CONNECTICUT

AGRICULTURAL EXPERIMENT STATION

NEW HAVEN, CONN

BULLETIN 152, JANUARY, 1906.

The Improvement of Corn in Connecticut.

CONTENTS.

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

CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

OFFICERS AND STAFF.

BOARD OF CONTROL.

His Excellency, HENRY ROBERTS, *Ex officio, President.*

PROF. F. G. BENEDICT .... Middletown.
PROF. W. H. BREWER, *Secretary* .... New Haven.
B. W. COLLINS .... Meriden.
T. S. GOLD .... West Cornwall.
EDWIN HOYT .... New Canaan.
J. H. WEBB .... Hamden.
E. H. JENKINS, *Director and Treasurer* .... New Haven.

STATION STAFF.

Chemists.

Analytical Laboratory.

A. L. WINTON, PH.D., *Chemist in charge.*

E. MONROE BAILEY, PH.B.
KATE G. BARBER, B.S.
J. L. KREIDER, M.A.
E. J. SHANLEY, PH.B.

Laboratory for the Study of Proteids.

T. B. OSBORNE, PH.D., *Chemist in charge.*
I. F. HARRIS, M.S.

Botanist.

G. P. CLINTON, S.D.

Entomologist.

W. E. BRITTON, PH.D.

Assistant to the Entomologist.

B. H. WALDEN, B.AGR.

Forester.

AUSTIN F. HAWES, M.F.

Agronomist.

EDWARD M. EAST, M.S.

Grass Gardener.

JAMES B. OLCOTT, *South Manchester.*

Stenographers and Clerks.

MISS V. E. COLE.
MISS L. M. BRAUTLECHT.

In charge of Buildings and Grounds.

WILLIAM VEITCH.

Laboratory Helper.

HUGO LANGE.

Sampling Agent.

V. L. CHURCHILL, New Haven.

The Improvement of Corn in Connecticut.

By Edward M. East.

Factors in the Increase of Crops.

Under uniform market conditions and on soil of a uniform value, the yield, the quality, and hence the profitableness of a corn crop depends on two sets of conditions (or forces); the first of which, environment, is external to the plant; and the second, heredity, resides within the plant itself.

Of the different factors in the environment of the corn plant, climatic conditions such as temperature, sunlight and rainfall are beyond our control; others, such as attacks of insect enemies and parasitic fungi, are slightly under our control; while tillage and the supplying of plant food to the crop are very largely under control. Both of these last named factors, however, are items of considerable yearly expense. The whole cost of the use of the land, preparing the soil, buying the seed, planting and cultivating is a "fixed charge," that is it is the same whether the crop is large or small. It is the variation in the size of the crop that makes the difference between profit and loss. The costs of harvesting, storing and marketing might also be included in this list, as they vary only slightly with increasing yields.

The actual cost of plant food used may be reduced by the use, as green manures, of legumes which fix nitrogen from the air in the soil, and by feeding the entire corn crop to stock on the farm and carefully saving and returning the complete manure to the soil. At present, it does not seem possible to maintain or increase our stock of soil phosphoric acid and soil potash without the use of a greater or less quantity of commercial fertilizer. If either compound is below normal in the soil, that is, if profitable increase in crop is given by application of compounds of either to the soil, then we should supply it in amount sufficient to produce a maximum crop without robbing the land.* A maximum crop, say one hundred bushels, will not always be reached, but the land should always be given the opportunity to produce it, and this practically reduces the cost of plant food, also, to a "fixed charge."

These conditions, then, which make up the environment of the crop, or which keep the environment in a suitable condition to produce a maximum crop, all involve expense to the farmer, and are to a very large extent a "fixed charge"; that is, the average expense though a number of years is about the same whether the crop is fifty bushels or eighty bushels per acre.

Let us turn now to the other condition affecting productiveness, heredity, the productive forces which reside within the corn germ itself. Here are powerful factors in crop production ready to act for or against us, with or without our knowledge or control. It is the province of the corn breeder to obtain knowledge of and to bring these factors under his control.

