

Section A. General Agronomy, Soils, Fertilizers, Production and By-Products - Chairman: H. D. Brown.

-----

COMPARATIVE YIELDS OF EQUAL PLANT POPULATIONS  
OF SUGAR BEETS WITH DIFFERENT SPACING RELATIONS

By  
G. W. Deming<sup>1/</sup>

In a preliminary report, F. G. Larmer<sup>2/</sup> gave the results obtained in California experiments with sugar beets hand thinned at 10-inch spacing as contrasted with doubles in hills spaced 20 inches apart. It was found that beets grown as doubles in hills 20 inches apart were comparable to beets grown singly 10 inches apart. In the California tests, increasing the spacing between two- and three-plant hills to 20 inches gave tonnage yields comparable to single-beet 10-inch spacing. Because of the significance of this finding, which centers interest on maintenance of the plant population while varying the pattern of arrangement, experiments were instituted to determine if varietal response was a factor in results to be obtained in such trials, and also to discover the magnitude of yield differences which might occur from departure from the customary singling method.

Materials and Methods

In 1938, eight varieties which were known to differ in yielding ability were selected for the comparison of results from 20-inch X 10-inch spacings and from similar plant populations in which the spacing was 20-inch x 20-inch. This test was planted near Ault in northern Colorado on land of high fertility. The previous crop was potatoes. The eight varieties were planted as a Latin square and the 64 variety plots were split for the following spacings: (1) single beets spaced 40 x 40 inches; (2) single beets spaced 20 X 10 inches; (3) two-plant hills spaced 20 X 20 inches. To accomplish this, the 8-row variety plots which were 90 feet long were divided into thirds, and the spacings as indicated were randomized on the 30-foot sub-plots. With the exception of a few plots, good to excellent stands were obtained. This test was harvested in late October in such a manner that yields could be computed on the basis of yields from normally-competitive beets as well as actual yields.

In 1939, three varieties were selected for the test: (1) a hybrid known to have high yielding ability, a relatively small crown, and not particularly heavy foliage; (2) a European brand said to have the ability to make maximum use of additional space (the performance of this variety did not bear out this expectation); and (3) a three-times inbred strain of very uniform top and root type and very low yielding ability.

The 1939 test was planted on the College Farm at Fort Collins, Colo., on land of high fertility. The preceding crop on this land was oats. The varieties were planted in six random blocks and these 18 variety plots were

---

1/ Assistant agronomist, Bureau of Plant Industry, U. S. Department of Agriculture. Agronomic investigations are cooperative with the Colorado Agricultural Experiment Station.

2/ Effect of Spacing and Density of Stand on Hill Production of Sugar Beets. Proceedings, American Society of Sugar Beet Technologists, 1938:16.



split for the following spacings: (1) single beets spaced 40 X 40 inches; (2) single beets spaced 20 X 20 inches; (3) single beets spaced 20 X 10 inches; and (4) two-plant hills spaced 20 X 20 inches. Excellent stands were obtained for varieties 1 and 2; the stand of the inbred varied from poor to good on individual plots. The test was harvested in October in the same manner as the 1938 test and yields were calculated in the same way.

Results of the 1938 and 1939 Tests

Since in both 1938 and 1939 tests each of the varieties exhibited the same relative trend in yield and sucrose percentage in each of the spacings, discussion of varietal reaction to differences in spacing will be omitted. Data from all of the varieties in each test have been averaged in considering the effect of the spacings. The results from spacings as wide as 40 X 40 inches showed that yields were low. These data are omitted in this report.

The 1938 Test

The 1938 comparison reported is between approximately equal plant populations which in one case were spaced singly in a 20 X 10-inch pattern and in the other case were present as two-plant hills spaced 20 X 20 inches. Table 1 summarizes the 1938 test for the two spacings, 20 X 10 inch singles and 20 X 20 inch doubles.

Table 1.---Comparisons for acre-yields of roots and gross sugar, sucrose percentages, and for marketable roots per plot for plots with single beets spaced 20 X 10 inches and two beets per hill spaced 20 X 20 inches; 8 varieties, 8 times replicated, averaged. Data obtained on basis of normally-competitive beets per plot and as actual plot yields: Ault, Colo., 1938. (Results given as 64 plot averages)

Spacing	Normally-competitive beet basis			Actual-yield data			Roots harvested	
	Acre yield		Sucrose <sup>2/</sup> percent	Acre yield		Sucrose	Total	Market- able <sup>3/</sup>
	Gross sugar pounds	Roots tons		Gross sugar pounds	Roots tons			
20 X 10 inches (singles)	5,673	19.89	14.28	5,532	19.41	14.28	197	196
20 X 20 inches (doubles)	5,300	18.46	14.35	5,345	18.63	14.35	200	179
F value <sup>1/</sup>	9.75*	14.76**	N.S.	4.70	6.97*	N.S.	N.S.	36.84**
Difference required for signifi- cance 19:1	282	.88	.58	205	.70	.58	5	7

1/ \* F exceeds 5 percent point  
 \*\*F " 1 percent "

2/ Sucrose determinations for each plot by using all normally-competitive beets from the plot to supply two composite samples.

