

STUDIES IN INHERITANCE IN SUGAR CANE.

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INTRODUCTION.

Although only a few experiments have been conducted in the breeding work with sugar cane at this Station, for the sole purpose of studying inheritance and related subjects, it has been the purpose, as the work progressed, to secure as many useful data as possible from the seedlings which were being propagated and selected. Points which are of interest are the extent to which characters are inherited from the parent varieties when the latter are self-pollinated; whether new types are produced in the nature of mutations; and in what manner and to what degree varieties can be expected to transmit their characters to seedlings when crossed. Various cane varieties have been tried as seed-producers, and it has become evident that, in general, when cross-pollination has not been attempted, there is clearly a difference in the appearance and apparent value of seedlings produced from the different varieties, and that there is also considerable difference in the amount of resemblance to the parent varieties. In many cases this resemblance is plain, and in others there is very little similarity. The reason for this may be that all cane varieties are probably more or less heterozygous, the cases of closer resemblance being due to more homozygous parentage. It is also possible that accidental intercrossing sometimes takes place between varieties growing in the same locality, and that this affects the appearance of the resulting seedlings. Resemblance to both parents has also been observed, when cross-pollination has been affected between varieties, and it is worthy of note that in some cases similarity to the pollinating parent is very plain.

SEEDLINGS SHOWING RESEMBLANCE TO SEED PARENT.¹

A very close resemblance of seedlings to parent cane, as to visual characters, has been observed every year since 1913 in seedlings pro-

¹ For descriptions of cane varieties see "A Method of Identification and Description of Sugar Cane Varieties and its Application to Types Grown in Porto Rico"; H. B. Cowgill, Plant Breeder, Insular Experiment Station, Porto Rico; *Journal of the Department of Agriculture*, Vol. 1, No. 3, July, 1917.

duced from seed of D-109.¹ This is a dark greenish-red to purple cane, usually reclining in habit, with buds before expanding semi-elliptical in shape. Many of the seedlings plainly show some or all of these characteristics, while the resemblance as to color is especially noticeable.

A great majority of the seedlings of T-77 are very much like this variety in color and habit, and resemble it more or less as to the form of the bud.

Out of thirty-four seedlings produced in 1916 from B-347, a light-colored cane, only two were of a darker shade than the parent, and seventeen of them showed spots on the internodes more or less like the characteristic spots on the parent variety.

The B-109 seedlings produced in 1916, one hundred and ninety-two in all, were all yellowish-green in color, being like the parent variety in this respect. They also resembled the parent more or less as to the shape of the internodes and the buds. One seedling was darker green than the parent variety and had a tinge of red on the upper internodes; one was a shade darker green, but without the reddish tint; three were greenish-yellow like the parent, but tinged with red on the upper internodes; three were the same color as the parent with the addition of brownish-red blotches on the stalks.

Other variations occurred among these seedlings as follows. Two were markedly glaucous; one had especially prominent buds; one had extremely short joints; two had many adventitious roots; one had especially thin stalks; one was very thick-stalked. There was also a great difference among these seedling as to vigor of growth. Those growing in the area of better soil were taller and of larger girth, while a majority of those on poorer soil appeared more or less stunted, some of them producing almost no stalks.

Out of three hundred and sixty-six seedlings from the variety D-448, which is a red cane, two hundred and twenty-one or sixty per cent, showed redness on the stalk, though some in a less degree than the parent variety. Thirty-four per cent were red all over the stalk, but some were a lighter red than the parent cane. Twelve per cent were as dark or darker than the parent.

¹ These seedlings and those of subsequent instances cited, except where cross-pollination is indicated, were raised from seed from open-pollinated tassels. For that reason the purity of the pollen can not be guaranteed. However, it does not seem probable that sugar-cane pollen is carried more than a short distance by the wind. It has no special adaptation for being transported and is soft and delicate. In some cases observed the stigmas of the florets were in close contact with the dehiscing anthers. The anthers are shed in great numbers, and possibly they pollinate other florets as they fall. For these reasons it seems probable that the tassels in the center of a field of a pure variety are, without exception, pollinated by pollen of the same variety. The similarity of the seedlings in many cases also tends to verify this belief. It is planned to bag tassels for self-pollination to obtain further data on this point.

Among these seedlings two non-glaucous wine-colored canes occurred; two were greenish-yellow; two were reddish-green and glaucous; three were light reddish-green and glaucous; one had distinctly tumid joints.

