STUDIES IN BULK CROSSES BETWEEN SOME BEET STRAINS

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Received June **30, 1960**

In a number of cultivated plant species hybrids have been produced of value to pracitical cultivation during the last decades. These have been planned for hybrid seed production on an experimental or even on a practical scale in a large number of other plant species in different parts of the world. The present author, during his time as plant-breeder of fodder-beets, has often observed a considerable inbreeding depression in crosses. Further, he has gained the impression that in special cases the hybrids are more luxuriant than the parents. These observations are in full agreement with the observations published by STEWART, GASKILL and COONS (11), DOXTATOR and SKUDERNA (2), SEDLMAYR (9) and BØGH (1). Under these circumstances the author found it to be of value to ascertain to what extent this heterosis can be exploited without using male-sterile material in bulk crossing between different fodder and fodder sugar-beet strains. The use of male-sterile material would naturally have been still more interesting and a step closer to the practical realization of the hybrid-seed production and usage. This would, however, have proved much more expensive in terms of time, money and work than the present investigation, which is performed with marketed strains. Further, the genetical and practical value of the parents used would have differed greatly if the strains had first been crossed with male-sterile material, and this would have made it impossible to compare the hybrids with the marketed strains used in the crosses. The present investigation concerning bulk crosses between marketed strains gives an idea of the practical value and the results of the crosses.

The present investigation also deals with an additional problem, namely, the effect on seed cultivation of different strains grown close together. It should be of considerable interest for seed growing and seed control to know to what extent the bulk crosses between strains differ in their performance or are better than the pure strains.

The possibilities of using the polycross method in beet breeding is investigated (1) and the exploitation of heterosis is discussed (13).

Material and methods

The present study was conducted during the years 1952—1957 at the Gullåker Plant Breeding Institute, Hammenhög, Sweden being carried out in connection with the practical plant-breeding work there. During the year 1952 only bulk crosses were performed whereas the yield trials were carried out in the years 1953—1957.

The following bulk crosses were investigated:

Colour of the roots	Number of strains taking part in the cross: 2	3	> 3
White	Milka × Solid	Gullåker × (Milka + Solid)	Gullåker × (Σwhite)
	Gullåker × Triumf	Solid × (Gullåker + Milka)	Vit Gröntoppig × (Σwhite)
	Gullåker × Milka	Milka × (Gullåker + Solid)	Monark × (Σwhite)
	Gullåker × Solid	Vit Gröntoppig × (Gullåker + Solid)	Triumf × (Σwhite)
	Triumf × Milka		Solid × (Σwhite)
	Solid × Triumf		
	Triumf × Vit Gröntoppig		
	Gullåker × Monark		
	Milka × Monark		
	Triumf × Monark		
	Solid × Monark		
	Hg 2083 × Triumf		
	Solid × Vit Gröntoppig		
Light red		Ljusröd × (Bacon + Rubra)	
		(Bacon × (Rubra + Ljusröd)	
Yellow	B. Kofor × B. Slättbo II		B. Svea × (ΣBarres)
	B. Kofor × B. Halvlång		B. Ferritslev (ΣBarres)
	B. Kofor × B. Svea		Ötofte Nova × (ΣBarres)
	B. Kofor × Hg 50—627: 1		B. Kofor × (ΣBarres)
			B. Halvlång × (ΣBarres)
			B. Slättbo II × (ΣBarres)

The Breeding Institutes of the strains used for crossing as are follows:

Solid, Ruba and Barres Halvlång are bred at The Swedish Seed Association, Svalöf, Sweden;
Triumf, Bacon and Barres Slättbo II at the Weibullsholm Plant Breeding Institute, Landskrona, Sweden;

Gullåker, Vit Gröntoppig, Ljusröd, Barres Kofor, Hg 2083 and Hg 50—627 :1 at the Gullåker Plant Breeding Institute, Hammenhög, Sweden;
Milka, Monark and Barres Svea at Pajbjergfonden, Børkop, Denmark, These three strains are however represented in Sweden by Algot Holmberg & Sons Ltd., Norrköping;
Øtofte Nova at Øtofte, Denmark; and
Barres Ferritslev at Ferritslev, Denmark.

The trials were sown on the following dates, the dates of thinning are in brackets: 21st—22nd April 1953, 3rd May 1954, 5th—13th May 1955, 9th—11 May 1956 and 30th April 1957 (30th May, 31st May, 20th—22nd June, 4th—5th June and 31st May).

