45% butter fat.

Foremost's Excelsior left two daughters, but the records of only one dam are available. Since this represents his final direct contribution to the herd the data are presented even though too scant for conclusions. Neither of his daughters carry the blood of the Eurotas family.

Other bulls appearing in Table 4 were not used in the herd but enter in simply as sires of females introduced into the herd.

Table 8 presents in condensed form the production data on daughters of the sires, with the difference in yield compared with their dam's record. Figure 1 illustrates the daughters' production graphically. This table and graph in particular show a definite increase in yield since the beginning and at the same time emphasize that only two bulls out of nine, Wolf Rock and Grassland Comet, furnished the stepping stones for higher levels of production.

It is realized that the number of daughters is too limited to evaluate correctly the transmitting qualities of most of the sires. Davidson (5) in a statistical comparison of daughter-dam production concludes that fifteen daughters of a sire are fairly representative of any larger group and that six pairs are the minimum number of comparisons upon which the probable transmitting ability of a bull may be safely based. The Bureau of Dairy Industry, U. S. D. A., has adopted five pairs as a basis for study of sires in cow testing associations. Grassland's Comet is the only bull to qualify for measurement by the minimum Davidson standard, and Royal Eurotas is the only other to meet the U. S. D. A.

AVERAGE PRODUCTION OF DAUGHTERS OF HERD SIRES

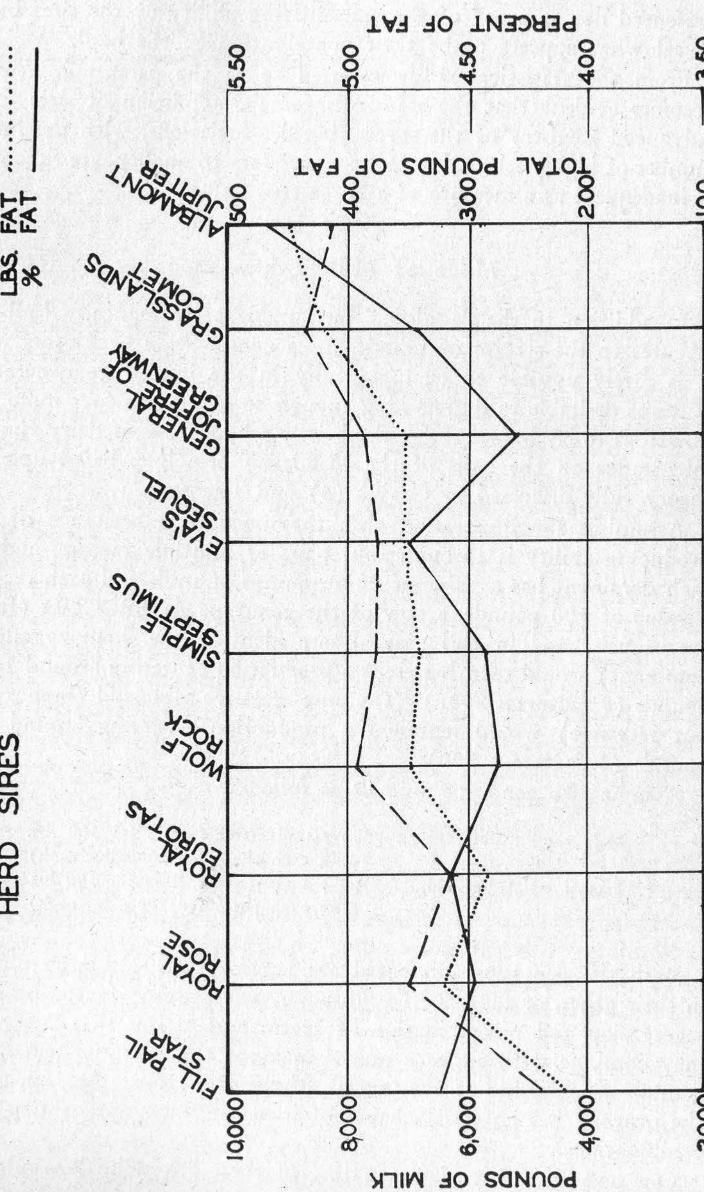


FIG. I

standard. These facts are fully appreciated, and the data are here presented not as proof of the transmitting ability of the sires but to reveal what appears to be their contribution to the herd.

From the statistical study referred to in the paragraph above it becomes evident that the standards for the admission of sires to the Advanced Registry of the several breed associations, with the limited number of highly selected daughters necessary to qualify, are ridiculously inadequate as a measure of a bull's true value.

Mode of Milk Inheritance

In addition to the daughters' measurable performance, a bull contributes to the stream of inheritance a combination of factors which it is rarely possible to evaluate fully in the immediate generations. It seems desirable to digress long enough to reveal this fact more fully as well as to lay before the reader briefly a hypothesis of dairy function inheritance on the basis of the Mendelian principle, based upon the theory fully discussed by Graves (6) and Turner (7).

Assuming for illustration that the mode of inheritance of milk producing ability is through four pairs of multiple factors, and that each dominant has a value of 2000 pounds of milk and each recessive a value of 300 pounds, a cow of the genotype AABBCCDD (factors are in pairs and in this case all are identical, i.e. homozygous and dominant) would then represent a production centering around 16,000 pounds (8 factors x 2000). The pure recessive aabbccdd (homozygous but recessive) would represent a production centering around 2400 pounds (8 factors x 300).

Assume two genotype animals as follows:

Male — aaBbCcDd = 7500 pounds (five factors for 300 lbs. milk each three for 2000 lbs. each)
Female — AaBbCcdd = 7500 pounds (five factors for 300 lbs. milk each three for 2000 lbs. each)

Both the genotypes presented are heterozygous, although differing in their genes, or factors. To illustrate with the first factor Aa in the segregation and recombination of sperm and ovum, the A (female) may combine with either *a* of the male, or the *a* of the female may combine with either of the two *a*'s of the male thus: Aa, Aa, aa, aa; the progeny has an equal chance of inheriting any one of these four combinations.

One possible result of the mating of these two animals would be a cow with the genotype AaBbCcDd representing a production centering around 9200 pounds. This cow bred back to her sire would make

possible 128 different combinations of these factors, distributed as follows:

1	centering	around	14,000	pounds	of	milk
7	"	"	12,600	"	"	"
21	"	"	10,900	"	"	"
35	"	"	9,200	"	"	"
35	"	"	7,500	"	"	"
21	"	"	5,800	"	"	"
7	"	"	4,100	"	"	"
1	"	"	2,400	"	"	"

This can be expressed in a different manner which will perhaps throw a little more light upon what actually happens. If we assume, in the second mating, the same bull—aaBbCcDd—whose sperm cells, after reduction, could vary as follows: aBCD, aBCd, aBcD, aBcd, abCD, abCd, abcD, abcd; and his daughter—AaBbCcDd—whose egg cells could vary as follows: ABCD, ABCd, ABcD, ABcd, AbCD, AbCd, AbcD, Abcd, aBCD, aBCd, aBcD, aBcd, abCD, abCd, abcD, abcd; it will be seen, then, that the bull with one factor pair being pure recessives can have but eight possible combinations of factors while the cow having all factor pairs heterozygous can have sixteen possible combinations. The mating of these two animals makes it possible for any one of the bull's eight possible combinations to unite with any one of the cow's sixteen possible combinations, making a total of 128 possibilities genotypically but not 128 levels of production, as the production would be controlled by the number of dominant and recessive factors present. If the bull's sperm cell aBCD should unite with the cow's egg cell ABCD, the resulting animal, AaBBCCDD, if a cow, would have a productive ability centering around 14,300 pounds of milk, or if a bull, the ability to transmit to his daughters a productive ability centering around 14,300 pounds of milk.

This theory could be applied to the case of Lute Storrs Masher to illustrate why we often do not get what we expect in breeding. Lute Storrs Masher's dam's record was 7376 pounds of milk and her sire's daughters averaged 7746 pounds of milk, while her own record was 9894 pounds of milk. Lute Storrs Masher, bred back to her sire, General Joffre of Greenway, produced Lighting Storrs Masher, with a record of 8479 pounds of milk. Lighting Storrs Masher, bred to Grassland's Comet, whose daughters averaged 8862 pounds of milk, produced Laureate Lightning Storrs, with a record of 7411 pounds of milk. Lute Storrs Masher, bred to Grassland's Comet, produced Lassie Lute Storrs, with a record of 7931 pounds of milk. Lassie Lute Storrs in turn when bred to Albamont Jupiter, whose daughters averaged 8217 pounds of milk, produced Buoyant Lassie Storrs with a record of 9633 pounds of milk.

