CONNECTICUT

AGRICULTURAL EXPERIMENT STATION

NEW HAVEN, CONN.

BULLETIN 150, JUNE, 1905.

The Selection of Tobacco Seed Plants.

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The Selection of Tobacco Seed Plants.*

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Every grower is familiar with the fact that no two tobacco plants are alike. Frequently the grower finds a plant in the field that almost or quite fulfils his ideal of a perfect plant. It would be very desirable to produce uniform crops of the type of these best plants, because they would be much more productive and of better quality. As a result of the investigations which have been carried on in the Connecticut valley and elsewhere, it has been found that it is possible for every grower to select the type of plant he desires to grow as seed plants, and by protecting the flowers produced by these plants from cross-fertilization, to secure uniform types or strains like the parent seed plants. This important improvement can be made by the grower in a simple and practical manner, as described in the following article, without any extra expense and with very little trouble or work. In view of the fact that any improvement in the yield or quality of the crop secured by seed selection is pure profit, because it costs no more to grow good plants than poor ones, there is no farmer who can afford to grow a poor type of tobacco when it is possible to produce improved strains.

Possibility of Improving the Quality of Tobacco.

There is no lack of either practical experience or experimental evidence to prove that improved strains of tobacco may be produced by systematic seed selection and breeding. In the Connecticut valley there are many strains of the broadleaf or seed leaf variety, which are adapted to certain market requirements, or local soil and climatic conditions. The broadleaf variety is commonly believed to have been produced from the Maryland smoking tobacco variety, the seed of which was brought into the valley over a half-century ago. The

* For a more complete discussion see Year Book U. S. Dept. Agric. 1904.

local strains, as the Halliday, the Willow brook, and many others, were produced by certain growers who selected a particular type of seed plant that suited their fancy for several years in the usual manner until the type became fairly uniform and constant. The popular Havana seed variety is reported to have been produced from seed originally imported from Cuba, and grown in Connecticut for a number of years in small patches, until the variety had become adapted to the soil and climatic conditions of this section. There are at present a number of strains of this variety, distinguished by peculiar shape of leaves or other characteristics, which have been secured by many years of careful seed selection by the growers. One of the most striking illustrations of the possibilities of seed selection is the origin of the White Burley variety. This variety, as is well known, was produced by a grower in southern Ohio, who noticed in his field of Red Burley these plants having the peculiarities of the now well-known White Burley type, and saved them for seed. From this beginning a great industry has been developed in southern Ohio, in Kentucky and other states. Numberless other illustrations might be cited in this connection, but on account of the fact that they are well known to almost every grower, and are matters of history, it is unnecessary to further comment on the work that has been done, in order to prove the fact that it is possible to greatly modify and improve this crop by an application of the laws of plant breeding.

In the season of 1903 the writer began a series of experiments in the Connecticut valley with tobacco in order to determine the possibilities of improvement by the application of the laws of plant breeding, as worked out in the cases of corn, cotton and other farm crops, and to find the methods by which this improvement could most rapidly be effected. It is not opportune in this short bulletin to go into details as to the results of the experiments in that and the succeeding season, which will be presented in a later and more extended bulletin, but the general results will be briefly discussed here and the practical results and methods presented for the help of the growers for this season. This matter is not theoretical or impractical and of scientific interest only, but it is intensely practical and can be applied by every grower of tobacco to the advantage of his crop, and with increased profits in his business.

Lack of Uniformity of Plants in the Average Tobacco Crop.

The extent of the variation or lack of uniformity among plants in fields of tobacco in the Connecticut valley is best illustrated in the crops grown from seed originally imported from Sumatra and Cuba, but grown in Connecticut for several years. In a careful and systematic study of such crops by the writer, it was found that the difference in plants was so great that it was possible to separate out and classify several distinct types. The differences between these types were just as marked as the distinguishing characteristics of the broadleaf and the Havana seed varieties. These variations were not due to local soil or fertilizer conditions, as generally supposed, but to the seed, as shown by the fact that they occurred in all parts of the fields investigated, in many cases two plants of radically different types growing side by side under as nearly uniform conditions as is ever secured. The type characteristics were very marked, and easily distinguished, even by the most casual observer. Some of these are shown in Plate I. In one of the types of Connecticut Sumatra the leaf was very long, narrow, heavy, with peculiar angular veins, unusual light greenish gray color, and of very peculiar and characteristic habit of growth. From its fancied resemblance to the so-called Belgian tobacco, it was called and is recorded as the Belgian type. Another of the types produced nicely rounded leaves, from eighteen to thirty on every plant, with very peculiar wavy or crumpled edges, comparable in many ways to the crumpled leaves of some varieties of lettuce. The leaves of this type were very thin and in most cases lacked strength and elasticity, so that when wrapped on cigars a considerable percentage was likely to break or be injured in some manner. From the characteristic wavy margin of the leaves, these plants of tobacco were classified as the crumpled type. Another type found in these crops, called the Sumatra, produced leaves that were nearly round and were borne in a drooping position on the stalks. This type of leaf in the field was pronounced by one of the extensive growers as ideal for cigar wrapper purposes, so far as the shape of leaf and other qualities that can be determined in the field were concerned. The leaves had good body, and extremely regular and fine veins, which stood out almost at right angles with the mid ribs. One of the most striking types