Luther Burbank has said; "Cultivation and care may help plants to do better work temporarily, but by breeding, better plants may be brought into existence, which will do better work always, in all places and for all time. Plants may be produced which will perform their appointed work better, quicker and with the utmost precision." Pure-bred strains of corn, for instance, have been produced which yield from five to fifteen bushels more, of corn per acre, under the same conditions of environment, than strains of unimproved seed corn of the same variety.

Such facts make it highly probable that many of our Connecticut varieties of corn, of which we have a number well adapted to the conditions in the state, may be made considerably more productive, and therefore more profitable, by careful continued selection. It is the object of this bulletin to indicate how this can be done.

---

*A 100 bushel crop of dent corn removes from the soil 50 lbs. nitrogen, 14 lbs. phosphoric acid, and 73 lbs. potash in the stalks and cobs; and 96 lbs. nitrogen, 38 lbs. phosphoric acid, and 23 lbs. potash in the grain.

BEGINNINGS OF DOMESTIC IMPROVEMENTS OF CORN.

Domestic animals have been selected and bred ever since our earliest historical records. From earliest times the difference of sex in animals was recognized and perhaps the value of crossing animals of superior merit. With plants the case is very different. The sexuality of plants was established comparatively recently (by Camarerius in 1691), and it is only during the past century that anything like a direct effort has been made for the improvement of cultivated plants.

Animal breeders have been fortunate in the fact that desirable qualities could be readily recognized and so the animals be readily selected for breeding. Plant breeders have been under the disadvantage of being able to control the male parentage in the breeding of very few plants, without great care and expense. In corn, which is a wind-pollinated plant, it is impracticable on any large scale. On the other hand, plant breeders have an immense advantage over animal breeders by being able to deal with very large numbers of individuals and to obtain the data from a generation in a comparatively short time. Although in an open field breeding plot, as that of corn, we can keep a pedigree record only through the female* side (the ears), we are able to progress comparatively rapidly, because from the isolation of the breeding plot and the selections made each year we know that the sires of the seed, that is, the stalks furnishing pollen, are in general all superior plants with the same amount of breeding behind them as the dams (the mother ears), although we cannot say which particular stalk or stalks have furnished the pollen for each individual ear. The principle may be illustrated as follows: a dairyman who owns a herd of pure-bred Jersey cattle might breed his cows to a number of pure-bred bulls, but keep the record of his herd only through the dams; he knows that in every case the sires of his calves are animals superior to common stock.

PRINCIPLES OF CORN BREEDING.

We do not yet understand many of the principles underlying corn-breeding, and cannot predict the limit of the

---

*Record of male plants can be kept when only two ears are used in each plot and all plants from one ear detasseled.

amount of improvement we can make, nor the time it will take to bring any definite result. We do have methods, however, which are more nearly correct, and which bring quicker results than the methods in general farm use, although even such primitive methods as were in use by the North American Indians have undoubtedly done much to improve corn in both yield and quality. The fact that corn has a large ear which must pass through the hands at husking time, and thus bring to notice its good and bad variations, has undoubtedly led to the conscious selection of the largest ears for seed from very early times, and has given to us many types of greater or less excellence.

The two factors in the improvement of corn are variation and heredity. Variation (the universal tendency of the offspring to depart in some respects from the character of the parents) furnishes us with ears of corn of greater and of smaller yielding powers under like conditions, and of more and of less nutritive value, while heredity (the universal tendency of blood relatives to possess like character) gives to the progeny of these individual ears, within certain limits, the same qualities possessed by the parents. For example, if on uniform soil we plant the kernels from fifty ears of corn of uniform appearance, planting kernels from each ear in a single row, we may find at harvest that the yield of corn from equal lengths of the separate rows, calculated to the acre, ranges from thirty to seventy bushels. There was an inherent power in the seed of one ear to produce seventy bushels, when under the same conditions the seed from another ear could produce only thirty bushels per acre. Now if we plant our corn the next year from ears that produced at the rate of seventy bushels per acre, we shall obtain in their progeny a strain of corn which will prove a better yielder than if we had planted ears from rows that yielded at the rate of thirty bushels per acre. Man, himself, cannot originate these variations, but he can be on the alert to recognize, isolate and fix those favorable variations which nature provides. The problem of corn breeding is to provide the best methods for recognizing, selecting and propagating such favorable variations as occur.

Examples of Improvement of Corn by Breeding.

