STUDIES ON SOME F_1 SUGAR BEET HYBRIDS
(Demonstration Paper)

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Considerable breeding work has been conducted on sugar beets both in foreign countries and in the United States. Much valuable information has been obtained as a result of this work. As a direct result of the work in the United States there are on the market today a number of American varieties of sugar beets.

The commercial varieties of sugar beet seed available for planting by the beet grower are largely hybrids. Thus in the development of new varieties of sugar beets hybridization is usually employed at some point. The point where hybridization is employed is determined by the material being developed. The formation of a hybrid by cross pollination of two strains may be the initial step in the development of a new variety or it may be the final step in the breeding process giving rise to F_1 commercial seed for planting by the grower.

In as much as hybridization occupies a prominent position in breeding programs on sugar beet improvement, a study of F_1 hybrids should add materially to our knowledge of how we might benefit the most from this process.

When hybridization is employed in the early stages of the development of a new variety for purposes of combining desirable characters, the plant breeder has available only a few selected roots of his strains to work with. In hybridizing two strains, the usual method employed is to plant roots of the two strains in close proximity to each other and allow them to cross pollinate since the sugar beet is naturally a cross pollinated plant. The sugar beet flower is a perfect flower having both staminate and pistillate parts. The question arises as to whether or not seed harvested from Strain A assumed to be pollinated by Strain B will give rise to a progeny materially different from that produced by the seed harvested from Strain B assumed to be pollinated by Strain A. Evidence obtained in our 1939 Breeding Strain trials of the progeny of F_1 hybrids at Sheridan, Wyoming, indicates that the seed borne by the mother parents may differ materially.

In the production of a new variety, consideration should be given to the foliage characteristics, a variety having large, upright, broad foliage appearing to be desired by our growers. Inasmuch as contrasts of these foliage characters appeared in the parent material of the hybrids, notations were made of the foliage character of the progeny of the F_1 hybrid. The parents of the hybrids studied were selected roots of commercially available varieties which have proven their ability to perform satisfactorily commercially, and were in general use in the various sugar beet territories in 1938. The hybrids were formed by the bagging method whereby a branch of each of the two parents was confined in a 6# kraft paper bag and the seed was harvested separately from each branch. Thirty-nine hybrids involved the contrasting traits of large and

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small top. Twenty-six of these hybrids exhibited the trait of the pollen parent, ten having large top and sixteen having small top; and thirteen of these hybrids exhibited trait of the mother parent, six having large top and seven having small top. Seven hybrids involved the contrasting trait of broad and narrow leaf blades. Six of these hybrids exhibited the trait of the pollen parent, two having broad and four having narrow leaf blades; and one of the hybrids exhibited the trait of the mother parent, broad leaf blade. Seven hybrids involved the contrasting traits of upright and flat foliage. Five of these hybrids exhibited the trait of the pollen parent, three having upright and two having flat foliage; and two of these hybrids exhibited the trait of the mother parent, both upright foliage.

These limited data indicate that the appearance of these contrasted foliage characters in the F_1 progeny of a cross may be dependent upon their introduction by the pollen parent.

Other desirable characters are also incorporated through hybridization. All hybrids in our breeding strains were evaluated on the basis of visual appearance as compared with our commercial check, taking into consideration size and shape of roots, together with size and shape of crown. The progeny of those hybrids which appeared to be equal to or better than the progeny of the commercial check were designated as good hybrids, those being inferior to the check were designated as being poor hybrids. This study involved 808 hybrids formed by harvesting 404 single crosses separately by mother parent as previously explained. The following table gives the results of the crosses involving one parent of the intermediate type and serves as a cross section of the data obtained. The term "Percent Good F_1 Hybrids" refers to the above mentioned classification whereby the entire progeny of a mother parent was considered as being good or poor.

TABLE 1

CLASSIFICATION OF THE PROGENY OF F_1 HYBRID SEED RESULTING FROM CROSSES OF 1 VARIETY OF INTERMEDIATE TYPE WITH SIX OTHER VARIETIES

Percent Good F_1 Hybrids When Parent Used As:			
♀	♂	Difference	Type Crossed With
0	100	100	Intermediate
100	0	100	Sugar
0	100	100	Tonnage
100	100	0	Intermediate
0	100	100	Tonnage
0	100	100	Intermediate
Average Difference		83%	(6 Varieties - 3 Types)

These data emphasize the differences which may be obtained by the use of selected roots of commercial varieties as male and female parents of a single cross, and show an average difference due to the use of this variety as the pollen or mother parent, of 83%.

As the number of individuals entering into the crosses is increased, the contrast between the use of the individual plant as the male or female parent is minimized by the compensating effect of averaging the results. This is illustrated in the following data where the results of all crosses between two varieties are averaged for one parent of the intermediate type.