The bulk crosses were performed in the following manner. The roots of the strains to be crossed were planted in alternate rows: in most cases in 5—6 replicates. The same number of roots of the strains was used. Open-pollination was then expected to yield theoretically ± 50 per cent crosses between both the planted strains if two strains were planted together, about 65—70 per cent if three strains were crossed together and more if the number of strains crossed was more than three. The present author found this percentage fluctuating in different cases. Cases were found in which the percentage was only 25, which possibly depended on differences in the flowering time. The seed from different planted strains was harvested separately and used in subsequent trials.

In the trials the following characteristics were investigated:

1. mean height of the neck of beets in centimetres:

2. the plumpness of the roots was ocularly estimated in the field on a 0—10 scale, in which 0 = very thin roots and 10 = round roots:

3. the branchiness of the roots was ocularly estimated in the field on a 0—10 scale, in which 0 = none of the roots branched, and 10 = all roots are very much branched:

4. root yield is given in kilograms per hectare:

5. the average percentage of dry matter in the roots:

6. dry matter yield in kilograms per hectare:

7. percentage of bolters, counted at harvest:

8. percentage of crosses is the percentage of roots with aberrant colour:

The distance between the rows has been 45 centimetres. The plots have in all cases been ten square metres. The number of replicates has in most cases been four, but in some cases five and in a few cases less than four. As always in trials with root crops the number of roots per trial has varied somewhat ($< \pm 4$ %). 90 plants per 10 square metres is the number of plants left, if possible, at the thinning.

The χ^2_{values} have been calculated in conformity with FINNEY (3) and the significance has been estimated in accordance with FISHER and YATES (4), being denoted by asterisks as follows: *** = $P \leqq 0.001$ (highly significant), ** = $P \leqq 0.01$ but > 0.001 (satisfactorily significant) and * = $P \leqq 0.05$, but > 0.01 (significant).

Pollination

Beta vulgaris is a typical cross-fertilizing plant (7), which is also true of the forage beets (5, 12). According to SCHNEIDER (8), each seed plant of the beets produces nearly one milliard pollen grains, which spread in every direction to a distance of 2000 m and more (6). The quantity of pollen is inversely proportional to the distance from the beet plant or the beet cultivation, according to STEWART and CAMPBELL (10). On the basis of these experimental results it may be assumed that in the present investigation, where the beet strains were grown in alternating rows, conditions must have been good for crossing and the fact that ± 50 per cent of the seeds developed must have been the result of cross-pollination — a statement that is in full agreement with KNAPP (7). No reason for considering that differences between sugar and forage beets may have influenced the results can be found. If the number of families, lines or strains is n, the percentage of crosses generally seen will be: $\frac{(n-1) \cdot 100}{n}$ %, according to KNAPP (7). This is valid only if the fertilization is free and not influenced by sterility, differences in the number of plants or differences in flowering time.

Table 1. — The characteristics of the check — Barres Kofor — and of the parents on an average in the experiments.

	Barres Kofor	The parents on an average	The white parents	The light red parents	The Barres parents
Number of strains and crosses ..	1	18	8	3	7
Number of trials	35	84	27	4	53
Mean height of the neck, centimetres	12.2	7.8	5.1	8.7	10.6
The plumpness of the roots (0—10)	5.0	4.8	4.7	4.5	5.2
The branchiness of the roots (0—10)	2.4	3.8	5.0	3.3	2.6
Root yield, kilograms per hectare	78590	72900	68890	71450	78040
Percentage of dry matter	13.7	15.6	17.1	15.6	13.9
Dry matter yield, kilograms per hectare	10750	10290	9930	10360	10680
Percentage of bolters	1.0	1.1	0.9	2.0	0.9
Percentage of aberrant roots ..	0.2	0.5	0.2	0.0	1.2

The standard performance of the material used

As it has been found more convenient to give the values in this paper as ± the mean of the parents and ± the mother, it is of interest to obtain an impression of the standard performance of the material used. The values for the check Barres Kofor and the average values for the parents are given. Further, the values for the parents of different root types are given in Table 1.

Generally it can be said that the yields have been rather large both as to root yield and dry matter yield. The percentage of bolters has been rather small, 1—2 per cent.

Comparisons between the hybrids and the mean of the parents

Altogether 32 different bulk crosses, which have been tried in 138 comparisons, are studied in the present investigation. The results of these comparisons are given in Table 2.

Table 2. — The hybrids in comparison with the mean of the parents and in comparison with the mothers.