During the last few years a great deal of work has been done by different Agricultural Experiment Stations toward corn improvement. Following their lead, associations of farmers have been formed in several states for the purpose of improving their strains of corn in yield and quality, and adapting them to the needs of particular localities. The members of these associations are engaged in corn breeding as a business enterprise, and pledge themselves to sell only corn with a registered pedigree, from breeding plots grown according to the rules of the association. These associations have been successful in their undertaking, and the members of one of them, with all of whom the writer is personally acquainted, have scarcely been able to supply the demand for the better seed, although it has been sold at more than double the former price.

Besides being able to increase the yield, vary the width of leaf, the amount of husk, the height of ear, etc., the Illinois Experiment Station has shown that it is possible to change the average composition of corn, and by selection has increased the protein content of a dent variety of corn, from an average of 10.9 per cent.* to almost 15.0 per cent. This will be appreciated by the Connecticut dairyman when he considers that the average protein content of wheat is but 13.3 per cent. and the average for oats is but 13.2 per cent. In fact it is a higher protein content than is found in several of the so called "concentrated feeds" now on sale in the Connecticut market.

Corn Breeding in Connecticut.

In trying to answer the question, what improvements are needed in Connecticut varieties, it seems advisable that work should be carried on looking toward the improvement of flint corn, of dent corn and of sweet corn. We have varieties of flint corn in Connecticut, which at present have an average protein content of over 13.0 per cent. These varieties, however, can unquestionably be improved in yield of grain, in general leafiness, height, strength and total yield of stalks. There are uniform dent varieties which are now producing fair yields

*All percentage statements made in this bulletin refer to water-free material.

of fodder corn, but need to be improved in yield of grain, earliness of maturity, nutritive value and hardiness. Finally, we have varieties of sweet corn which need improvement in quality, reduction in the thickness of husk, a shorter time for ripening seed, and various minor points, of value to canners.

The old belief that corn growers would profit by bringing in seed from other localities in order to prevent a deterioration in yield and quality has been shown by careful experiments to be without foundation. It is true that we may bring in a well-bred seed corn from some careful breeder in another locality, and by inattention to selection have it degenerate in quality within a few years; but this only shows to greater advantage the value of having strains of corn selected for, and adapted to, particular soils and climates; strains that have become used to the imperfect physical and chemical conditions of certain soils, or the lack or superabundance of moisture in certain climates. Such adapted strains we have found in Connecticut where they have been subjected to a certain amount of selection on the same farm for many years and with some of these varieties the Connecticut Agricultural Experiment Station is now at work along the lines of improvement suggested above.

Methods of Selection.

There are three general methods of selection for corn improvement; first, the selection from the crib; second, the selection at husking time from the general field crop; third, selection *in* the field and use in a separate breeding plot. The first two methods have been until within a few years the only methods in use, and the progress made by their use has been very slow. The second method is a slight improvement over the first because better care can be given the selected corn during the winter; but neither does what it might be supposed to do toward the isolation of corn which has the power to yield well, and the power to transmit this quality. The reason is that no account is taken of the strength of the stalk, manner of bearing the ear, production of suckers, growth of brace roots, amount of leaves, etc., all of which necessarily have a great deal to do with the end in view. Moreover, the good qualities of a handsome ear selected from the crib may all be due to the accidental advantages of its environment; that is, it may have grown in a more fertile spot of ground, or it may have had the advantage of more space, and hence more plant food and sunlight, through accident to, or poor germination of, the neighboring kernels.

The third method of selection is the one which most commends itself, and which I wish to describe in detail. The method consists, in brief, of determining in a breeding plot the actual productive capacity of *each individual ear* used, and in selecting and breeding only from those ears which have proved their yielding efficiency.

The general plan is to grow a breeding plot upon uniform ground separate from the general field of corn. This breeding plot consists of a number of parallel rows of corn, each separate row having been planted from the kernels of *one* ear, so that the corn produced by each row represents the offspring of one single female parent. The rows being of equal length and the stand approximately alike (the germinating capacity of each ear having been tested), the weights of the corn produced on each row become an exact measure of the productive capacity of a single mother plant, and each ear from a row is the daughter of a mother which had a known productiveness. A pedigree record on the female side may, in this manner, be established. It often happens by this method, that in testing two seed ears practically alike in size, weight and general appearance, one yields at the rate of forty bushels per acre and the other at the rate of eighty bushels per acre. We find some very good-sized, nice looking ears in the forty bushel row, and we find some very poor ears in the seventy bushel row. By the other methods of selection the good ears from the forty bushel row would have an equal chance of selection for seed with those of the eighty bushel row, except for the probable greater number of them in the latter. All will agree, however, that there is an advantage in planting corn which came from the eighty bushel row.