TABLE II

CLASSIFICATION OF THE AVERAGES OF THE PROGENY OF F_1 HYBRID SEED RESULTING FROM CROSSES OF 1 VARIETY OF INTERMEDIATE TYPE WITH 11 OTHER VARIETIES

No. of Crosses	Ave. % Good F_1 Hybrids When Parent Used As: ♀	♂	Difference	Type Crossed With
2	100	0	100	Intermediate
16	86	67	19	Sugar
26	67	79	12	Tonnage
27	64	77	13	Tonnage
8	100	75	25	Intermediate
6	100	100	0	Intermediate
3	50	100	50	Intermediate
9	75	40	35	Intermediate
3	100	50	50	Tonnage
4	100	50	50	Intermediate
2	100	100	0	Sugar
Total 106	942	738	354	(11 Varieties - 3 Types)
Average	86	67	32	

Increase in percent good hybrids = 86 - 67 + 67 = 28%.

The data presented in Table I and II show a reduction in the average difference from 83% when based on individuals to 32% when based on the averages of the variety crosses. For the particular variety, considered in Table II, difference between averages of the parent effect of all 106 crosses show an increase of 28% in good hybrids when the variety is used as the female parent as compared to its use as the male parent. These results are typical of the results where the data are assembled by varieties. Due to the volume of the data collected it is not presented at this time, but they show that the 35 varieties studied varied from 0 to 203% increase due to parent use. The average percent increase due to parent use for the 35 varieties was 45%. Some of the varieties had a greater percent of good F_1 hybrids when used as the female parent and others as the male parent, whereas other varieties showed no differences due to parent effect. The average percent good F_1 hybrids for all varieties when used as the female parent was 74, and when used as the male parent 75, which shows lack of consistant influence of either male or female parent. Fifty-seven percent of all hybrids tested showed a variation in the progeny due to the use of the variety as the male or female parent.

Compilation of the data by types, shows considerable variation indicating that the variation between varieties is greater than the variation between types. In general, the data indicate that better yielding hybrids will be obtained, when crossing two types, by using the heavier yielding of the two types as the mother parent as illustrated by the following data.

TABLE III
CLASSIFICATION OF THE AVERAGES OF THE PROGENY OF F_1 HYBRID SEED RESULTING FROM CROSSES OF TYPES

Parent Type	No. Crosses	Ave. % Good F_1 Hybrids When Parent Used As: ♀	♂	Percent Increase due to parent use:	Type Crossed With
Inter.	33	73	46	59	Sugar
Tonnage	31	73	60	22	Sugar
Tonnage	132	73	66	11	Intermediate

In addition to the production of hybrid seed by the bagging method from selected roots where limited amounts of seed are obtained, there is also the method of producing hybrid seed in quantity by planting blended seed of parent varieties, and obtaining F_1 hybrid seed by natural crossing of the entire progeny the following year. This seed is harvested in bulk irrespective of parent plant since it is the product of a large group cross of unselected material. The blend of seed used for such plantings is known as a mechanical mixture and the F_1 seed resulting therefrom is referred to as a genetic mixture.

In connection with the production of genetic mixtures the question has been raised as to what criterion will give us a fair estimate of the performance of these genetic mixtures prior to production of the seed and subsequent agronomic evaluation. The following study was undertaken to determine whether the arithmetic average of the performance of the parent forms would serve as an index to the performance of their mechanical mixtures or their genetic mixtures.

The following table presents data taken from variety tests conducted at Sheridan, Wyoming, during the seasons of 1938 and 1939. The tests were of the Quasi-Factorial design having 91 varieties with ten replications in 1938 and 144 varieties with six replications in 1939. The data are based on total plat yields. The parent forms consist of Extreme Sugar, Sugar, Intermediate, Tonnage, and Extreme Tonnage types of unselected commercially available varieties. The data involve mixtures of equal and unequal proportions but do not include extreme proportions such as 95 percent extreme sugar and 5 percent extreme tonnage mixtures.

COMPARISON OF GENETIC MIXTURES, MECHANICAL MIXTURES, AND THE WEIGHTED AVERAGE OF THE PARENT FORMS WITH THE ARITHMETIC AVERAGE OF THE PARENT FORMS