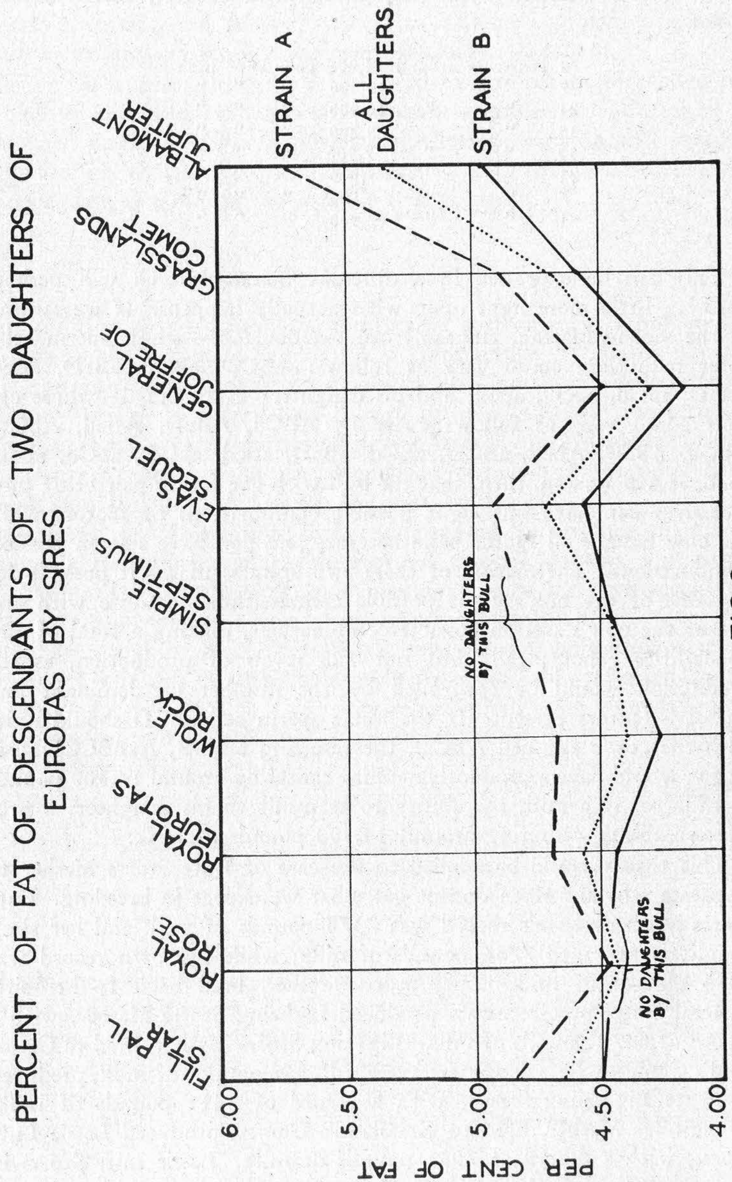


FIG.2

The butter fat percentages may be observed in the same way. The butter fat percentage of Lute Storrs Masher's dam was 4.92 and that of her sire's daughters averaged 4.33, while her own percentage was 4.86. A daughter, Emerald Joffre, resulting from mating Lute Storrs Masher to her own sire, General Joffre of Greenway, had a butter fat percentage of 4.12, while another daughter of Lute Storrs Masher by Grassland's Comet had a butter fat percentage of 5.27.

Further Observations on Full Sisters and Half Sisters

Figure 2 shows in graphic form the influence of both male and female parents on the butter fat percentage of the offspring. The upper broken line (Strain A) represents the average butter fat percentage of the descendants of Lily Eurotas, whose butter fat percentage was 4.81. The lower solid line (Strain B) represents the average butter fat percentage of the descendants of Eurotas 2nd, full sister to Lily Eurotas, whose test was 4.50 percent.

The fat percentage (4.13) of the original cow, Eurotas, was exceedingly low for the Guernsey breed (4.98), although undoubtedly she must have transmitted factors for a higher test than she herself revealed. Although the herd bulls were used in common in both strains, the average butter fat percentage of the daughters of each generation have kept well apart, and following the use of Albamont Jupiter are still farther apart than at the beginning. The fact that the butter fat percentages of the two strains have kept well apart indicates the decided influence of the female parent, while the tendency of the two lines to remain parallel, at the same time indicates the decided influence of the male parent. This is in close agreement with the findings of Burrington and White (8) in a study of two Holstein strains in the College herd. The dotted line representing the fat percentages of all the daughters of the various herd sires parallels the other lines, keeping nearly equidistant from the lines representing the percentages of Strain A and Strain B, which is to be expected, with the small number of daughters of each bull that were not from cows of either strain A or strain B. The figures are given in Table 9.

Table 10 shows some rather striking comparisons of the records of half sisters and full sisters. The record of Lily Eurotas more nearly approaches the record of her half sister Franconia than it does that of her full sister Eurotas 2nd. The inbred full sister daughters of Eurotas 2nd have records that are very close together except in fat percentage. Storrs Eurotas, one of these inbred full sisters, had full sister daughters whose records should approximate each other. This has happened in the production of milk, but the fat percentage shows a difference of 0.3. Eurotas Mansfield, the other inbred full sister, also had full sister daughters, one of which, Wolf Rock's Eurotas, is considerably above either of the daughters of Storrs Eurotas in both

TABLE 9

Butter Fat Percentages of Herd Sires on Two Strains Originating From One Cow

		Fill Pail Star	Royal Rose	Royal Eurotas	Wolf Rock	Simple Septimus	Eva's Sequel	General Joffre of Greenway	Grass-land's Comet	Albamont Jupiter
Eurotas 4.13	Descendants of Lily Eurotas 4.81 Strain A	4.81	4.48	4.68	4.66	4.47	4.92	4.49	4.88	5.73
	Average all Daughters of Herd Sires	4.64	4.46	4.56	4.40	4.47	4.74	4.33	4.70	5.35
Eurotas 4.13	Descendants of Eurotas 2nd 4.50 Strain B	4.50	4.46	4.46	4.27	4.47	4.55	4.17	4.60	4.98

milk and butter fat production and midway between them in the percentage of butter fat. The other, Eurotas Mansfield, produced considerably less milk and butter fat and had a very much lower butter fat percentage than either of the daughters of Storrs Eurotas. The half sister daughters of Storrs Eurotas, Genial Eurotas and Storrs

TABLE 10

Comparison of Some Records of Full Sisters and Half Sisters

Dam	Daughters		Sire*	Milk	% Fat	Fat
Eurotas	Eurotas 2nd		C	6705	4.50	295.0
"	Lily Eurotas		"	3675	4.81	182.0
		Difference		3030	.31	113.0
Eurotas	Lily Eurotas		C	3675	4.81	182.0
Francille	Franconia		"	3750	4.62	181.0
		Difference		75	.19	1.0
Eurotas 2nd	Eurotas Mansfield		E	6587	4.24	280.6
" "	Storrs Eurotas		"	5887	4.67	268.3
		Difference		700	.43	12.3
Storrs Eurotas	Storrs Eurotas 2nd		H	7561	4.62	349.3
" "	Simple Eurotas		"	7300	4.32	328.9
		Difference		261	.30	20.4
Eurotas Mansfield	Wolf Rock's Eurotas		G	8638	4.48	390.2
" "	Eurotas Mansfield 2nd		"	6488	4.06	265.3
		Difference		2150	.42	124.9
Simple Eurotas	Genial Eurotas Storrs		K	10116	4.56	458.2
" "	Storrs Sunbeam		J	6492	4.13	296.2
		Difference		3624	.43	162.0
Storrs Sunbeam	Salient Sunbeam Storrs		K	10977	4.60	515.9
" "	Sagacious Storrs Sunbeam		"	9857	4.49	448.1
		Difference		1120	.11	67.8
Naomi's Beauty	Naomi's Beauty 2nd		E	7540	4.61	347.2
" "	Eurotas Naomi		"	6216	4.59	281.4
		Difference		1324	.02	65.8

Sunbeam, show an extreme variation in the production of milk and butter fat as well as in butter fat percentage. Grassland's Comet is the sire of Genial Eurotas Storrs, and General Joffre of Greenway is the sire of Storrs Sunbeam; and when the effect of these two sires is observed, in Table 7, the reason for the variation can be seen. Storrs Sunbeam, the poorer producer of the two daughters of Simple Eurotas,

*Refer to Key to Bulls, Table 6.

NOTE: The sire of Eurotas Mansfield and Storrs Eurotas also has Eurotas 2nd for his dam.

when twice bred to Grassland's Comet, the sire of Genial Eurotas Storrs, the better producing daughter of Simple Eurotas, produced Salient Sunbeam Storrs and Sagacious Storrs Sunbeam, whose records of production are about on the same level as that of Genial Eurotas Storrs, their dam's half sister, rather than that of their own dam. Naomi's Beauty 2nd and Eurotas Naomi, also full sisters, have production records that vary from each other by 1324 pounds in milk and 65.8 pounds in fat but only .02 in butter fat percentage.

Discussion

The data herewith presented show the effect of single females used as foundation animals in establishing a herd of pure-bred cattle. Eurotas alone, of the three females first purchased in 1896, in the second attempt to establish the College Guernsey herd, has descendants in the herd today. That the present herd contains thirteen female descendants of Eurotas in contrast to seven the result of other purchases, reveals the dominating influence of this one cow. The two cows purchased in 1903 have left no descendants. Seven cows purchased from 1922 to 1924 have not as yet left a strong, favorable imprint.

