Beet Population Studies

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Acre-beet populations in relation to sugar yield have been studied extensively during the past 20 years by state and federal experiment stations and sugar beet companies. During the period 1920 to 1928 in the Arkansas Valley of Colorado, experimental data showed that for average lands beets grown in rows 20 inches apart and spaced 12 inches apart in the row (26,136 beets per acre) gave most satisfactory results. Immer *(3)*[2] in experiments with acre populations ranging from 12,960 beets to 24,502 beets, in row spacings of 22 inches to 16 inches, reported yields from higher acre populations. Nuckols *(5)* obtained higher yields from acre populations of 35,500 beets than from lesser populations. Skuderna et al (6), in eight multiple tests conducted in six states, found significant differences in favor of 20-inch by 12-inch spacing over 20-inch by 16-inch spacings (26,136 and 19,602 beets per acre respectively) in half of the tests, the others showing no significant differences. Brewbaker and Deming (/) found that uniformity of stand as well as space allotment affected beet yields. These authors also had evidence of large differences in favor of 18-inch rows over 24-inch rows when equal acre populations were compared. Culbertson *(2)* in tests of acre poulations ranging from 14,256 beets to 49,004 beets, in row widths of 22 inches to 16 inches, found, as an average of seven tests, that rows spaced 16 inches and beets spaced 8 inches in the row produced higher yields than other spacing patterns and lesser acre populations. Skuderna and Doxtator (7, *8)* found that a 20 inch by 10 inch plant spacing gave higher yields than a 20 inch by 15 inch plant spacing as an average, but a significant effect of varieties and of fertilizers was also observed.

The purpose of this paper is to present results obtained during the 3-year period, 1943 io 1945, on the relation of space allotments of sugar beets under varying conditions, to yield.

Experimental Results

Three experiments were conducted at Rocky Ford, Colo., in 1943 to test the relative yielding ability of beets in different acre populations. Beefs were planted in 20-inch rows, and hills were spaced 8, 12, 16, and 20 inches in the row. Four replications of plots four rows wide by 50 feet long wore used in each test,and total harvest was made of the two center rows of each plot. The tests were in cooperation with three farmers and were on land of average fertility for the

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[2]Italic numbers in parentheses refer to literature cited.

area. Data obtained from each test were averaged and are given in table 1.

Table 1.—Average results obtained from four spacing allotments in three tests, Rocky Ford, Colo., 1943.

Space allotment inches	Population per acre	Tons beets per acre	Sucrose percent	Gross pounds sugar per acre
20 x 8	30,204	17.07	15.01	5,120
20 x 12	26,136	16.50	14.85	4,934
20 x 16	19,602	16.14	14.84	4,770
20 x 20	15,682	15.83	14.91	4,721
Significant difference (19:1)		1.08	.42	316

In this experiment there were sizeable average yield differences between three test areas. There was, however, no differential response of the various spacings to the different areas. As an average of the three tests, significant differences were obtained for acre yields of beets and sugar in favor of closer spaeings.

At East Grand Forks. Minn., in 1944, a test was conducted using two varieties, four fertilizer treatments, and three space allotments. This test was planted in 18-inch rows and plots were six rows wide by 50 feet long, each treatment being replicated 6 times. Two 20-beet samples were used for yield data and two 10-beet samples were taken for sugar percentage from each plot. The analysis of variance table for sugar per acre yields is given in table 2.

Table 2.- Analysis of variance table for sugar per acre yields. East Grand Forks. Minn., 1944.

Variation due to:	D/F	Sums squares	Mean squares	F
Blocks	5	591,090	118,208	
Varieties	1	1,890,854	1,890,854	7.86
Fertilizers	3	1,216,657	405,552	1.68
Spacings	2	16,859,497	8,429,749	34.88**
Varieties x fertilizers	3	2,141,764	680,588	2.82*
Varieties x spacings	2	2,070,256	1,035,128	4.28*
Fertilizers x spacings	6	354,690	59,115	
var. x fert. x spac.	6	6,117,277	1,019,546	4.22**
Remainder (error)	115	27,780,982	241,652	
Total	143	57,032,016	412,811	

* Significant beyond 5 percent point
** Significant beyond 1-percent, point

From this analysis it is apparent that different space allotments greatly affected yields and were of appreciably greater importance than other variables. However, the significant effect of varieties and of fertilizers observed in this test is important enough to be taken into consideration in determining which spacing of beets will give the maximum yield.