All seedlings produced from D-117 seed have shown marked resemblance to this variety in color and in habit of growth, but they have shown more variation in the type of the internode and the bud. Abnormalities such as dwarfed canes, extremely short internodes, wedge-shaped internodes, and buds of unusual form have been common. In using the term abnormality the writer includes only stools distinctly different from the varieties cultivated for commercial purposes, and especially those unfit for commercial cultivation.

Approximately nine hundred D-117 seedlings were grown to maturity in 1916-17. In color they were almost uniformly like the parent variety. No dark-colored canes whatever were found among them. One seedling only out of this number was a slightly different color, being green instead of yellowish-green. The most marked variations were in length of stalk and length of internode. Some of the stools were reclining in habit, but most of them were as erect-growing as the parent variety.

In all, twenty-four abnormal stools were found among these seedlings.¹ Nine of them were classified as "dwarfs." They had stalks not over three feet long and almost uniform in length; internodes one-half to one inch long; usually semi-prominent buds; erect-growing leaves; and often few or many shoots growing from the base of the stool. Some of the abnormal cepas were similar to the dwarfs, but had one or more long stalks.

Other unusual characters in these abnormal canes were stalks with all or many of the buds sprouted, and stalks with many adventitious roots. Still other unusual characters, especially among the dwarfs, were the presence of dead stalks in the stools and a tendency for the entire stool to have withered or weak tops. Some stools also had stalks with wedge-shaped internodes, each averaging about an inch long on one side of the stalk, and narrowed down to sometimes practically nothing on the opposite side. It is planned to grow some of these variations to see whether the abnormal characters are inherited.

¹It might be assumed that the unusual types which are found among cane seedlings are due to characters acquired by intercrossing of various types of cane at an early stage in the development of the species, and that these characters have been hidden by reason of the dominance of others, since cane has been propagated by sexual means for an unknown period of time. But the question also presents itself whether such abnormalities are not of the character of mutations, and whether some of the other variations in cane seedlings may not also belong to the same class.

RESEMBLANCE OF SEEDLINGS TO PARENTS IN CANES FROM CROSS-
POLLINATED TASSELS.

Seedlings produced from tassels of Crystallina cane, which had been bagged and pollinated by D-109 in 1916, showed resemblances to both parent varieties. Some of them were almost identical in appearance with the pollinating variety, while a few closely resembled Crystallina. Between these two types many variations could be found.

The method followed in crossing is described in the Fourth Annual Report of this Experiment Station.¹ A bag of closely-woven cheese-cloth is supported by means of a bamboo pole over a tassel of a variety which is, for practical purposes, pollen-sterile. Cut tassels of the variety which is to furnish the pollen are tied in position inside the bag, so that the wind will carry the pollen, as it is shed, to the stigmas of the tassels of the other variety. This method has proven very satisfactory for our purposes, as a large number of crossed seedlings are produced, and there is very little possibility of any pollen fertilizing the ovaries of the female parent tassel except that from the tassels introduced into the bags, or occasionally that from its own anthers. If the variety used for a pollinator happens to be a dark-colored cane and the other lighter colored, as was the case in this cross, it is then possible to observe many seedlings which show this character of the male parent. There is then little possibility of doubt but that they are the result of cross-pollination. Where the parents are not so distinctly different it is impossible to be absolutely certain whether individual seedlings are from cross-pollination or from self-pollination of the variety intended for the seed parent. The progeny taken as a whole, however, can be considered largely cross-pollinated seedlings.

The canes resulting from cross-pollination last year have grown well and many of them appear promising for commercial culture. Only one abnormal stool was found among them. This was a very small stool, the stalks being only about one-fourth inch to one-half inch in diameter and proportionately short. The leaves were also relatively small. Except for its size this cane was quite like D-109, the variety used as a pollinator.

The following types were observed among these seedlings:

1. Typical D-109.
2. Typical Crystallina.

¹Fourth Annual Report, Board of Commissioners of Agriculture of Porto Rico, pp. 22-23, 1914-15.

3. Like D-109 as to color but with internodes and buds like Crystallina.
4. Like D-109 in shape of internodes and buds, but of a lighter color and very glaucous.
5. Canes greenish-red to wine color, very little glaucousness, with buds more resembling those of Crystallina than D-109, and with internodes intermediate between the two.
6. With internodes like those of D-109, color like Crystallina, but larger in diameter than either.
7. With internodes and buds like Crystallina, but the color darker and somewhat like that of D-109.
8. Like D-109 as to internodes and buds, but like Crystallina in color.
9. Like D-109 in color but with large nodes, constricted internodes and with buds somewhat like those of Crystallina.
10. Like Crystallina as to buds and internodes but more glaucous.