I have found in a comparison of a number of ears that the smallest ear sometimes yields the greatest amount of grain in the next generation, when planted by the row system. The explanation is that this ear came from a strain that possessed to a remarkable degree the power of transmitting good yielding qualities, and while this individual happened to be small, possibly through disadvantage in environment, it still had the hereditary qualities of the strain from which it came. This principle has long been recognized in animal breeding. A breeder of fast horses in choosing a sire between two stallions of equal trotting ability will breed from the one having the largest get of fast colts. And since we now know that the breeding of plants is in its essentials like that of the breeding of animals, we use this method, based entirely on performance, in all breeding work. If we wish to increase the yield of grain we compare the amounts of grain produced by equal rows from single ears; if we wish to increase the protein, we plant ears which are high in protein content and select from the progeny which show the highest average protein content; or if we wish to increase the height of the stalk we select the high stalks from a "single ear row" in which they average high, but not from extremely high individuals in a row where the stalks were, on an average, short. Occasionally we find extreme variations, as yet unexplained, in rows when we would not expect to find them, and in passing these over we may possibly miss something of value, but in commercial corn breeding we cannot usually afford time to study abnormal variations of obscure cause, for only by stedfastly following the performance method are we likely to gradually attain our end.

Some combinations of character are naturally antagonistic, as very high yields and extreme earliness; and in such cases results are slow to obtain and are bounded by rather narrow limits.

Starting a Breeding Plot.

Those who wish to start breeding plots for corn improvement should begin with the best obtainable stock. A strain of corn which has given success in the neighborhood, or upon the same kind of soil, is the best;—one which is known to have had some attention paid toward its selection in the past. Having decided upon the variety he will use, the breeder should go through a field of it in the fall before the stalks are thoroughly ripe, and mark the best plants of those that have had no advantage of position in the field. He should select those which are of medium height, with strong stems, good brace roots, and broad healthy foliage; and which bear good ears at a proper height from the ground, covered with a moderate thickness of husk.

At cutting time, cut and stack these marked plants separately, and, when cured, make a final selection of the ears, taking only those that husk easily, that show uniform, deep, wedge-shape kernels, and possess strong vitality as shown by germination tests. Reject all ears that show any real fault, such as space between the rows or hybrid kernels, but do not spend time upon fancy points which have no probable correlation with yield; as shape of the dents, colors of the kernels, or fancy shapes. Finally, shell off the kernels from each ear and make a selection by comparative weights of grain.

Degrees of Relationship among Corn Plants.

It is possible to have several degrees of relationship among corn plants. First, the pollen from a plant may fertilize the ovules of the same plant. This we call self-pollination or inbreeding. Second, the pollen of a plant may fertilize the ovules of a sister plant, or one which has grown from the kernels of the same mother ear; this we call close-pollination or close-breeding. Finally, pollen from a plant may fertilize the ovules of a plant not closely related although of the same variety; this we call cross-pollination or cross-breeding. There are other relations between varieties, but with those we need not here concern themselves.

It has been demonstrated by the Illinois Experiment Station, that there is in the field a large possibility of inbreeding because a part of the pollen of each plant is shed at the same time that some of the silk on the same plant is mature. Such inbreeding has practically no effect upon the commercial field of corn where the crop is sold or fed and has no chance to reproduce itself. In the breeding plot there is a different condition with which to deal. We have there parallel rows of corn, each row being the progeny of one mother ear; and besides the probability of a great deal of inbreeding, there is also a possibility of close-breeding. Moreover when a small number of ears are selected and planted several of them from the same mother ear, the relationships between plants have a tendency to keep very close, and the effects of close-breeding tend to accumulate from year to year.