produced very large leaves, in many cases larger than the largest strains of the broadleaf variety, and a characteristically large number of them. While the growth of the plants was very slow in the first part of the season, they produced ripe tobacco as soon as the early maturing types. The rate of growth of the plants of this type in twenty-four hours, at the middle of the season, was nearly double that of corn at the most favorable time for rapid growth. Another type produced characteristically small leaves, called the greenleaf type, because of the deep shade of green color of the leaves. The average length of the leaves of this type was not more than one-quarter the average length of the leaves of the broadleaf type. The leaves were very uniform in size as well as shape from the top to the bottom of the plants. The number of leaves per plant was very large, in many cases plants producing forty desirable leaves. This increase in number of leaves in this type was not accompanied by a corresponding increase in the height of the plants, but was correlated with short internodes or spaces between the leaves on the stalk.

In all of the crops grown from freshly imported seed, there appeared a large proportion of abnormally early, small, heavy leaved types, commonly called freaks. These plants had in most cases the branching habit of the wild or unimproved varieties of tobacco, and for this and other well-founded reasons were supposed to be reversions to some of the unimproved varieties from which the present varieties have been developed. These freaks were particularly noticeable in the crops grown from freshly imported Cuban seed. In one typical field of this kind, the writer found about thirty-three per cent. of the plants to be of this freak type. The irregular stand can be seen in Plate II, prepared from a photograph of this field. Inasmuch as the leaves produced by the freak plants are almost wholly worthless for wrapper purposes, it can readily be seen that such crops are not profitable to the growers. After a most careful study of this subject it can be safely said that in no case should growers depend on freshly imported seed for their main crops of tobacco. If it is desirable for the grower to test foreign, imported or new seed of any kind, it should be done on a small scale until it is determined that the variety is adapted to local soil and climatic conditions,

or acclimated strains are produced by seed selection and breeding.

The variation *in type* in the broadleaf, Havana seed and other so-called native varieties is not so marked as in the case of varieties grown from recently imported seed. The *individual variation* or differences between different plants as regards the number, shape, and size of leaves, the number of suckers, the number of seed pods and other characters are nearly as great as among plants grown from imported seed. In every field examined some plants were found with nearly double the number of leaves found on the average plants in the field. Many plants produce rounded leaves, while others bear long, narrow and pointed leaves. Some plants have a large number of suckers, while others have comparatively few of them. Some plants produce from one hundred and fifty to two hundred seed pods, while others bear from twenty-five to one hundred pods. In many instances the writer has found plants that produce ripened leaves two weeks earlier than the remainder of the crop. Many plants produce leaves that ripen uniformly from the top to the bottom of the plants, while others produce bottom leaves and lower leaves that ripen from ten days to two weeks before the upper or top leaves are ready to harvest. Some plants produce leaves with large and coarse veins, while others in the same field bear leaves with fine and small veins. Individual plants were found in all fields bearing leaves having more desirable body, stretch or elasticity, color or appearance, and other characteristics, than the other plants in the same field. In fact the tobacco crops present the greatest amount of variation in type and individual characteristics of any farm crop known to the writer. The large number of grades of color, sizes, and qualities of leaves, which the growers find necessary to assort after the tobacco is cured or fermented, is definite evidence of the lack of uniformity in this crop. This lack of uniformity in the crop is detrimental to its value, not only because some of the grades are poor and of very little value, but also on account of the cost of assorting these variations into their respective grades.

Increase in the uniformity of the tobacco crop means increased yield and a more valuable crop. Inasmuch as it

costs as much, if not more, to grow a crop lacking in uniformity, as to grow a uniform crop of desirable plants, this increase in value is pure profit to the grower. The methods of seed selection and breeding presented in this bulletin have been found both experimentally and in farm practice to produce more uniform crops of tobacco, with no extra expense to the grower.

Self-Fertilization and Cross-Fertilization of Tobacco.