Twelve service bulls have been used in the herd over a period of thirty-five years, ten of which have daughters old enough to have records of production. These ten sires left thirty-four cows that produced milk in the herd for two hundred days or more. Ten of the other 49 cows with records were purchased and the other five were carried by dam into the herd. It will be noticed that 34 is an average of one daughter for each year of the herd's existence. Tuberculosis, contagious abortion, accidents and the production of bull calves have all been contributing causes in limiting the female increase. Fairview Maid, for example, a sister of Eurotas, produced five bull calves in succession which was her entire produce while in the herd.

Table 11 presents an interesting breeding record of Lute Storrs Masher. This cow was of acceptable type, possessing an unusually well shaped udder and was a good producer. She was considered to be a very desirable cow, and yet it is remarkable that she could have made so little contribution to the herd after eleven years of regular breeding. The final possibility for any permanent contribution from this cow rests upon her last daughter, born in 1928, and her single granddaughter, Buoyant Lassie Storrs.

The information in Table 11 is introduced merely as an illustration of the effect of circumstance in the development of a dairy herd. A similar occurrence might have wrecked the contribution of the best sire of all, Grassland's Comet. This bull was purchased as a calf at a time, when for one reason and another the herd was cut down to five milking cows. Comet's first two crops of calves from these cows were all bulls; his third crop consisted of three bulls, a pair of twins

of opposite sex (the heifer was infertile) and one heifer which died. Thus the herd was at a complete standstill for three years and Comet was six years of age before his first daughter freshened.

TABLE 11

Lute Storrs Masher 87066. Born, August 23, 1916. Sire—General Joffre of Greenway 31313. Dam—Lorin Masher 61496.

Produce	Sire
Oct. 18, 1918—Female—Lighting Storrs Masher*	General Joffre of Greenway
Dec. 6, 1919—Male	Grassland's Comet
Jan. 4, 1921—Male / Female (non-breeder) } Twins	Grassland's Comet
Feb. 19, 1922—Female—Lassie Lute Storrs (eradicated as abortion reactor)	Grassland's Comet
Apr. 5, 1923—Male	Grassland's Comet
July 9, 1924—Male	Albamont Jupiter
Oct. 20, 1925—Male	Albamont Jupiter
Dec. 14, 1926—Male	Foremost's Excelsior
Jan. 2, 1927—Male	Foremost's Marshall
Nov. 20, 1928—Female—Grateful Lute Storrs	Princess' May Royal

*Sold as producer after one lactation. Extremely weak loin.

Another illustration in connection with Grassland's Comet is interesting. He was sired by Jethro Bass and out of Alice for Short, with a record of 14,874 pounds of milk and 736.05 pounds of fat, testing 4.95%. Naturally a good deal was expected of this bull, but as related above, a long wait ensued before his daughters came into milk.

It was soon noticed that his daughters tested a little lower than the breed average, 4.70%. He was regarded as a capable sire for milk production but as one inclined to lower the test. It was not until the present dam-daughter study was made that it was realized that he had been bred to cows with low tests, his immediate predecessor having lowered his own daughters 0.21%, which following others was the lowest point in the whole career of a rather low testing herd. When it was observed that Comet's daughters tested .40% higher than their own dams Comet won the place that he deserved in our estimation.

Possibly Comet's true worth as a sire can be more correctly measured by the application of the Mount Hope Farm bull index.* Applying this formula the transmitting capacity of Comet for milk

*Mount Hope Farm, Williamstown, Mass. The milk transmitting power of the sire when the daughters exceed the dams equals daughters' milk $+0.4286 \times$ the difference between dams' and daughters' milk; the percentage of fat equals daughters test $+1.5 \times$ the difference between dams' and daughters' test.

is found to be 9,462 instead of 8,862, the average of his daughters; and for percentage of fat 5.30 instead of 4.70, the average of his daughters.

Grassland's Comet was sent to the University of New Hampshire in exchange for Albamont Jupiter and upon his return to Connecticut was sold to a Connecticut breeder where he was finally lost as a tuberculosis reactor. He was sold as a proved sire but even so his true ability was not fully appreciated at that time.

In the daughter and dam comparisons, in some cases an increase in milk production was accompanied by a reduction in butter fat percentage, while in other cases it was accompanied by an increase. Reductions in milk production were accompanied either by increases or decreases in butter fat percentages. These facts indicate what is already quite well known, that milk producing ability and butter fat percentages are inherited separately and that a single sire or dam may increase or decrease one or both or may increase one and decrease the other.

Summary

This bulletin is a history of the Guernsey herd of the Connecticut Agricultural College covering a period of thirty-five years since its foundation in 1896. The production records kept over this period have been converted to a comparable basis for a study of the contribution of the various individuals.

This is one of four breeds maintained in the dairy herd. The numbers have not been large but in this respect it is comparable to the majority of dairy herds. Forty-nine cows have contributed to the production records. Ten sires used in the herd have contributed through milking daughters. In the appendix are presented the pictures of many of these animals.

An attempt was made to establish a Guernsey herd in the late eighties. This trial met with failure on account of tuberculosis. In 1896 three females and a bull were purchased. Other female purchases were made as follows: two in 1903, two in 1922, and five in 1924. The sires, ten in number, brought into the herd are to be found in Table 8. The complete list of sires represented by daughters including purchased females, will be found in Table 4.

Only one of the three original (1896) cows has left descendants in the herd. This cow, Eurotas, has contributed to the herd through two daughters, one to the ninth and the other to the seventh generation. The two cows purchased in 1903 have left no trace and it is still uncertain whether or not the seven purchased in 1922 and 1924 will leave their permanent stamp. Thirteen of the present twenty females are descended from the cow Eurotas. This illustrates emphatically how few cows, for one reason or another, make permanent contributions

to a herd through the female line, and hence the very great importance of carefully selecting foundation cows.

All of the sires except Albamont Jupiter were brought in while young. The breeding behind them, in most cases, appeared promising. The influence of the first sire upon the yield of his daughters was unfavorable; the daughters of the next two produced about the same as the original cows; while the fourth brought about a distinct improvement in milk and net fat increase in spite of a lowered test. The next three sires held the production at the level of their predecessor and the eighth brought the milk and fat test up sharply. The ninth sire further increased the fat while slightly lowering the milk. The tenth sire has two daughters but only one daughter-dam for comparison. The net influence of all these sires has been an increase in both the milk and the percentage of fat, brought about chiefly by two, possibly three, of the nine sires. This again emphasizes the great need to find and employ some better means than ordinarily used in the selection of sires.

As mentioned, one of the original cows, Eurotas, produced two daughters, descendants of both of which are at present in the herd. One of these daughters tested 0.31% lower than the other. The descendants of the higher testing sister have continued to test higher than those of the other (Table 9). Sires have been used in common on both strains and their influence is also apparent as both groups move in the same direction under their influence, yet remaining apart. This same fact was observed in an earlier study of the College Holstein herd (8).

In the daughter-dam comparisons, even with full sisters and half sisters from the same dam, it was observed that the percentage of fat might decrease or increase in conjunction with either an increase or decrease in milk. This demonstrates what has already been established, that the precise level of percentage of fat and quantity of milk are inherited independently of each other. It is impossible to tell simply by the character of the product of a cow what may be the range of her transmitting capacity.

The same applies in the selection of the sire on the basis of his pedigree indications. The Advanced Registry, as generally operated by breeders, permits too much discrimination in choosing the animals to be tested to furnish a basis for predicting accurately the transmitting range of either a cow or a bull. Relatively unselected daughter-dam and daughter-sire comparisons are necessary for this, furnished only by a complete record of all animals in the herd. An estimate of the genetic makeup of a dairy animal can be arrived at, even though the number of individuals is small, if comparable records are available and the records of all animals of varying relationships are compared.

As has been often said, a study made of the records of dead bulls is belated. But this study has been the means of correcting some misconceptions held concerning the bulls used in this herd, and anyone who makes a similar study of his herd will be convinced beyond doubt of the importance of such an analysis as a guide to progress in herd improvement.

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Pictorial Record of the GUERNSEY HERD At the Connecticut Agricultural College

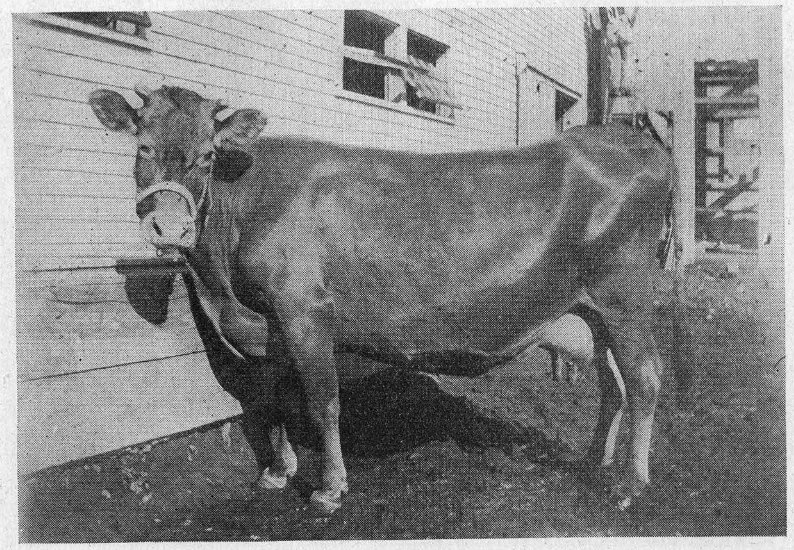

FIG. 3. EUROTAS, FOUNDATION COW OF HERD.