In an experiment at the Illinois Experiment Station, by detasseling alternate rows of a breeding plot, a cross was forced upon the detasseled rows, while in rows not detasseled there still remained the same tendency to self-pollination. From the best yielding among these tasseled rows, more or less inbred corn was selected for the next year's seed, while cross-bred corn was selected each year from the best detasseled rows, and crossed again. In this manner the experiment was carried on for three years, each year planting rows that were to be left tasseled from corn that was grown upon tasseled rows, and planting rows that were to be detasseled from corn grown on detasseled rows. *Thus the hereditary effect of probable inbreeding upon the yield in a breeding plot was determined, and it was found that the crossed rows yielded in the second and third years an average of about ten bushels per acre more than the tasseled rows.* The effect would probably have been greater except that the pollen falling on the detasseled rows came from rows more or less inbred.

To overcome this difficulty the breeder *detassels* every alternate row in his breeding plot, and *selects all seed for planting next year's breeding plot only from the detasseled rows.* This makes it absolutely certain that all the corn which is planted in the breeding plot, is the product of a cross in each and every previous year since breeding began.

The Breeding Plot.

In size the breeding plot should be as large as it is possible to put upon uniform land and have given to it all the attention that is necessary to bring success. A convenient size is one of ninety-six rows wide and not less than one hundred hills long. Ninety-six rows are taken on acccount of the number of times two is contained as a factor, as will be seen is necessary, when making the selections.

*In this plot are planted ninety-six ears of the corn which has

*Note.—Breeding plots should always be planted in hills and not in drills, if planted by machine, in order to give the plants more nearly equal soil area.

been selected the previous fall in the manner described, planting each row with the kernels from only one ear. The plan of planting the ears in this first breeding plot need not be considered, because all previous pedigree or relationship between the ears is unknown. In all succeeding years the corn is to be planted according to a plan hereinafter described which has been devised to separate as widely as possible rows which are probably related. This method will reduce close relationships to a minimum and avoid their evil results.

DETASSELING.

When the first tassels appear, those borne on stalks in *all even numbered* rows should be *pulled* out before any pollen falls. Cutting the tassels from the stalk has an injurious effect, and carelessness sometimes deprives the stalk of several undeveloped leaves. If the tassel is given a steady, upward pull when at the right stage, it will separate at the top joint without injury to the plant. The even-numbered rows will need detasseling several different times to prevent any pollen from maturing, but if this is done completely, all self-pollination or close-pollination is absolutely prevented.

At the same time the odd-numbered rows should be carefully looked over, and any stalks or suckers which are very small and weak, which are barren, or which possess other bad characteristics which they are likely to transmit,* should be detasseled before any pollen can mature. Sometimes a whole row should be detasseled, because of the uniform appearance in it of some particularly undesirable character.

MAKING SELECTIONS FROM BREEDING PLOT.

When the crop is almost mature, the breeder should go carefully through each of the forty-eight even or detasseled rows and select from ten to twenty good ears, taking into consideration the different points of advantage and disadvantage concerning the stalk, as was done in the selection the previous year. These stalks are numbered and tagged to correspond

*NOTE.—Barrenness is probably not transmittable, but we should always act on the safe side, on disputed questions.

with a number in the record book. The ears are harvested when mature, tagged with the same tag, and placed together with all those from the same row, in bags marked with the row number. Then each of the forty-eight detasseled rows is harvested and weighed up separately, together with the selected corn from the same row.

A comparison of the total weights of the ears from each row is the basis of selection of the rows from which to take seed for the next year, and in this selection fifty per cent. of the rows are discarded. The forty-eight rows are however considered in four quarters as shown on page 15. We select the six best yielding rows out of the twelve detasseled rows in each quarter. This is done for two reasons; first, in order to avoid selecting too many ears from a few extremely good rows and thus breed from closely related plants; and second, a comparison by weight of each quarter's rows by themselves avoids somewhat the error of comparing two rows widely separated, and on uneven ground.

After comparing the ears from each row, noting the points mentioned on page 11, the final selection for the next year's planting should include four ears from each of these twenty-four rows, again making the ninety-six ears. Two ears from each row are used to plant in odd-numbered rows to furnish pollen (tasseled rows), and two to plant in even-numbered rows to be detasseled, and from which all seed is to be taken.