All results are expressed as percent of the commercial check

Mixture	Year	% Sucrose				Tons Per Acre				Lbs. Gross Sugar/Acre				% Stand			
		Arith. Ave.	Wtd. Ave.	Mech. Mix	Gen. Mix	Arith. Ave.	Wtd. Ave.	Mech. Mix	Gen. Mix	Arith. Ave.	Wtd. Ave.	Mech. Mix	Gen. Mix	Arith. Ave.	Wtd. Ave.	Mech. Mix	Gen. Mix.
1 - 10 Varieties	1938	100	100	-	98	96	98	-	91	96	97	-	89	99	100	-	102
	1939	100	100	100	99	107	108	104	99	106	107	104	98	108	110	110	107
2 - 10 Varieties	1938	100	100	-	-	98	98	-	-	99	98	-	-	100	99	-	-
	1939	100	100	98	98	107	106	114	97	107	105	111	95	107	105	101	100
3 - 7 Varieties	1938	100	-	-	99	99	-	-	97	99	-	-	96	101	-	-	95
	1939	100	-	98	100	107	-	95	105	106	-	93	104	108	-	101	100
4 - 5 Varieties	1938	97	-	-	99	104*	-	-	94	101	-	-	93	99	-	-	90
	1939	98	-	100	99	107	-	109	103	105	-	108	102	108	-	95	100
5 - 5 Varieties	1938	99	98	-	-	101	103	-	-	100	100	-	-	102	102	-	-
	1939	99	98	98	-	103	105	102	-	102	103	100	-	104	107	101	-
6 - 4 Varieties	1939	98	-	98	-	105	-	102	-	103	-	99	-	105	-	95	-
7 - 4 Varieties	1939	98	-	98	-	97	-	117*	-	94	-	114*	-	104	-	105	-
8 - 4 Varieties	1938	97	97	-	-	104	105	-	-	101	101	-	-	98	98	-	-
	1939	96	96	99*	-	106	106	116	-	102	102	115	-	105	105	108	-
9 - 4 Varieties	1939	96	-	98	-	103	-	114	-	98	-	111	-	104	-	111	-
10 - 4 Varieties	1939	98	-	97	-	106	-	110	-	103	-	106	-	107	-	101	-
11 - 2 Varieties	1938	96	96	95	-	103	104	111	-	100	100	105	-	102	102	105	-
	1939	98	97	96	-	104	103	110	-	102	100	105	-	105	105	108	-

Differences for significance for odds of 19:1 for 1938 and 1939 respectively are: Percent Sucrose: 4 and 3; Tons Per Acre: 9 and 19; Pounds Gross Sugar Per Acre: 9 and 20; Percent Stand: 10 and 15.

*Significantly superior.

PERCENTAGE COMPOSITION AND TYPES

No.	Varieties	Percentage Composition																			
1	Unequal Parts:	32	-	10	-	10	-	9	-	9	-	9	-	7	-	7	-	5	-	2	
	*Types:	T	-	I	-	I	-	ES	-	I	-	ET	-	ES	-	T	-	I	-	I	
2	Unequal Parts:	16	-	16	-	16	-	14	-	11	-	6	-	6	-	6	-	6	-	3	
	Types:	T	-	I	-	I	-	ES	-	S	-	T	-	I	-	I	-	ES	-	I	
3	Equal Parts:	15	-	15	-	15	-	15	-	15	-	15	-	15							
	Types:	T	-	T	-	S	-	I	-	ES	-	S	-	ET							
4	Equal Parts:	20	-	20	-	20	-	20	-	20											
	Types:	T	-	T	-	I	-	I	-	I											
5	Unequal Parts:	30	-	30	-	20	-	10	-	10											
	Types:	T	-	ET	-	I	-	S	-	I											
6	Equal Parts:	25	-	25	-	25	-	25													
	Types:	T	-	T	-	I	-	I													
7	Equal Parts:	25	-	25	-	25	-	25													
	Types:	T	-	I	-	I	-	T													
8	Unequal Parts:	27	-	27	-	26	-	20													
	Types:	ET	-	I	-	T	-	I													
9	Equal Parts:	25	-	25	-	25	-	25													
	Types:	T	-	I	-	I	-	S													
10	Equal Parts:	25	-	25	-	25	-	25													
	Types:	T	-	I	-	I	-	I													
11	Unequal Parts:	60	-	40																	
	Types:	ET	-	I																	

*Types: ES = Extreme Sugar; S = Sugar; I = Intermediate; T = Tonnage; ET = Extreme Tonnage.

Examination of the data shows that only four comparisons out of the hundred and sixty-eight exhibit significant differences. The arithmetic and weighted averages of the parent forms of varieties used in unequal proportions in mechanical and genetic mixtures, do not differ significantly. The arithmetic average of the parent forms and the mechanical mixtures differ significantly in only three of the forty-eight comparisons. The arithmetic average of the parent forms and the genetic mixtures differ significantly in only one of the twenty-eight comparisons.

The data show that for the mixtures used in this study, the arithmetic average of the performance of the parent forms serves as an index to the performance of mechanical mixtures or genetic mixtures of commercial varieties whether proprotioned equally or unequally.

SUMMARY

The data presented based on selected roots of commercial varieties show that the appearance of some foliage characters in the progeny of the F_1 hybrid of single crosses of such roots may be dependent upon their introduction by the pollen parent. Other data based on 808 crosses give differences in percentage of good F_1 hybrids depending upon whether the variety was used as the male or female parent. The average difference in good hybrids for all 35 varieties studied was 45%. The data indicate that better yielding hybrids of the nature studied may be obtained, when crossing two types, harvesting the seed separately by parent, by using the heavier yielding of the two types as the female parent.

Data presented on the performance of certain genetic mixtures produced from quantities of mechanical mixtures of seed of commercial varieties show that the arithmetic average of the performance of their parent forms serves as an index to the performance of such genetic mixtures.