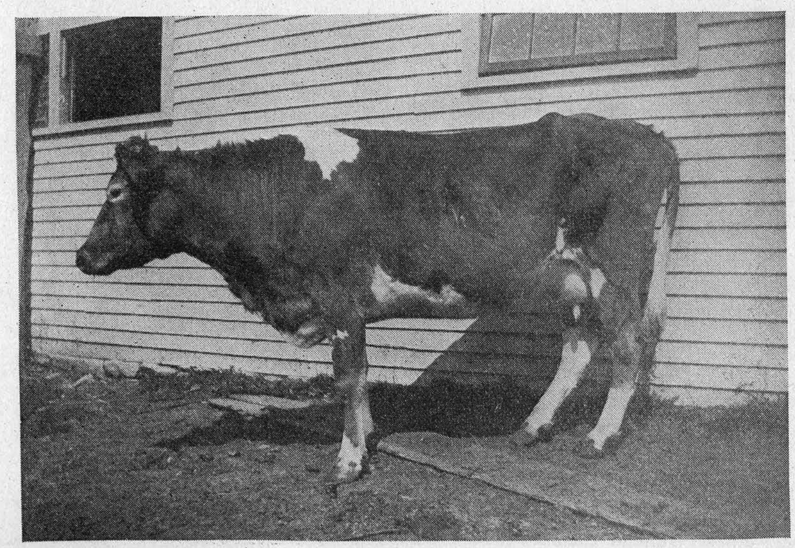

FIG. 4. FRANCILLE, PURCHASED WITH EUROTAS BUT LEFT NO DESCENDANTS.

FIG. 5. FILL PAIL STAR.

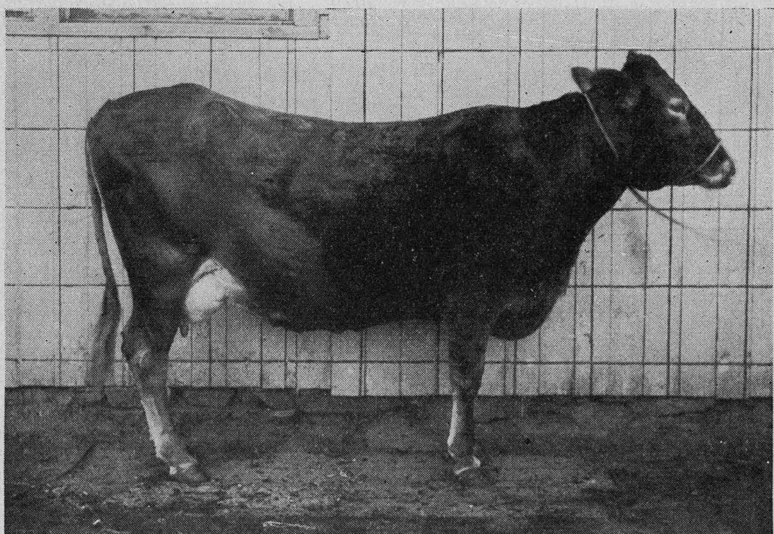

FIG. 6. EUROTAS 2ND, DAUGHTER OF EUROTAS AND FILL PAIL STAR.

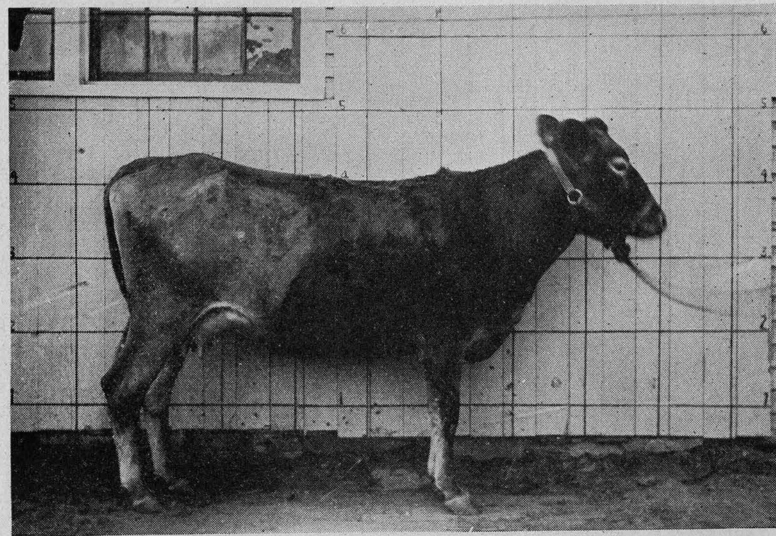

FIG. 7. STORRS EUROTAS, DAUGHTER OF EUROTAS 2ND AND HER HALF BROTHER, ROYAL EUROTAS.

FIG. 8. SIMPLE EUROTAS, DAUGHTER OF STORRS EUROTAS AND SIMPLE SEPTIMUS.

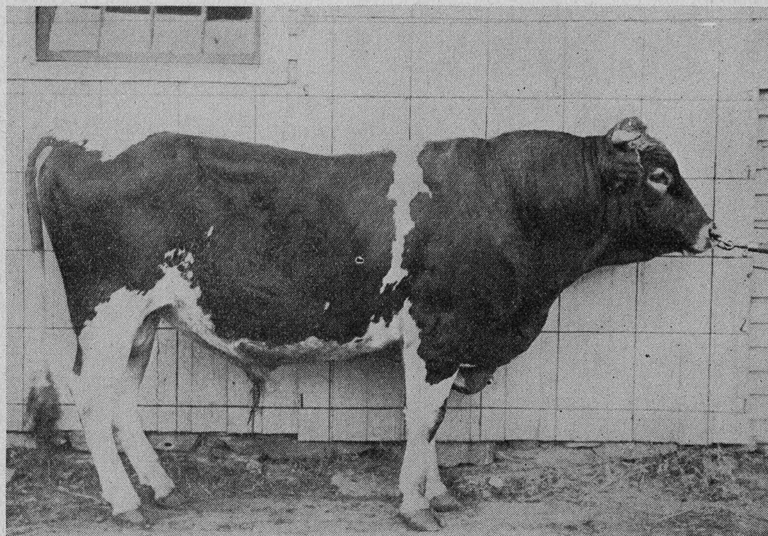

FIG. 9. SIMPLE SEPTIMUS.

FIG. 9a. SIMPLE SEPTIMUS IN YOKE, 1911.

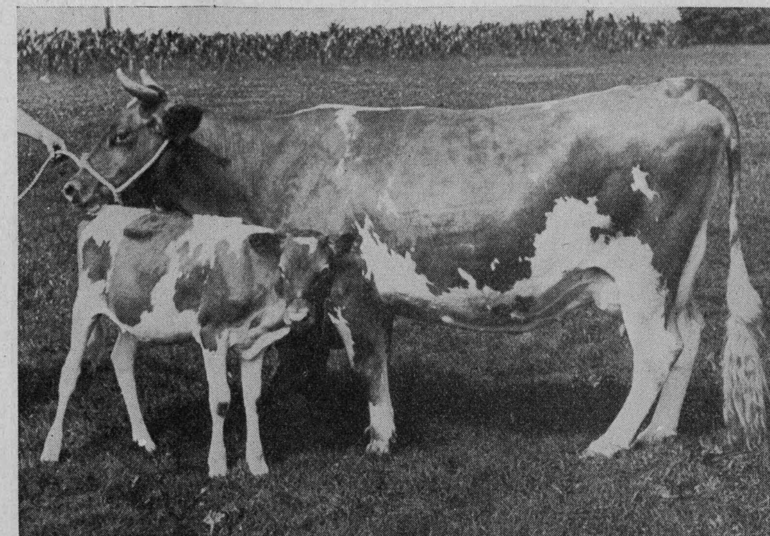

FIG. 10. GENIAL EUROTAS STORRS WITH HER CALF, DAUGHTER OF SIMPLE EUROTAS AND GRASSLAND'S COMET.