	Mean of all crosses in comparison with	
	the mean of the parents	the mothers
Number of combinations	32	49
» » trials of the crosses	138	119
Mean height of the neck, centimetres	+ 2.0	+ 1.3
The plumpness of the roots (0—10)	+ 0.9	+ 0.8
The branchiness of the roots (0—10)	— 1.3	— 0.8
Root yield, kilograms per hectare	— 390	— 940
Percentage of dry matter	— 0.6	— 0.5
Dry matter yield, kilograms per hectare	— 340	— 250
Percentage of bolters	— 0.1	— 0.3
» » aberrant roots	+ 0.6	+ 1.0

On an average the roots have not beet more branched than the average of the parents in every individual cross. The difference is considerable or about 15 per cent.

The root yield is on an average 390 kg smaller per hectare than the mean of the parents. This is only about 0.5—0.6 per cent of the average root yield of the parents used. The dry matter content is on an average about 0.6 per cent lower than the average of the parents. This is about 4 per cent of the dry matter content. This results in the fact that the performance of the hybrids is not as good in dry matter yield as in root yield. On an average the dry matter yield has been 340 kilograms smaller in the hybrids than the mean of the parents. This means that the dry matter yield has been nearly four per cent smaller in the hybrids than the mean of the parents.

The percentage of bolters has not on an average been increased in the hybrids in comparison with the mean of the parents.

The percentage of aberrant plants or crosses has been larger — about double — in comparison with the mean of the parents. The difference between the hybrids and the mean of the parents must be considered to be considerable.

Table 3. — The hybrids in comparison with the mean of the parents.

	Mean of all crosses	Number of strains involved in the crosses		
		2	3	>3
Number of combinations	32	17	5	10
Number of trials of the crosses	138	104	14	20
The branchiness of the roots (0—10)	— 1.1	— 1.1	— 1.6	— 1.0
Root yield, kilograms per hectare	— 390	— 1250	— 690	+ 1230
Percentage of dry matter	— 0.6	— 0.3	— 1.5	— 0.7
Dry matter yield, kilograms per hectare	— 390	— 280	— 500	— 280
Percentage of bolters	± 0.0	— 0.5	— 0.6	+ 1.0
» » aberrant roots	+ 0.6	+ 0.5	+ 1.6	+ 0.2

On the basis of these comparisons it may be assumed that the yield performance, especially the dry matter yield, in the present material has been smaller, than in the parents. The roots have not been more branched and the percentage of aberrant individuals has been larger than for the parents on an average. The percentage of bolters has been on an average the same for the hybrids as for the parents.

The corresponding comparisons between the hybrids and the mother strain of the crosses are given in Table 2. The results largely agree with the comparisons of the mean of the parents given in Table 2. The most striking difference was found in the root yield, which was much smaller (940 kilograms) on an average than in the corresponding mother strains.

Both in comparison with the parental mean and with the mothers the hybrids have the neck of the root higher over the surface of the soil than the parents. The plumpness of the roots was more noticeable in the hybrids than in the parents (Table 2).

The influence of the number of strains used in the crosses

In this connection it must be considered of importance whether or not there are differences between hybrids with a different number of strains involved in the crossing system. Such a comparison is given in Table 3. The differences as to the branchiness of the roots were not large. It is interesting to note that the branchiness shows a tendency to be smaller in the hybrids than on an average in the parents.

Table 4. — The hybrids in comparison with the mothers.

	Mean of all crosses	Number of strains involved in the crosses 2	3	> 3
Number of combinations	49	32	5	12
» » trials of the crosses	119	90	8	21
Mean height of the neck, centimetres	+ 1.3	+ 1.4	— 1.3	
The plumpness of the roots (0—10)	+ 0.8	+ 1.1	— 0.3	
The branchiness of the roots (0—10)	— 0.8	— 1.3	+ 1.1	— 0.3
Root yield, kilograms per hectare	— 940	— 1630	— 3050	+ 1810
Percentage of dry matter	— 0.4	— 0.5	— 0.3	— 0.3
Dry matter yield, kilograms per hectare	— 250	— 330	— 470	+ 40
Percentage of bolters	— 0.3	— 0.9	+ 0.7	+ 0.8
Percentage of aberrant roots	+ 1.0	+ 0.9	+ 3.1	+ 0.5

The root yield performance of the hybrids with a higher number of strains than three involved has been much better than that of hybrids with only two parental strains involved. The difference was higher than three per cent of the average yield. The dry matter percentage was, however, in the present material considerably better for hybrids with only two strains involved in the crosses than for the hybrids with more than three strains involved in the crosses. The dry matter yield in both groups was consequently 280 kilograms smaller than that of the mean of the parents.