Plan for Planting

The plan for planting the breeding plot for this year and for each succeeding year, in such order as to obtain the greatest possible amount of cross-breeding, and to avoid the evil effects of close-breeding and inbreeding, is shown in Table I. In this table are worked out plans for planting which may be followed perpetually by substituting the number of the rows of your own selection, that is, your own best producing rows for the numbers given in the guide systems. In the guide systems, for the sake of convenience, the first six even-numbered rows of each quarter have been used as the selected rows, and have been placed in the proper order for the next year's planting. There is a slight change in the system in alternate years, and the

TABLE I.—PLAN FOR PLANTING THE BREEDING PLOT TO AVOID IN-BREEDING—(after the Ill. Exp. Sta.).

The numbers given in the "Guides" designate the field rows from which the seed ears are taken. (All even-numbered rows are detasseled.)

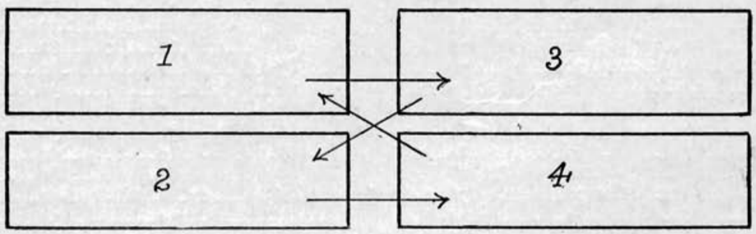
Field row No.	Guide system for even years.	Guide system for odd years.	Field row No.	Guide system for even years.	Guide system for odd years.
1	76	78	51	2	4
2	2	2	52	52	52
3	80	82	53	6	8
4	6	6	54	56	56
5	84	86	55	10	12
6	10	10	56	60	60
7	78	76	57	4	2
8	4	4	58	54	54
9	82	80	59	8	6
10	8	8	60	58	58
11	86	84	61	12	10
12	12	12	62	62	62
13	78	76	63	4	2
14	2	2	64	52	52
15	82	80	65	8	6
16	6	6	66	56	56
17	86	84	67	12	10
18	10	10	68	60	60
19	76	78	69	2	4
20	4	4	70	54	54
21	80	82	71	6	8
22	8	8	72	58	58
23	84	86	73	10	12
24	12	12	74	62	62
25	52	54	75	26	28
26	26	26	76	76	76
27	56	58	77	30	32
28	30	30	78	80	80
29	60	62	79	34	36
30	34	34	80	84	84
31	54	52	81	28	26
32	28	28	82	78	78
33	58	56	83	32	30
34	32	32	84	82	82
35	62	60	85	36	34
36	36	36	86	86	86
37	54	52	87	28	26
38	26	26	88	76	76
39	58	56	89	32	30
40	30	30	90	80	80
41	62	60	91	36	34
42	34	34	92	84	84
43	52	54	93	26	28
44	28	28	94	78	78
45	56	58	95	30	32
46	32	32	96	82	82
47	60	62	97	34	36
48	36	36	98	86	86

NOTE:—Numbers 49 and 50 are omitted for the convenience of having end to end rows with the same final digit.

two systems are distinguished as "guide system for even-numbered years" and "guide system for odd-numbered years," respectively.

The seed for even-numbered rows is always kept in the same quarter in which it grew, while the seed for odd-numbered rows is always brought from another quarter. To facilitate this plan it is convenient to have the field shaped as it is shown in the diagram, that is, quarters three and four end to end with quarters one and two, although no particular arrangement is absolutely necessary. The direction of changing the "tasseled seed" is illustrated in the diagram.

DIRECTION OF THE ANNUAL CHANGE OF SEED FOR TASSELED ROWS.



For the first quarter "tasseled seed" is brought from the fourth quarter, for the fourth quarter from the second, for the second from the third, and for the third from the first. This is done in order to carry the seed to bear "tasseled stalks" as far away as possible from their sister ears, which are to remain in the quarter in which they grew and produce "detasseled stalks."

THE MANNER IN WHICH WE ARRIVE AT THE "PLAN FOR PLANTING IN EVEN YEARS" IS AS FOLLOWS: *First consider the even-numbered rows of quarter number one. Place the selected rows in proper ascending sequence as,* **2**, 4, **6**, 8, **10**, 12,—*then place them in sets of three, using alternate numbers and repeating*: 2, 6, 10,—4, 8, 12,—2, 6, 10,—4, 8, 12.