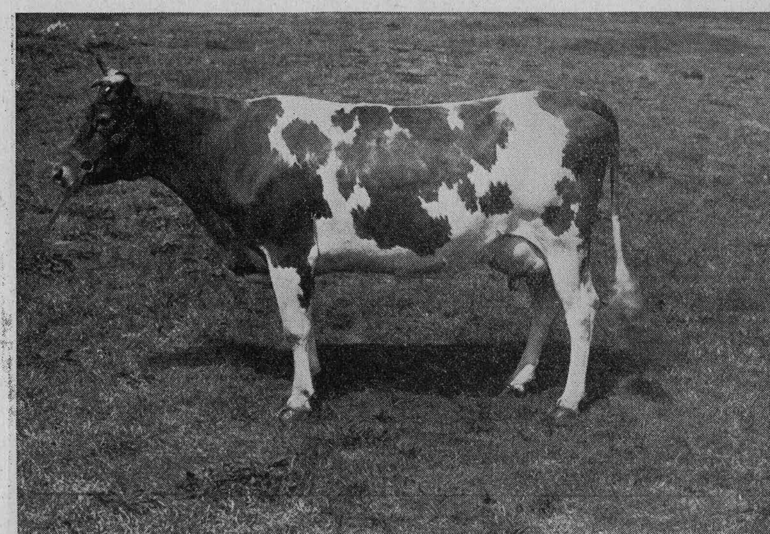

FIG. 11. SALIENT SUNBEAM STORRS, GRANDDAUGHTER OF SIMPLE EUROTAS, THROUGH STORRS SUNBEAM, AND BY GRASSLAND'S COMET.

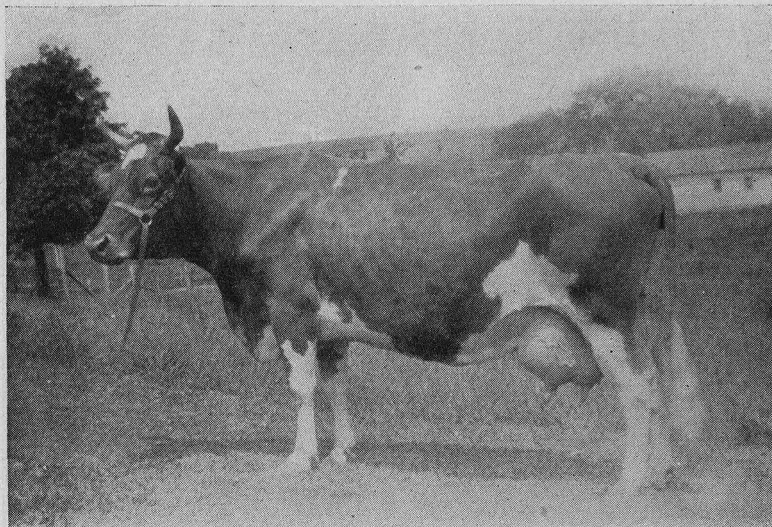

Fig. 12. Sagacious Storrs Sunbeam, full sister to Salient Sunbeam Storrs.

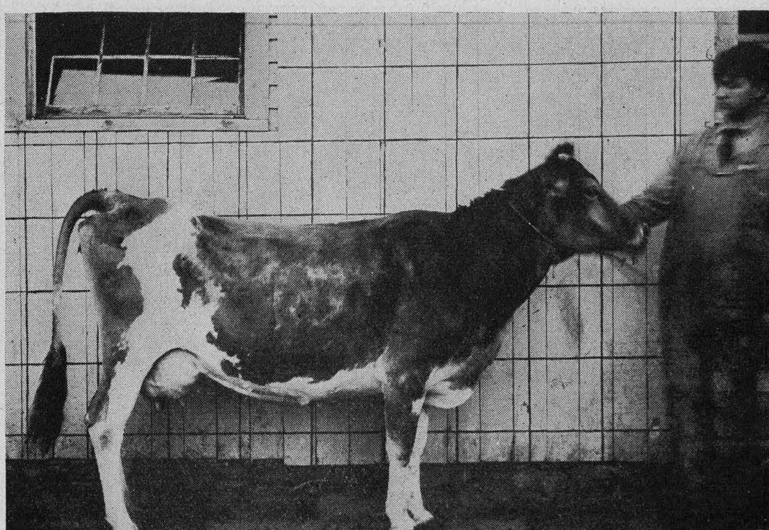

Fig. 13. Lily Eurotas 2nd's Rose, granddaughter of Lily Eurotas (out of Eurotas) and by Royal Rose.

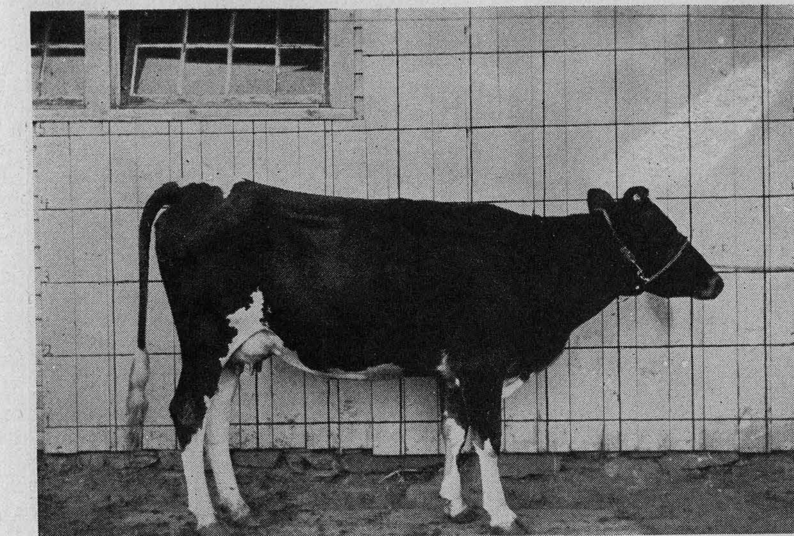

Fig. 14. Eurotas Rose, daughter of Lily Eurotas 2nd's Rose and Royal Eurotas.

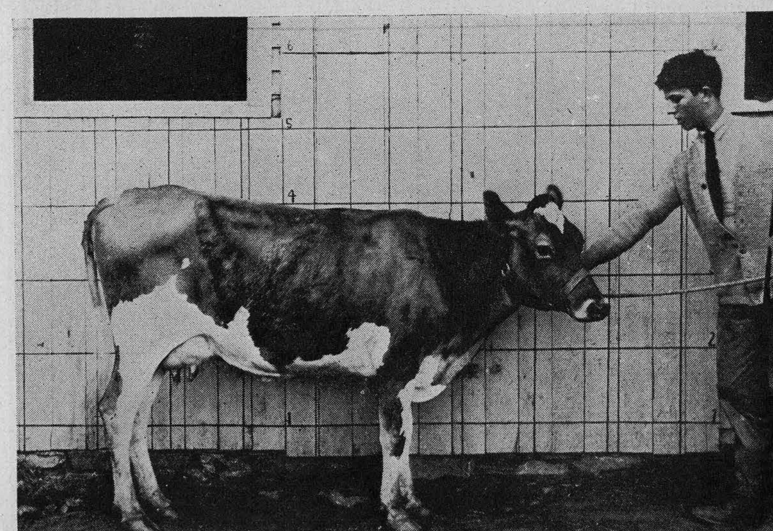

Fig. 15. Lily Rock, daughter of Lily Eurotas 2nd's Rose and Wolf Rock.

FIG. 16. LORIN MASHER, DAUGHTER OF LILY ROCK AND EVA'S SEQUEL.

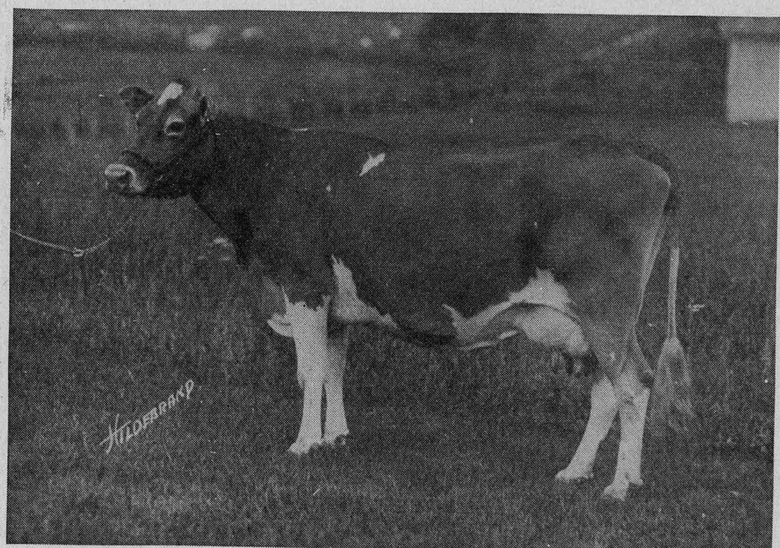

FIG. 17. LUTE STORRS MASHER, DAUGHTER OF LORIN MASHER AND GENERAL JOFFRE OF GREENWAY.