The comparisons in Table 4 between groups of hybrids with different numbers of strains involved in the crosses show about the same differences between groups of 2 and > 3 strains as in Table 3, but the yield values are more negative for the first-mentioned group and more positive for the group with hybrids in which more than three strains are involved in the comparisons with the mother than in the comparisons with the parental mean.

Differences between different materials

It is further of interest to see to what extent there are differences between different types. In Tables 5 and 6 the values are given for crosses between different white beets and crosses between different beets of the Barres type, in Table 5 the values in comparison with the parental mean and in Table 6 the values in comparison with the mothers are given. The differences between the progeny and the parents show a tendency to be larger in the group of white beets than in the Barres beets.

In comparison with both the mean of the parents and with the mothers the hybrids have not been branched as much. This is especially striking in the group of white beets in which only two strains are crossed. In both the comparisons in Tables 5 and 6 the root yields of the crosses in which more than three strains are involved have been larger than the crosses in which only two strains are used. It it also interesting to observe that the effect of crossing as regards the root yield has been on an average negative in the group of white beets and positive in the Barres group.

Table 5. — The hybrids in comparison with the mean of the parents for different types.

	White		Barres	
	Two strains crossed together	> 3 strains crossed together	Two strains crossed together	> 3 strains crossed together
Number of combinations	13	4	4	6
Number of trials of the crosses	76	8	28	12
The branchiness of the roots (0—10)	— 1.6	— 1.0	— 0.1	— 1.2
Root yield, kilograms per hectare	— 2410	— 1180	+ 2520	+ 2830
Percentage of dry matter	— 0.4	— 0.9	± 0.0	— 0.5
Dry matter yield, kilograms per hectare	— 410	— 540	+ 120	— 110
Percentage of bolters	— 0.9	+ 0.3	+ 1.1	+ 1.4
Percentage of aberrant roots	+ 1.2	— 0.5	— 1.6	+ 0.7

The dry matter percentage shows a greater tendency to increase in the group of the white beets than in the group of the Barres beets. Consequently, the Barres

Table 6. — The hybrids in comparison with the mothers.

	White		Barres	
	Two strains crossed together	> 3 strains crossed together	Two strains crossed together	> 3 strains crossed together
Number of combinations	24	6	8	6
» » trials of the crosses	63	9	26	12
Mean height of the neck, centimetres	+ 2.6	+ 5.1	— 3.3	
The plumpness of the roots (0—10)	+ 1.1	+ 0.6		
The branchiness of the roots (0—10)	— 1.7	— 0.2	± 0.0	— 0.4
Root yield, kilograms per hectare	— 3070	+ 800	+ 2680	+ 2840
Percentage of dry matter	— 0.7	— 0.1	— 0.2	— 0.5
Dry matter yield, kilograms per hectare	— 500	+ 220	+ 180	— 130
Percentage of bolters	— 1.3	+ 0.3	+ 0.4	+ 1.3
Percentage of aberrant roots	+ 1.7	+ 0.2	— 1.5	+ 0.8

crosses gave relatively larger dry matter yields than the white beets. This was abundantly clear in the comparisons between the hybrids and the parental mean. The percentage of bolters has shown a clear tendency to increase in the Barres group. A small increase was shown in the white crosses in which more than three strains are crossed. In the group of strains with white root, in which only two strains are crossed, the percentage of bolters is much smaller in the progeny generation than in the parental generation.

Table 7. — Comparison between the yield characteristics in some reciprocal crosses.

Cross	Number of trials	Root yield kilograms ± the mother	Dry matter percentage ± the mother	Dry matter yield kilograms ± the mother
Gullåker x Solid	4	— 3260	— 2.3	— 480
Solid x Gullåker	4	— 5590	± 0.0	— 630
Gullåker x Milka	4	— 4900	— 1.1	— 1340
Milka x Gullåker	5	— 2350	+ 0.7	— 160
Milka x Solid	5	— 3870	+ 0.5	— 120
Solid x Milka	5	— 1150	— 0.7	— 530
Gullåker x Monark	3	— 6880	— 0.2	— 1160
Monark x Gullåker	4	— 3940	— 0.3	— 740
Milka x Monark	3	— 5530	+ 0.7	— 150
Monark x Milka	3	— 380	— 1.8	— 900
Solid x Monark	4	— 2700	— 0.3	— 400
Monark x Solid	3	— 1650	— 2.4	— 1370
B. Kofor x B. Svea	3	+ 2400	— 0.1	+ 210
B. Svea x B. Kofor	3	— 2500	— 0.5	— 840