Then for the odd-numbered rows bring seed from the proper quarter (fourth in this case), and make the plan in the same manner, except that the order of the two sets of three is reversed in the second set of six. Suppose the rows to be 76, 78, 80, 82, 84, 86; *then the plan would be* 76, 80, 84,—78, 82, 86,—78, 82, 86,—76, 80, 84.

The plan of planting for the odd-numbered years is the same as that of even years, except that the two sets of six are transposed in planting the odd-numbered rows.

The corn breeder should work out a "plan for planting" for both odd-numbered and even-numbered years, by these directions, using as selected rows the first six even-numbered "field rows." These plans should duplicate the "guide systems" shown in the table and should be compared with them for correctness. After once working out the system it is very simple to make actual working plans for breeding plots in the same manner, putting down the six rows actually selected in each quarter in ascending sequence and following the directions for arranging as before.

Increase Plot.

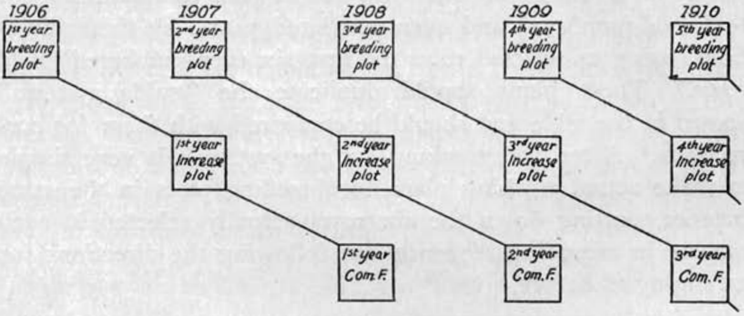
This is a plot to be grown from the remaining good seed corn from the selected rows after the seed for the breeding plot has been selected. The plot may be as large as the seed will permit, and is grown in order to increase the amount of "pedigreed" seed. The seed for planting this field should be mixed together and planted where no pollen from other corn can reach it. No rows need be detasseled but no particularly weak and no barren stalks should be allowed to mature pollen. A record of the yield per acre should be kept.

Commercial Field.

From the best* seed from the increase plot, seed is taken to plant a commercial field, or field from which seed may be sold as registered seed corn. The yield here also should be carefully computed and recorded. This plan will bring the seed from the commercial field always two years behind the breeding plot. If a breeding plot is started in 1906, in 1909 it will have had three years selection; then in the winter of 1911-1912 seed from the commercial field can be sold with three years breeding behind it, as is shown in the following diagram.

*"Best" here means a selection such as was made in order to start the breeding plot, as we cannot here test actual productive efficiency.

As can be seen, any seed from the increase plot not used in the (commercial) field could be sold as having one more year's breeding than that from the commercial field of the same year.



Record Keeping.

A register sheet for keeping the records of the breeding plot, which is used at the Experiment Station, is here shown in miniature. The full size sheet is 12 × 18¾ inches, which fits a Sieber and Trussel Mfg. Co. loose leaf ledger cover.*

Some of the columns for data found on the record sheet are not necessary to every corn breeder. They are being used, however, at the Experiment Station, to further the improvement of corn as fast as possible. Almost all of the headings to the columns are self-explanatory; some, however, need explanation.

The "registered number" is made up of five† places, and is the permanent number designating any ear of corn planted in a breeding plot. It may be considered as being divided into three parts. The first figure denotes the year of breeding, the next two places denote the row in which the ear is planted, and the last two places represent the row from which it came the previous year. Suppose 10600 to be a register number for the first year. The first figure 1 would mean that this was the first year's breeding. The next two places 06 would mean that it was to be planted in row 6. The last two places are ciphers,

---

*Note.—The station will gladly supply these sheets to any one wishing to take up the breeding and selection of corn, and will also cheerfully give any necessary help in arranging plans for planting or other details of the work.

† In the tenth year of breeding and after, it would contain six places.

CORN REGISTER

OF EARS PLANTED IN BREEDING PLOT

Size of Plot.. *Breeder*..