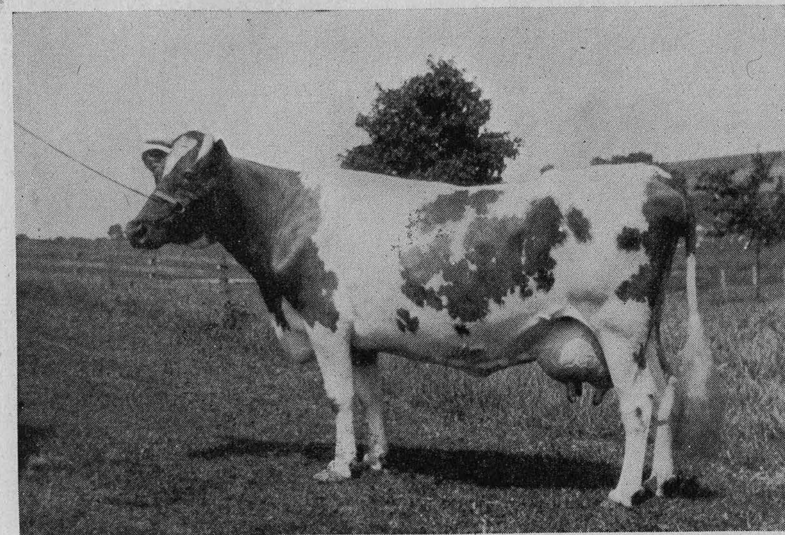

FIG. 18. BUOYANT LASSIE STORRS, GRANDDAUGHTER OF LUTE STORRS MASHER AND BY ALBAMONT JUPITER.

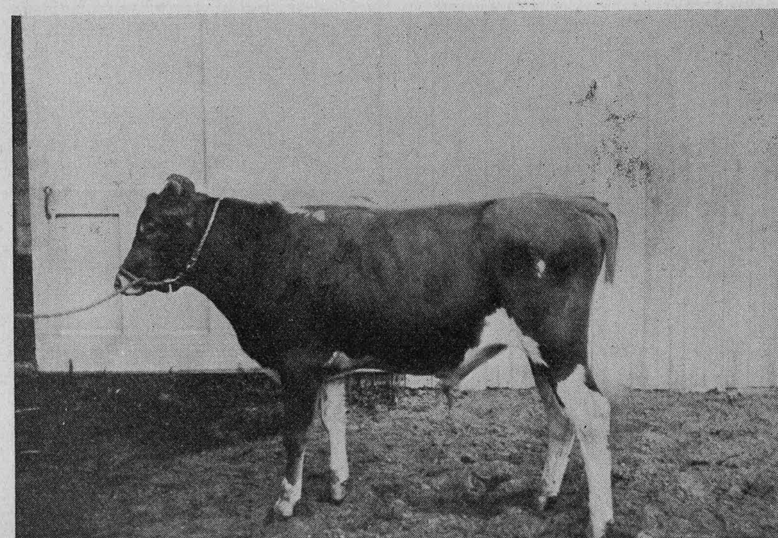

FIG. 19. WOLF ROCK.

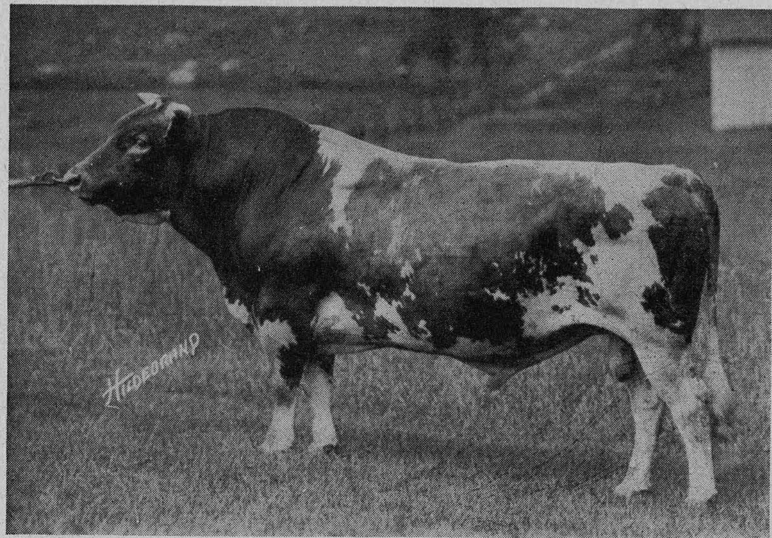

Fig. 20. Grassland's Comet.

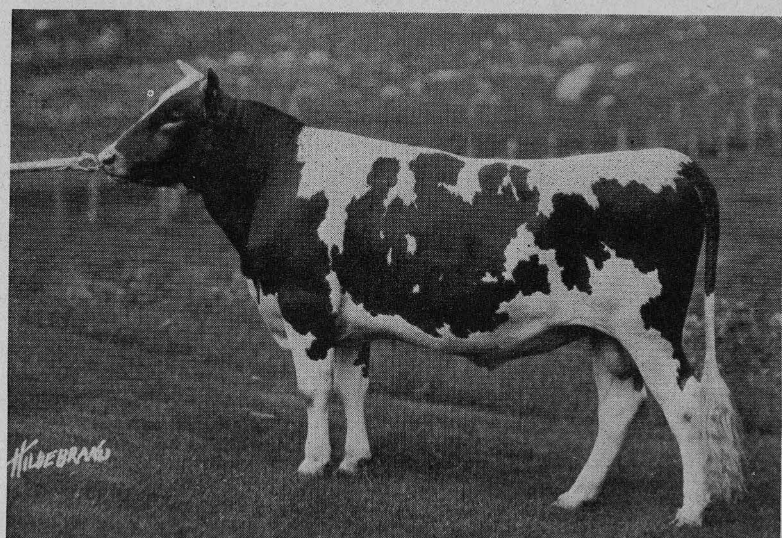

Fig. 21. Albamont's Jupiter.

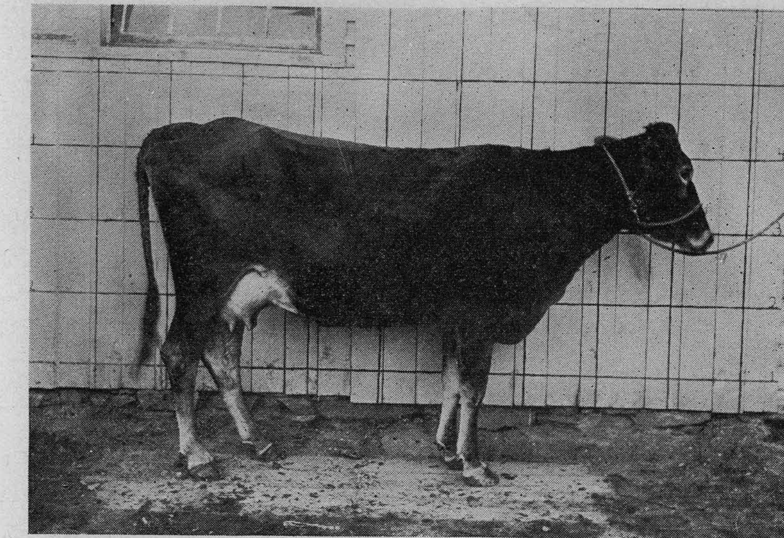

Fig. 22. Eurotas Mansfield, daughter of Eurotas 2nd and her half brother, Royal Eurotas. Full sister to Storrs Eurotas. This line has produced no animals of merit.

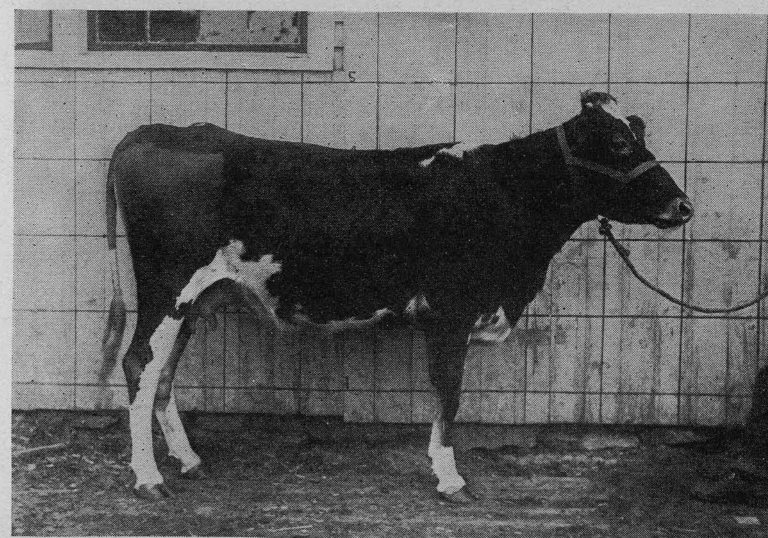

Fig. 23. Wolf Rock's Eurotas, daughter of Eurotas Mansfield and Wolf Rock.

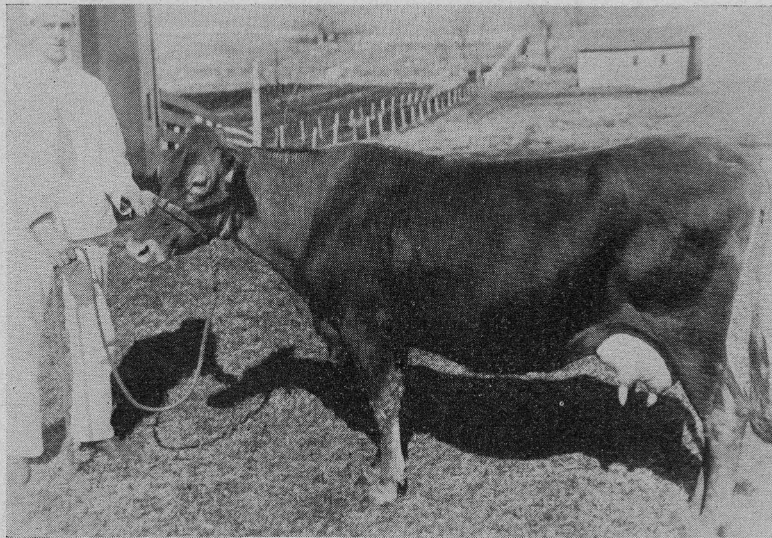

Fig. 24. Eurotas Mansfield 2nd, full sister to Wolf Rock's Eurotas.