In order to present the methods of seed selection and breeding, it is necessary to refer to the tobacco flowers and the natural method of fertilization in tobacco plants. The appearance and structure of the flower may be seen in Plates III and VI. The tobacco flower consists of a brightly colored tube-like corolla, enclosing five, more or less, stamens, *i. e.,* slender filaments bearing at their ends plump bodies, called anthers, in shape somewhat resembling a cigar. When the flower is just about to open, these anthers contain a large amount of fine dust-like particles, the pollen grains, or the male fertilizing element of the flower. At the base of the flower is a small pod-like receptacle, which later forms the seed pod and which bears a long, slender, rod-like projection, having a knob-like swelling at the tip, the whole being called the pistil. This knob-like portion is the receptive part of the female portion, or stigma of the flower, on which the pollen falls which fertilizes the flower. In the early stage of the development of the flower, this stigma projects above the cluster of anthers, but later the anthers gradually grow past it, at the same time opening and discharging the pollen so that it falls on and fertilizes the stigma. At this time the stigma will be found to be covered with a sticky substance to which the pollen adheres. Gradually the anthers push out of the opened flower and project beyond the stigma. The different stages in the development of the flower and seed are shown in Plate VI. At the base of the tube-like corolla will be found a secretion of sweetish honey-like substance, which can be shaken out of the flowers and falls like drops of rain on the plant. Many species of bees and other small insects crawl down into the opened flowers and feed upon this honey-like substance. The writer has observed humming birds feeding on this honey, similar to the

manner in which they visit the flowers of the common honeysuckle. In passing to and from these flowers, they naturally carry the pollen from flower to flower, and from plant to plant and rub it off on the stigmas, and in this way effect "cross-fertilization" among the plants in the field. Cross-fertilization must be very general among tobacco seed plants in the field under the ordinary conditions.

A flower is "self-fertilized" when the seeds are produced by the impregnation or fertilization of its pistil by pollen from its own stamens. It is "cross-fertilized" when seeds are produced by impregnation with pollen from another plant. In some species of plants cross-fertilization is absolutely essential to seed production. In other species it produces more and better seed than self-fertilization. But tobacco belongs to still another class of plants which are abundantly self-fertile and in which self-fertilization is apparently more effective for seed production than cross-fertilization.

Charles Darwin found in greenhouse experiments that "in six trials with crossed and self-fertilized" (tobacco) "plants, belonging to three successive generations, in one alone did the crossed show any marked superiority in height over the self-fertilized; in four of the trials they were approximately equal; and in one (i. e. in the first generation) the self-fertilized plants were greatly superior to the crossed. In no case did the capsules from flowers fertilized with pollen from a distinct plant yield many more and sometimes they yielded much fewer seeds than the capsules from self-fertilized flowers."

Advantages of Using Seed from Self-Fertilized Flowers.

In the last two years, extensive experiments have been made in the Connecticut valley on the relative value of seed produced by exclusive self-fertilization and of seed produced by natural cross-fertilization. These experiments have been made with the Connecticut Havana, Broadleaf, Sumatra and Cuban types of tobacco, under cloth and in the open, and on a commercial scale; in all cases with like results. These results we consider are of the very greatest importance to growers and are here very briefly summarized.

Seed produced by exclusive self-fertilization for the two generations covered by our observations has been lighter in

color, heavier, freer from mold or fungous disease, and in all ways more valuable, as will appear in what follows.

The plants grown from self-fertilized seed reproduced exactly the character of the mother plant from which they came. If the parent had large leaves, so did all the progeny. If the parent had small leaves, so did all the progeny; and in both cases the average size was the same as the average size of the parent's leaves. This uniformity and exact reproduction of the characters of the mother plant are well shown in Plate IV. Figure A shows two rows of plants from the self-fertilized seed of a single mother plant. The uniformity in size of the plants as well in the shape, size, veining and number of leaves is very striking. The adjoining rows of tobacco are of a different type. Figure B, on the same plate, shows a like uniformity in two rows of plants from seed of a single mother plant of the so-called Belgian type.

Plants from a parent with few suckers had correspondingly few suckers. The shape of the leaves of the offspring was closely like the shape of the parent's leaves.

The same correspondence appeared in the number of leaves. If the parent had thirty-five leaves, the offspring averaged about thirty-five leaves. If the parent bore ten, the offspring averaged ten.

In a word, the individual characters, such as shape and color of leaves, numbers of leaves and suckers, body or texture, size of veins, time of maturity, and all other observed characters were transmitted from the parent seed plants to their offspring with marvelous uniformity.

Two particular experiments emphasize this accurate transmission of individual characters by the seed of self-fertilized flowers.