The following data concerning these canes were also noted:

	Number.	Per cent.
Total stools	560	100
Stools as red as D-109.....	147	28.3
Stools darker than Crystallina.....	294	52.5
Stools having internodes like D-109.....	246	43.9
Stools having no character like D-109, and with color and internodes like Crystallina.....	42	7.5

These observations were made when the canes were quite mature, so that there was the least possible chance of subsequent change in appearance; but cane varieties are extremely variable and their appearance is affected in many ways by outside influences, such as soil conditions, moisture and sun-light, so that it is difficult to separate different types. Should varieties still more distinctly different be chosen for crossing, more definite results would possibly be secured in the resulting seedlings. The above data, however, show certain points which are worthy of note. They indicate that there is a form of combination of characters in some, at least, of the seedlings resulting from a cross between two varieties of cane. This may be due to certain characters derived from each parent variety, being dominant in the heterozygous seedlings. It also appears that there is greater variation in seedlings so produced, than in those obtained from tassels not cross-pollinated.

As to the economic value of the seedlings produced by crossing,

there is little to be said at present. Many produced by this cross appear very promising, and a relatively large number were selected for extension and further trial, although their true value will not be definitely known until they have been tested further.

Available data as to the sucrose content of the juice of three of the groups of seedlings under consideration, as well as of two other groups which were germinated in 1912, are given here. The distribution is in classes which differ by one per cent, grouped on the nearest half per cent.

Per Cent Sucrose in Juice of Seedlings of Different Percentage Groups.

	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	Totals	Mean	Standard Deviation	Coefficient of variability
1912																
Orabelle percentage	..	..	..	..	2	2	0	3	4	4	6	2	23	17.72 ± .292	2.05 ± .205	11.6 ± 1.168
D-117	..	..	1	2	6	9	10	21	21	5	3	..	87	16.22 ± .117	1.62 ± .083	9.9 ± .510
1916																
D-448 percentage	1	1	0	0	3	4	6	11	8	4	..	..	38	15.97 ± .215	1.97 ± .152	12.4 ± .959
D-117	..	1	1	1	5	5	8	2	2	..	..	..	21	14.84 ± .196	1.43 ± .139	9.6 ± .934
Crys. X D-109 percentage..	1	2	0	2	6	9	8	13	7	..	..	..	48	15.16 ± .181	1.89 ± .130	12.9 ± .873

There are some differences shown in the frequency distributions of these populations; however, seedling canes are very much affected by environmental influences, and no data are at hand to show that frequency distributions of subsequent generations of such groups would show the same relation as that shown here. Moreover, it is the individual seedlings that are of interest, as new varieties are formed by asexual multiplication of these; and even though we assume the above to be the case, we still cannot say that the chances of selecting superior seedlings are greater in a percentage group showing a relatively high frequency distribution, than a low one, until it is shown that the individual ranges of variation of subsequent generations of the separate seedlings of these groups bear a relation corresponding to that of these first generation seedlings. The coefficients of variability of these groups of seedlings range from $9.6 \pm .934$ of the D-117 parentage group of 1916, to $12.5 \pm .873$ of the Crystallina \times D-109 parentage group, the latter being a little greater than that of the D-448 parentage group, which was $12.4 \pm .959$. Statistics of different years are probably not comparable, though it is notable that the coefficient of variability of the D-117 canes was the same for both years. In both years the coefficient of variability of the D-117 canes was the smallest, and in the 1916 seedlings those of D-448 and Crystallina \times D-109 were about the same. The number of individuals in any group is not sufficiently large, and the data at hand are not sufficient to allow conclusions to be drawn. The table is included with the other data at hand at this time, mainly for the purpose of pointing out a line of work which may give results when it has been completed.

CONCLUSIONS.

1. Seedling sugar canes in their first generation show a degree of resemblance to the varieties from which they were produced.
2. The results of the work at this Station indicate that resemblance of color is more marked than that of any other characteristic.
3. There is wider variation in seedlings than in canes produced from cuttings of the same variety.
4. The greatest variation in seedlings produced from tassels of a single variety is in the size and form of the plants, and of their component parts.
5. Certain varieties produce better seedlings than others.
6. Abnormalities are common in seedling canes, whereas in canes

produced from cuttings they are rare. Certain varieties produce many more abnormal seedlings than others.

7. New types of cane are produced by crossing varieties.

8. Variation is apparently increased by a single combination of two varieties.

9. Crossing seems to produce a recombination of characters of the parents in some of the resulting seedlings, this probably being due in a measure, to dominance of certain characters derived from each parent.

10. Only slight differences in sugar content of the juice have been observed between groups of seedlings produced from different varieties.