Fig. 25. Naomi's Beauty, purchased in 1903.

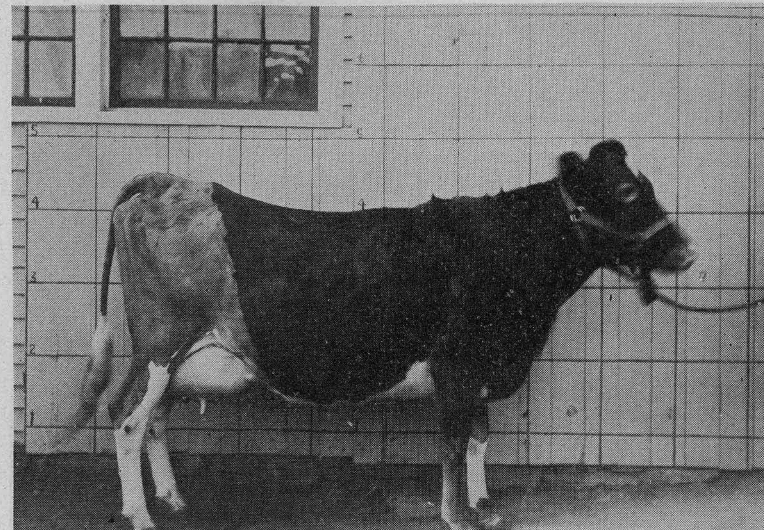

Fig. 26. Eurotas Naomi, daughter of Naomi's Beauty and Royal Eurotas.

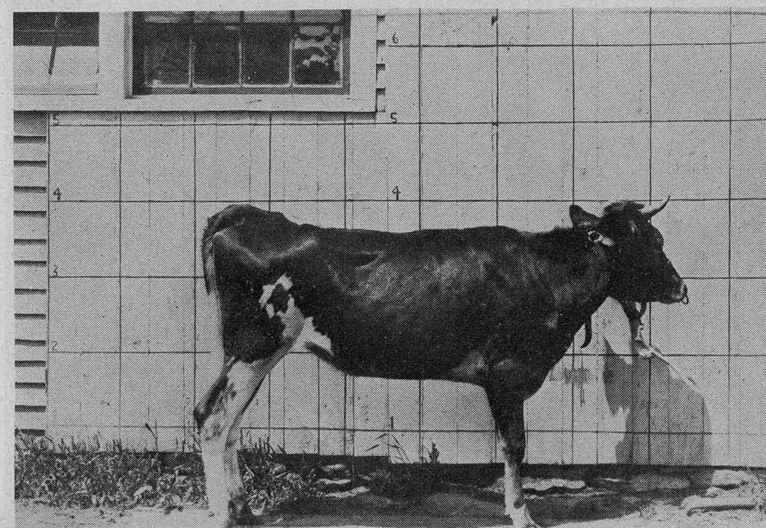

Fig. 27. Eurotas Naomi 3rd, daughter of Eurotas Naomi and Young Truth.

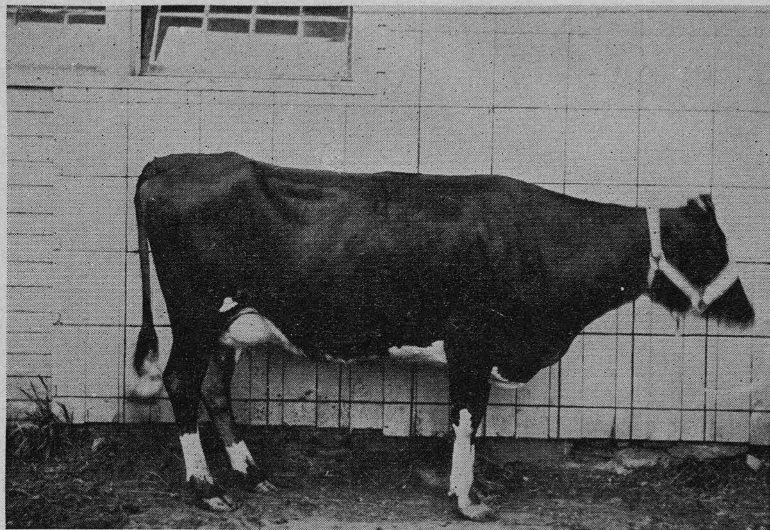

FIG. 28. STORRS NAOMI, DAUGHTER OF LADY NAOMI, PURCHASED IN 1903, AND ROYAL ROSE.

FIG. 29. EVA OF STORRS, DAUGHTER OF STORRS NAOMI AND EVA'S SEQUEL. EVA PASSED IN 1920, THE LAST SURVIVOR OF THE NAOMI GROUP.

FIG. 30. YEARLING DAUGHTERS OF FOREMOST'S MARSHALL, 115,243, TAKEN IN 1929. FROM LEFT TO RIGHT THEY ARE OUT OF CARMINE LORIN STORRS, GENIAL EUROTAS STORRS, ERNESTINE OF GREEN LODGE, JULIA ELLEN STORRS, SALIENT SUNBEAM STORRS AND SAGACIOUS STORRS SUNBEAM.

FIG. 31. CAROLINE'S MAY ROYAL, 162,143, PRESENT HERD SIRE. JUNIOR CHAMPION AT THE NATIONAL DAIRY SHOW, 1929. GRAND CHAMPION EASTERN STATES EXPOSITION, 1931.

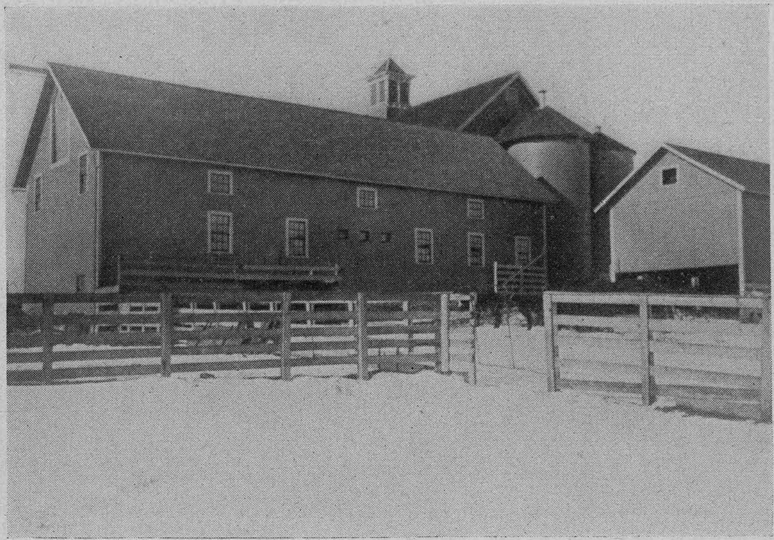

Fig. 32. Rear view of barns with paddocks, 1911.

Fig. 33. View of barns from main road, 1911.

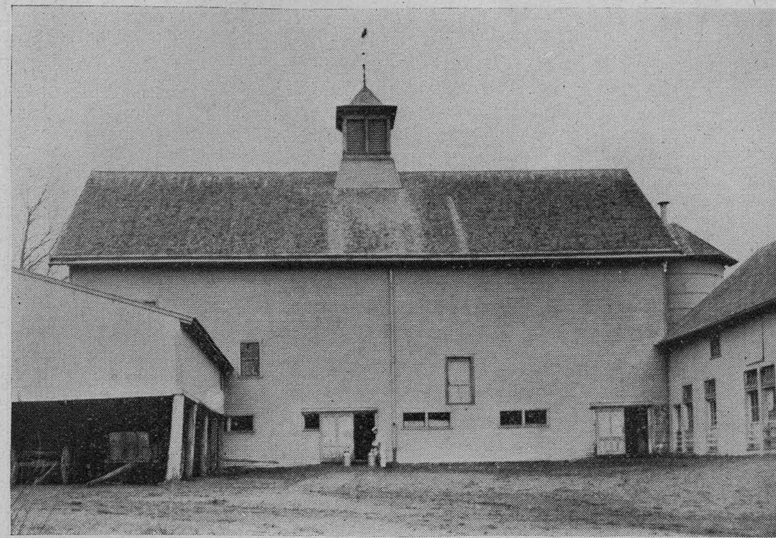

Fig. 34. View of barn from Dairy Building, 1911.