A detailed examination of certain reciprocal crosses

In Table 7 are given the yield characteristics for nine reciprocal crosses, which involve the highest number of experiments of the crosses investigated. Characteristic of the six firstmentioned (all crosses between white strains) is that they have in all cases given smaller root and dry matter yields than the mother variety. On an average, in these crosses the dry matter percentages of the reciprocals counted together were lower than those of the mother-strains. *The results for the best crosses, that possibly can be commercially exploited, are given only as averages in the tables, but neither the names of the parents nor the results of them are individually given in this paper.*

On the basis of the presented material (Table 7) it can be expected that there are differences in the combining abilities between different strains (cp.

Table 8. — The effect of crossing between five fodder sugar beet strains.

Strain	The mean of reciprocal crosses ± the mother: Number of trials	Root yield per hectare	Percentage of dry matter	Dry matter yield per hectare
Solid	36	— 2443	— 0.5	— 875
Milka	36	— 2865	— 0.3	— 655
Gullåker	31	— 3838	— 0.4	— 895
Monark	23	— 2655	— 0.3	— 568
Triumf	14	— 3985	— 0.1	— 868

Milka × Solid and Gullåker × Monark). This is still more emphasized in the data given in Table 8, which shows that considerable differences were found. Further the large differences between the material of white and that of Barres beets should be pointed out.

Table 9. — Direct comparisons between F_1 and F_2.

	F_1	F_2
Number of combinations investigated	7	7
» » trials of the crosses	11	9
The branchiness of the roots (0—10)	+ 0.3	+ 0.3
Root yield, kilograms per hectare	— 2790	— 3060
Percentage of dry matter	— 0.4	— 0.3
Dry matter yield, kilograms per hectare	— 270	— 650
Percentage of bolters	+ 2.1	+ 0.5
» » aberrant roots	+ 5.4	— 0.6

Comparison between F_1 and F_2

It was possible to compare the first and second progeny generation in 7 different combinations (Table 9). The branchiness of the roots was the same in both generations. Both the root yields and the dry matter yields per hectare were, relatively seen, smaller in F_2 than in the first progeny generation. It must be considered possible that the differences between both these generations in the yield characteristics mentioned would have been still larger if the number of plants had been as large for F_1 as for F_2. The percentage of bolters was much larger in the first progeny generation than in the second progeny generation. The difference was satisfactorily significant ($\chi^2 = 10.47^{**}$).

Discussion

On an average the root yields, the dry matter content and the dry matter yields have been smaller for the progeny than for the parents. It can therefore be stated as regards the present material that it is not possible to produce practically usable hybrids without knowing the combining abilities of the parents and the performance of the progeny. Further, it can be concluded that crossings between marketed beet strains during seed cultivation must be avoided. Consequently, rather large distances between different strains of the same beet type to avoid crossings must be considered a justifiable demand and one that should be observed by the seed testing representatives in field control. It must, however, be stated that on an average neither the root form nor the height of the neck have been negatively influenced by the crossing of the strains. The above-mentioned points and the fact that the roots have not been more branched in the hybrids than in the parental strains must be considered both important and striking. Of further interest is the fact that the percentage of bolters has not increased on an average. That the percentage of aberrant roots of strange colour has been higher in the hybrids than in the pure parental strains cannot be considered to be of any practical consequence.

The hybrids in which more than three strains have been used have on an average shown somewhat better results in root yields than the hybrids between only two strains, but the differences are non-significant and must be considered dependent on the fact that the proportion between different materials has varied in the different groups. Further, the dry matter yields for both the groups are on an average the same in the comparisons with the means of the parents.

Upon the whole, the performance of the Barres strains has been better in root yield, percentage of dry matter and dry matter yield per hectare than that of the white strains in the crosses. This is naturally very interesting and indicates that the combining ability of the Barres strains has been better than that of the white strains on an average.