3/ Weighing 0.4 pounds or more when topped at lowest leaf scar.



### Discussion of 1938 Test

Since the difference in sucrose percentage in the beet for these two spacings falls far short of the level of statistical significance, the evidence from this test is that quality of the beets, as measured by this value, is approximately equal. The yield of roots from the 20 X 10 inch singles exceeds the yield from the 20 X 20 inch doubles by 1.43 tons and 0.78 tons for competitive beets and actual yields, respectively. These differences exceed the five percent point of probability. The advantage of the 20 X 10 inch singles is less clearly shown in gross sugar as calculated. On the normally-competitive beet basis, the difference was significant; but it was not significant on the actual-yield basis. Approximately equal numbers of beets were harvested from each of the spacing treatments, averaging 197 from the 20 x 10 inch singles and 200 from the 20 X 20 inch doubles. Since a perfect stand would have been 216 beets, it is evident that the average stands were excellent. When the number of beets of marketable size is considered, there is a considerable difference in favor of the 20 X 10 inch singles. Of the beets from the 20 X 20 inch doubles, 8.5 percent failed to reach a marketable size of 0.4 pound, which approximates a beet slightly in excess of 1 inch in diameter at the crown line.

### The 1939 Test

The 1939 test differs from that of the previous year in that a plant population only half as great was also included, namely, single plants spaced 20 X 20 inches. The variety-space plots were 30 feet long, except in Randomized Block VI in which the plot length was 25 feet. Eight-row plots, with data taken from the six inner rows, were used with the 20-inch rows; 4-row plots were used with the 40 X 40 inch spacing, all beets harvested.

As previously stated, the interaction of varieties and spacings, if any, may be regarded as negligible. However, because of the wide differences in the yielding capacity of the varieties used in 1939, the results by varieties under the different conditions of spacings for stands, sucrose percentages, and actual yields are given in Table 2. Competitive-beet yields were of the same order and are omitted.

In the 1939 test, the yield of the inbred is undoubtedly significantly less than that of either of the normal varieties. Although the yield of the hybrid exceeds that of the commercial, the difference was not found large enough to be statistically significant. Since the yields of all three varieties exhibit the same general trends in the different spacings employed, the data for spacing effects in the following summary, Table 3, are given as averages of varieties. The 40 X 40 inch spacing results are omitted.

### Discussion of Spacings, 1939 Test

The difference in sucrose percentages of the beets grown as singles in a 20 X 10 inch spacing pattern and those grown as doubles in a 20 X 20 inch pattern falls, as in 1938, within a range of chance occurrence. It is judged that the quality of the beets from these two spacings is not significantly different. While sucrose percentage of the roots from the 20 X 20 inch pattern, plants grown as singles, was not found to be significantly lower in this test, there appears to be a trend toward lower sucrose percentages when the plant population is reduced one-half.



Table 2.--Results from spacing test at Fort Collins, Colo., in 1939 for three varieties with four types of spacings, actual-yield basis. (Data given as 6-plot averages.)

Spacing pattern	Variety	Acre-yield of			Roots harvested per plot 1/	
		Gross sugar pounds	Roots tons	Sucrose percent	Total	Marketable
20 X 10 inches, singles	Hybrid	6,653	21.40	15.55	200	191
do.	European brand	6,059	18.89	16.08	206	195
do.	Inbred	2,840	8.09	17.63	184	153
20 X 20 inches, doubles	Hybrid	5,569	17.89	15.59	206	177
do.	European brand	5,322	16.70	15.97	207	177
do.	Inbred	1,892	5.49	17.18	146	106
20 X 20 inches, singles	Hybrid	5,866	19.16	15.32	106	106
do.	European brand	5,240	16.71	15.73	104	103
do.	Inbred	1,742	5.23	16.74	81	74
40 X 40 inches, singles	Hybrid	2,334	9.11	12.82	(182)	(181)
do.	European brand	1,824	6.81	13.42	(184)	(183)
do.	Inbred	464	1.54	15.07	(152)	(138)

1/ Stands in the first three spacing patterns are given as 6-plot averages; full stands for the 20 X 10 inch pattern, singles, and the 20 X 20 inch, doubles, would require 216 beets and for the 20 X 20 inch, singles, 108 beets. The stands for the 40 X 40 inch spacings are given as totals for the six plots of each variety.