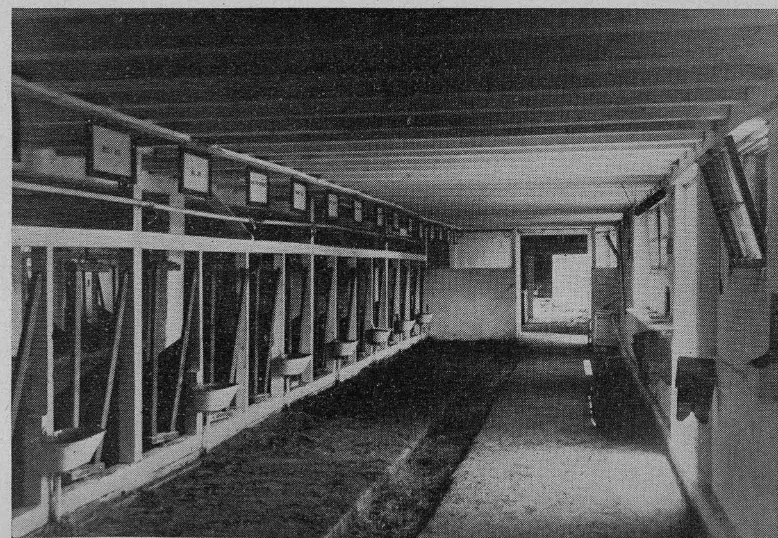

Fig. 35. Interior view, showing platforms and stanchions, 1909.

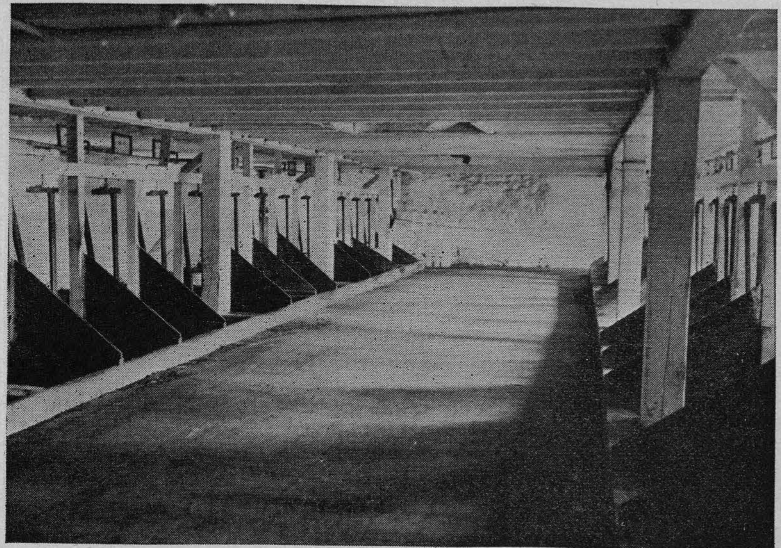

FIG. 36. INTERIOR VIEW, SHOWING FEED ALLEY, 1909.

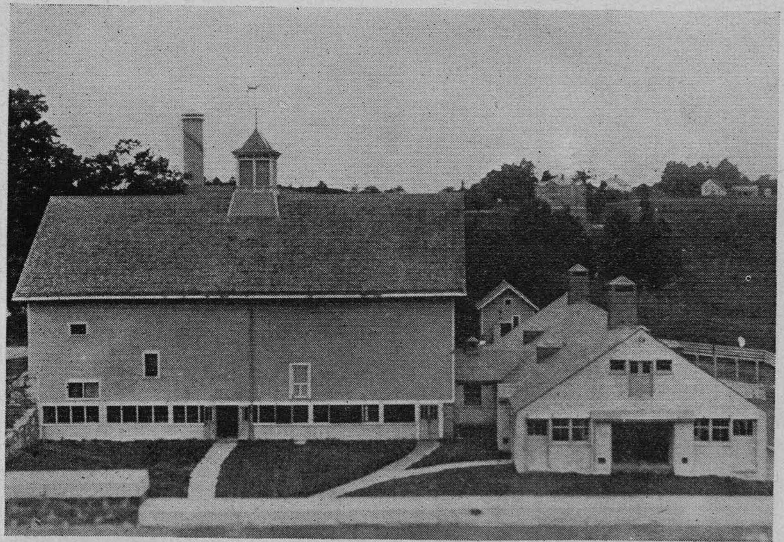

FIG. 37. VIEW OF BARN FROM DAIRY BUILDING, 1915, SHOWING NEW ADDITION AND OLD BARN REMODELED.

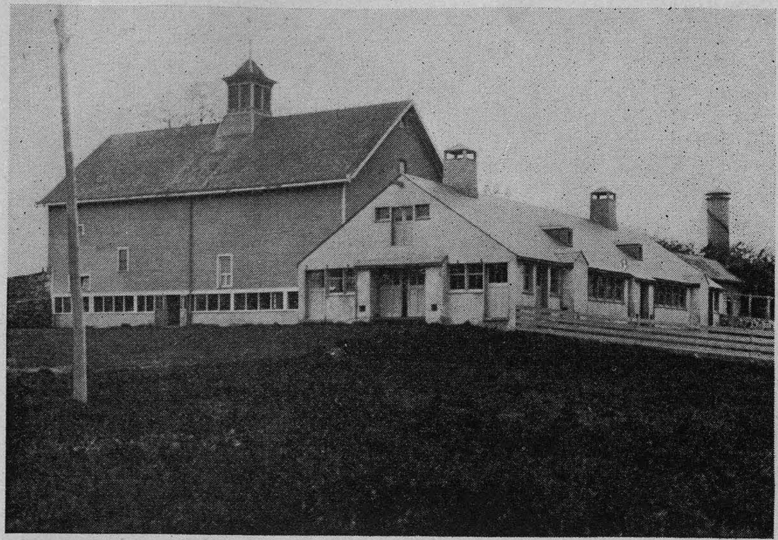

FIG. 38. VIEW OF BARN IN 1916.

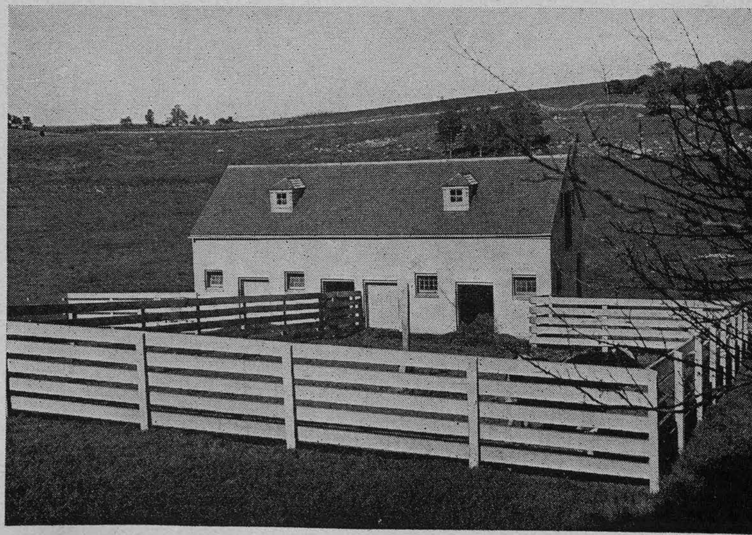

FIG. 39. BULL BARN BUILT IN 1918.

FIG. 40. VIEW FROM MAIN ROAD IN 1922. STORAGE BARN COMPLETED IN 1920.

FIG. 41. SHOWING 1913 BARN, 1920 BARN, 1924 BARN, AND MANURE SHED BUILT IN 1915. WATER TOWERS, NOT SILOS, BEYOND. PHOTO IN 1929.

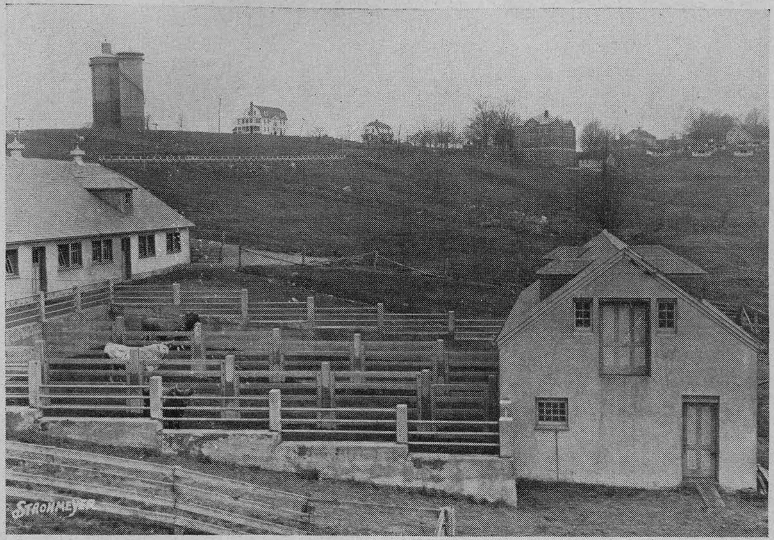

FIG. 42. SHOWING BULL BARN IN FOREGROUND, AND NEW PADDOCKS COMPLETED IN 1930.