In a field of Connecticut Sumatra, several hundred parent plants of different types were selected and the seed saved under bag; hence it was exclusively from self-fertilization. The progeny of these plants were set out in separate rows in the same field, under as uniform conditions as it is possible to secure, the following season. One of these types produced leaves which would not burn, even with all of the tests that were applied. Growing side by side with this type, in several parts of the field, was another type, which, tested in the same

ways, had the most perfect burn of any kind of tobacco grown in any part of the world. Here were two types, from the same original lot of seed, the parents grown in the same field, the progeny grown under as uniform condition as is ever secured in the field, the tobacco cured and fermented absolutely alike, one of which would not burn, and the other burned perfectly.

One more instance is presented because of its specially interesting nature and importance. A field was set out with plants grown from imported seed, which were attacked by a fungous root disease, and all died with the exception of a few plants. These resistant or immune plants were found irregularly over the field, and produced ripe tobacco of excellent quality. All the other plants were completely destroyed with the exception of one or two semi-resistant plants that produced a large amount of seed, but very few and extremely small leaves. The seed was saved separately from the resistant and semi-resistant plants, and sowed in separate sections of the seed beds. The resistant seed produced perfectly resistant plants, both in the seed bed, and in the field where the plants were destroyed the previous year. These are shown in Plate V. Most of the seedlings from the semi-resistant seed died in the seed bed, but enough were finally secured to set out one or two rows in the field. These plants grew slowly, some died, and none reached maturity, all having the characteristics of the diseased plants in root, stalk and leaves. Some of the resistant seed was sowed on the seed beds where the diseased seedlings had been destroyed by the disease, and this immune seed produced perfectly resistant plants under these circumstances.

These extensive observations and experiments show that the transmitting power, as defined by Dr. H. J. Webber, or the "prepotency" of the seed of tobacco from self-fertilized flowers is wonderful, and we believe of very great practical importance. With an understanding of its value, with keen observation of the characters of individual tobacco plants which it is desirable to retain and reproduce, and with very little labor, the grower can modify, change and improve his strain of tobacco and can produce crops which are uniform in all respects and like the parent plants which he selects for self-fertilized seed production.

Method of Selecting Plants and Securing Self-Fertilization.

We may now briefly describe how this is to be done. In the first place, the field from which the selections of seed plants are to be made should be gone over carefully, before the plants are topped, and the plants which come nearest the ideal of the grower should be selected for seed plants. This selection can be made at any time before topping, during the cultivation of the field as well as by special visits for this purpose, and during the topping process. The grower should, at these times, carry a handful of tags in his pocket and tie one on each of the plants which suits his fancy. No good selections are ever made, or permanent progress accomplished, by hit or miss and careless methods. The seed heads of the selected seed plants must be covered before any of the flowers open in order to prevent any possible cross-fertilization. If, by accident, some flowers have opened before the seed heads are bagged, they should be carefully picked off and thrown away. It is a good plan to pick off all of the top leaves down to where the plant would have been topped if it had not been saved for seed. All of the large lower seed branches should be broken off, and only the central cluster of seed-bearing branches left for seed purposes. As a rule, each mature pod contains from three to seven thousand seed, so it can be readily seen that a few pods will produce a large amount of seed. Of course, the grower should save many times the amount of seed that he expects to use.

The common manila twelve-pound grocery bag, procurable at any good grocery, hardware, or general store, is admirably suited for this purpose. The bag with a roof-shaped bottom is better than the square-bottom shape because it sheds the rain better. The bag should be carefully fitted over the seed head, and the open end tied around the stalk below the seed head, not so tightly as to injure the plant, or so loosely as to allow the bag to be slipped or blown off by the wind, or allow the visits of insects which might crawl up the stem inside the bag. The adjustment of the bag is shown in Plate VII.

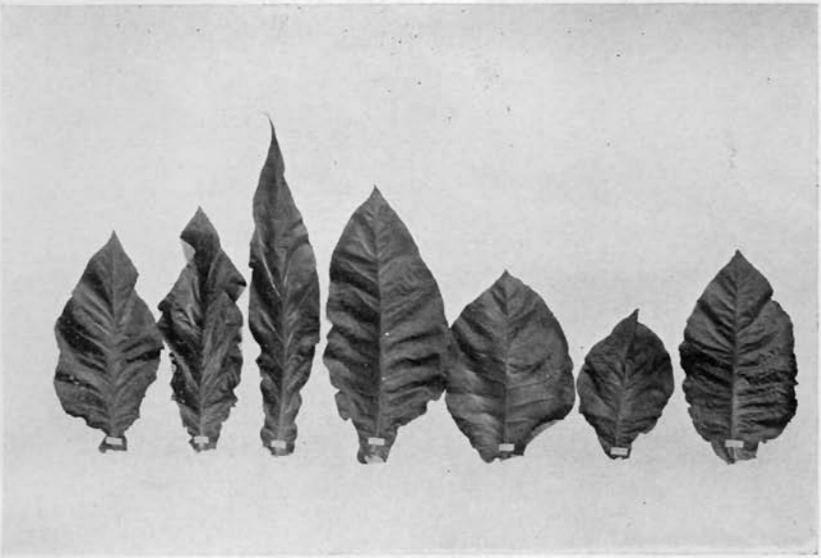
As the plant grows in height, the bag should be moved up the plant so as to accommodate the extra growth and prevent the seed head from pressing against the bottom of the bag, which might injure or break off the flowers and seed pods. Late in the season, after all or most of the pods have set, the bags