Distance between hills.......................... *Variety*..

Distance between rows.......................... Located in.......................... Date.................. *Purpose*..

	Designation.		Description of Mother Plant.										Description of Seed Ears.											Record of Resulting Rows.						
	Register No.	Annual Ear No.	Height of Stalk.	Height of Ear.	Length of Shank.	Strength of Stalk.	Foliage.	No. of Suckers.	Secondary Root System.	No. Days Maturing.	Husk.		Length of Ear.	Butt Cir. Ear. Top Cir.	Weight of Ear.	Weight of Cob.	Butt Cir. Cob. Top Cir.	No. Rows Kernels.	No. Kernels in Row.	Shape of Kernels.	Ease of Husking.	Per cent. Protein in Grain.		Planted in Field Row No.	Corn, Pounds per Row.	Corn. Bushels per Acre.	Stover, Pounds per Row.	Stover Tons per Acre.	Per cent. Protein in Grain.	
	Average..																													

Rotation..................................
Fertilizers Applied....................
Vitality of Seed........................
Date of Planting........................
No. Kernels per Hill..................
Per cent. of Stand......................

Stalks per Hill, after thinning.......
Per cent. Stand, after thinning.......
Dates of Detasseling...................
Date of Cutting..........................
Date of Husking.........................

Remarks:

Yield of Multiplying Plot, Year (....).......
Yield of Commercial Field, Year (....).......

because this is the first year's breeding and we have no pedigree record of the mother ear. Now suppose an ear coming from the row representing this ear (row 6) was to be planted in row 4 the next year, its register number would be 20406; 2 meaning second year's breeding; 04, that it is to be planted in row 4; 06, that it came from row six in the previous year. By this means any ear can be easily traced back for any number of years on the pedigree record.

The annual ear numbers are the numbers given to the selected stalks in the fall, and transferred to the ears when harvested.* These numbers are used to designate the ears during the winter while comparing them, making germination tests, etc. The data taken on the stalks at the fall selection should be taken in a separate record book, and when the final selection of ears is made, only such data as refer to ears actually planted should be copied on the permanent register blank.

The records of the ears are then put down, and these if taken in full will practically permit of the reconstruction of the ear on paper should a study of its characteristics be needed in after years. The data taken upon the ears is also valuable in comparing the percentage of transmission of any good quality from an ear to its progeny.

The last, and most important of all records, is the recording of the breeding performances of these ears, under the general heading, "Records of resulting rows." These records are our bases of comparison for selection of rows, and mistakes made here are very far-reaching in their consequences. It should be noticed that in making the weights of rows of equal length, that each quarter, in which rows are to be compared among themselves, should be cut on the same day, and husked and weighed upon the same day, in order that the moisture in the corn will be as nearly equal as possible when the rows are compared.

Knowing the distance apart of the rows and hills, it is easy to calculate the yield of each row to bushels per acre, and compare them on that basis. If the hills and rows are $3\frac{1}{2} \times 3\frac{1}{2}$ ft., there are 3556 hills in an acre; then, if we have weighed up

*When two ears are borne on a stalk, give them the same number and distinguish upper and lower, as 89 U. and 89 L.

one hundred hills in each row, we will obtain the yield in bushels per acre by multiplying our weight by 35.56 and dividing by the number of pounds in a bushel. The latter item will be from seventy to eighty pounds according to the amount of drying it has received, between cutting and husking.

In conclusion, I might say that it will probably always be more profitable for farmers who grow only a small amount of corn, to buy their seed; but they should be able to buy it from some reliable seed corn grower, who grows a breeding plot and is striving to the best of his ability to select a strain of corn that will be adapted to their locality,—one that will produce better yields on that particular soil, and under those climatic conditions. Such seed is worth an advanced price in the market, and does obtain it as is shown by the great demand by growers for pure-bred seed at advanced prices in the states of the middle west. There is scarcely a doubt but that several men in each county in Connecticut could make such work financially profitable, besides being benefactors to the state at large.

The Connecticut Agricultural Experiment Station would be glad to correspond with any farmer who desires to start a corn breeding plot. If requested, the agronomist of the station will come and assist the breeder in deciding the location, planning the rotation and the general management of the breeding plot.