Table 3.--Effects of various spacing patterns on acre-yields of gross sugar, roots, on sucrose percentages, and on marketability of roots. The results are given on basis of normally-competitive beets harvested per plot, and also as actual plot yields. Calculated yields are based on roots weighing, when topped, not less than 0.4 pound: Fort Collins, Colo. 1939. (Data given as 18-plot averages.)

Spacing pattern	Based on normally-competitive beet basis			Based on actual plot yields			
	Acre-yield of			Acre-yield of		Roots harvested 2/	
	Gross sugar pounds	Roots tons	Sucrose percent	Gross sugar pounds	Roots tons	Total	Marketable
20 X 10 inch, singles	5,416	16.82	16.42	5,184	16.12	203	193
20 X 20 inch, doubles	4,440	13.90	16.25	4,261	13.36	206	177
20 X 20 inch, singles	4,546	14.50	15.93	4,282	13.70	105	104
Difference required for significance 19:1	461	1.28	0.68	478	1.45	-	-
F value 1/	13.43**	14.46**	1.33	12.05**	10.67**	-	-
Excess of singles from 20 X 10 inch pattern over doubles, 20X20 inch pattern	976	2.92	0.17	923	2.76	-3	16

1/ Values marked \*\* exceed the 1 percent point.

2/ Because of lack of vigor, the inbred variety produced an abnormally large number of very small roots. The data for total and marketable roots harvested are based on the two other varieties in the test. Full stand for the first two spacing patterns listed would consist of 216 beets per plot, and for the third spacing pattern, 108 beets.



In this test, the acre-yield of gross sugar and roots of the 20 X 10 inch singles significantly exceeds the yield of the 20 X 20 inch, two-plant hills, both on the basis of normally-competitive beets taken from the plots and as actual plot yields. The differences are probably highly significant for this test, since, in every case, they considerably exceed the statistical requirement for significance for odds 19:1. In acre-yields of gross sugar and of roots, the 20 X 20 inch, two-plant hills, and the 20 X 20 inch, singles, did not differ significantly in this test. Stands of the hybrid variety and the commercial brand used in this test were excellent as shown by the total beets harvested, full stands, being 216, 216, and 108 beets, respectively, for the three spacing treatments in the order given in Table 3. The tendency for the number of unmarketable roots to increase when beets are grown two plants in a hill, as contrasted to one plant in a place, but spaced closer, was again shown.

### Conclusions

Under the conditions of these tests, although plant populations for the two treatments were approximately equal, the yields from sugar beets spaced 20 X 10 inches and grown one plant in a place exceeded the yields from two-plant hills spaced 20 X 20 inches. It is to be noted that, whereas acre-yields of gross sugar in the 1938 test did not differ significantly between the two spacing patterns, significant differences were shown in 1939. These results suggest that conditions such as adequacy of water supply, soil fertility levels, or other factors, may have influence. In this connection, attention is called to the 1939 results in which with plant populations reduced by one-half in the spacing pattern, singles, 20 X 20 inches, the yields were essentially equal to those from the sugar beets grown in two-plant hills of the same spacing.

### Summary

Results are given for variety-spacing tests conducted with sugar beets in 1938 and 1939 in northern Colorado. In 1938, 8 sugar-beet varieties were grown in a replicated test, on which the following spacing patterns were superimposed: 20 X 10 inch, singles; 20 X 20 inch, doubles; 40 X 40 inch, singles. In 1939, 3 varieties were used with the same spacing patterns as in 1938, with an additional one, 20 X 20 inch, singles. Significant differential responses among the varieties to spacing patterns were not found in either season. The number of unmarketable roots in both 1938 and 1939 was greater when the sugar beets were grown two plants in a hill than when spaced closer and grown as singles. The acre-yield of roots was significantly larger in both seasons with beets grown as singles with a 20 X 10 inch spacing than when grown as doubles with twice the spacing in the row. The acre-yields of gross sugar obtained with these spacing patterns were not significantly different in 1938 but were very significantly in favor of singles spaced 10 inches in the row in 1939. It is suggested that conditions of water supply, fertility levels, and other factors, may influence results from such trials.