should be opened and all of the loose flowers and other debris shaken out, after which it should be immediately retied and allowed to remain in this condition until the pods have turned brown, indicating maturity. Some growers advocate picking off the leaves from the seed plants as they ripen, while others allow them to remain until the seed heads are harvested. If the suckers are carefully kept removed, it will be perfectly safe to allow the leaves to remain on the seed plants. On the other hand, if it is desirable to save the leaves, they can be picked off as they ripen without injury to the seed.

We would advise those who wish to make the most careful selection and who have the facilities for it, to pick the leaves from the separate seed plants, when they are ripe, cure them as usual in the barn with the rest of the crop, keeping the leaves of each plant by themselves, suitably labeled. If opportunity offers, let them be fermented with other tobacco during the winter. They can then be judged quite fairly as to burn, colors and texture, and the seed of the very best of them saved for the following crops.

When the pods are mature, the seed heads, bags and all, should be cut off, and hung up in a dry, airy place, where they can thoroughly dry out with a free circulation of air. After drying it is a good plan to keep them where the temperature does not fall much below zero. In the spring, when the time comes for the preparation of the seed for sowing, the largest and best pods should be picked off by hand, and thoroughly threshed out to remove all seed. The seed should then be separated with the seed separator in the way described in Bulletin 149 of this Station.

PLATE I.



Differences in characters of leaves from plants of the same variety of tobacco.

PLATE II.

Tobacco grown in Connecticut from Seed just imported from Cuba, showing freak plants and irregular stand.

A Flower-Head of Tobacco ready to cover. The opened flowers show position of anthers and stigmas at time of fertilization.

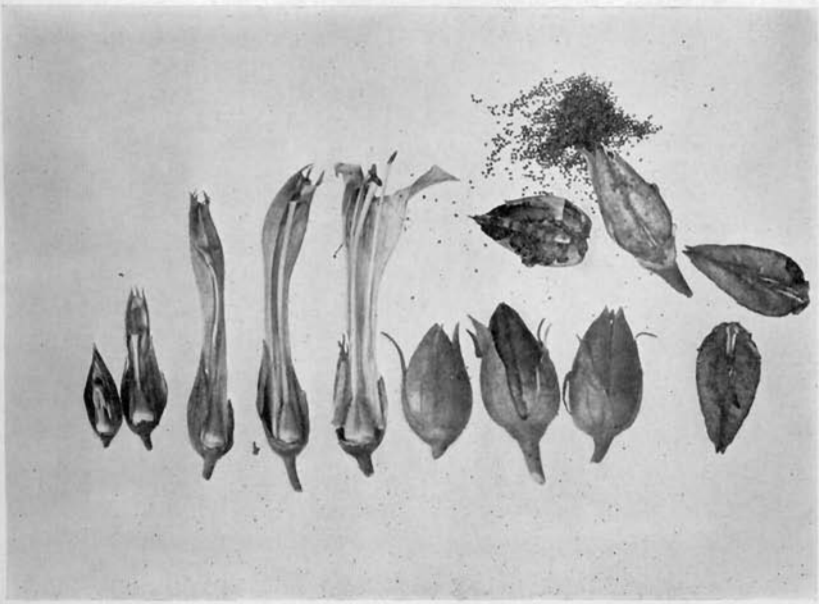
Fig. A. Uniformity in Tobacco Plants from Self-fertilized Seed. The two central rows of one strain ; adjoining rows from a different strain of same variety.

Fig. B. Uniformity in Tobacco Plants from Self-fertilized Seed of Belgian type.

PLATE V.

Resistant and semi-resistant Plants growing on infected Soil.

PLATE VI.



Different stages in the Development of the Tobacco Flower and Seed.

Flower Head protected from foreign pollen ("cross-fertilization"), by a manila bag.