Of considerable interest are also the data showing that F_1 seems to be more favourable as to the yield features than F_2. The greatest disadvantages as regard the F_1-generation have been the facts that in the actual material the percentages of bolters and crosses have been much higher than in the F_2-generation. *These results indicate that the greatest possibilities for getting favourable combinations in the present material seem to be found in the group of Barres strains, the best generation appearing to be the first progeny generation; and that possibly a larger number of strains involved than three is somewhat more favourable than only two or three strains.* The author does, however, suggest that it is possible to get much better combinations than those described in the present paper if, on the one hand, a larger amount of material with more marketed and theoretical strains is used, and, on the other, families of different strains and crosses; and the strains and families possessing the best combining-ability features are used for building hybrids and strains. Further, if it is possible to use the strains and families, with the best combining-ability features, in more extensive crossing systems the results will be still better than the average results obtained in the present experiments.

Summary

In the years 1952—56 the present author allowed different beet strains at the Gullåker Plant Breeding Institute to hybridize. In the years 1953—57 these hybrids were compared in trials with regard to their yield performance and some other practical features with the parents. Altogether 34 hybrids were compared in 138 comparisons with the parents.

The progeny generations gave on an average smaller root and dry matter yields than the parents. The dry matter percentage was lower in the progeny generation than in the parental generation. The roots were not much more branched in the progeny generation than in the parental generation. The position of the roots in the soil and the form of the roots were not negatively influenced by crossing. Nor was the percentage of bolters larger than in the parental generation.

The hybrids in which more than three strains were involved showed a tendency to give larger root yields than the strains in which only two strains were crossed. A corresponding increase in dry matter was not obtained.

Considerable differences were found in the combining abilities between different types and strains and it seems to be possible to find combinations which have better yield performances than the parents.

The consequence of crossing for the seed testing in field is discussed.

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SELOSTUS:

JUURIKASKANTOJEN VÄLISISTÄ RISTEYTYMISTÄ

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Vuosina 1952—56 tekijä on Gullåkerin kasvinjalostuslaitoksella suorittanut juurikaskantojen välisiä risteytyksiä, joista saatuja risteytymiä on kokeiltu ja tutkittu vertailevissa kokeissa mainitun kasvinjalostuslaitoksen koekentillä vuosina 1953—57. Näitä risteytymiä on verrattu vanhempiinsa, minkä lisäksi risteytymien F_1- ja F_2- sukupolvia on verrattu toisiinsa. Yhteensä on kokeiltu 34 erilaista risteytysyhdistelmää.

Tutkimustuloksista ilmenee mm., että käytetyn aineiston risteytymät ovat keskimäärin antaneet pienemmän juurikas- ja kuiva-ainesadon kuin niiden vanhemmat. Myös kuiva-ainepitoisuus on ollut risteytymissä keskimäärin pienempi kuin vanhemmissa. Juurikkaiden haarakkuus ei keskimäärin ole ollut suurempi risteytymissä kuin vanhemmissa. Risteytys ei ole vaikuttanut epäedullisesti juurikkaiden muotoon eikä niiden kasvutapaan. Sama koskee myös ensimmäisen vuoden aaluvien lukumäärää.

Huomattavia eroja eri risteytymien välillä on havaittu varsinkin juurikkaiden ja kuiva-aineen hehtaarisatoihin nähden. Niinpä esimerkiksi barreskantojen väliset risteytymät ovat olleet vanhempiinsa verrattuina huomattavasti paremmat kuin käytettyjen valkoisien rehusokerijuurikaskantojen väliset risteytymät. On luultavaa, että voidaan löytää näitä vielä paljon parempiakin risteytysyhdistelmiä, mikäli käytetään hyväksi suurempaa aineistoa sekä etsitään ja kokeillaan kaikkein parhaiten yhdistymiskykyisiä perheitä.

F_1-sukupolvi on antanut suuremman sekä juuri- että kuiva-ainesadon kuin F_2-sukupolvi. Väriltään vanhemmista poikkeavien taimien ja aaluvien lukumäärä on ollut huomattavasti suurempi F_1-sukupolvessa kuin F_2-sukupolvessa.

Kokeissa on vertailtu keskenään risteytymiä, jotka on rakennettu risteyttämällä keskenään eri määriä kantoja (2, 3 tai > 3). Vertailuista ilmenee, että tutkitut risteytymät eivät eroa toisistaan paljoakaan kuiva-ainesatoon nähden. Toisaalta juurisato näyttää olleen suurempi sellaisilla risteytymillä, joita rakennettaessa on risteytetty useampia kuin kolme kantaa keskenään, kuin sellaisilla, joiden valmistukseen on käytetty vain kahta kantaa.