As an average of all fertilizers it was found that one variety produced a significantly lower yield of sugar per acre than the other variety at the 18-inch by 3 8-inch spacing. At the 18-inch by 15-inch spacing, yields of both varieties were equal. Since the standard procedure in growing beets in the East Grand Forks area is to cross block before thinning and follow by two or more cross cultivations in a space pattern of 18 by 18 inches, using a variety which will produce the highest yields at this spacing is required.

The average data obtained on the three spacings are given in table 3. Under the conditions of this test, 18-inch by 12-inch space allotments gave significantly higher acre yield of beets and sugar than 18-inch by 15-inch spacings and higher sucrose percentage than 18-inch by 18-inch spacings.

Table :J.—Yield results from 18 by 18, 18 by 15, and 18 by 12 inch spacings of beds. East Grand Forks. Minn., 1044.

Space allotment	Population per acre	Tons beets per acre	Percentage sucrose	Pounds sugar per acre
18 x 18	19,360	17.02	14.45	4008
18 x 15	23,232	17.07	15.06	5317
18 x 12	29,040	19.06	15.30	5746
Significant difference (19:1)		.64	.28	201

In 1945 a strip test of two-beet and one-beet hills in 1he standard hill spacing of 18 by 18 inches, was conducted at East Grand Forks, Minn. This test was to determine if higher acre populations obtained by thinning to two-beet hills without change in the 18 by 18 inch hill pattern would increase yield. Twenty competitive hills were harvested in six adjacent locations of each strip for yield and sucrose percentage, before complete harvest of each strip. The results obtained are given in table 4.

Table 4.—Yield comparison of one beet and two-beet Hills spaced 18 by 18 inches apart, East Grand Forks. Minn., 1945.

Hill population	Acre population	Tons beets per acre	Percentage sucrose	Pounds sugar per acre
	Data from competitive beet samples			
1	10,360	12.34	13.35	3305
2	38,720	13.36	13.88	3705
Approximate odds (4)		112:1	12:1	819:1
	Data from complete strip harvest			
1		9.97		
2		10.20		

The use of two-beet hills gave a reliable increase in yield over single beets in the 18 by 18-inch hill spacings in this test and is

further evidence that in 1945 sugar per acre yields could have been increased by use of higher acre populations in this area.

The relation of different hill populations, and spacings of hills, to yield, was compared in standard 20-inch rows at Rocky Ford, Colo., in 1945. This test was of Latin Square design planted in six replications of plots four rows wide by 50 feet long. Harvest of the two center rows for yield was made from each plot, and sucrose percentage for each plot was obtained from two 10-beet samples. Whole seed sized 7/64 to 10/64-inch and germinating 65 percent with *n* very high single germ count was used for the test, planting being made with a precision drill.

A relatively poor stand was obtained and it was difficult to leave beets closely spaced in those plots which were to be thinned as double and triple hills. As a result, beets in these hills were, on an average, much more widely spaced than normal for experiments of this type. The data obtained are given in table 5.

Table 5.—Hill spacing and population test in 20-inch rows, Rocky Ford. Colo., 1945.

No. beets per hill	Spacing of hills in row, inches	Population per acre after thinning	Percentage of marketable beets	Tons beets per acre	Percentage sucrose	Pounds sugar per acre
1 beet	8	39,204	85.4	9.50	15.75	3,013
1 beet	12	26,136	89.0	9.85	15.23	3,005
2 beets	18	34,848	82.3	9.15	15.49	2,843
1 beet	18	17,424	98.9	9.63	14.58	2,811
2 beets	12	52,272	69.7	8.68	15.61	2,730
3 beets	18	52,272	65.1	8.39	15.32	2,612
Significant difference (odds 19:1)				.90	.68	368

This test field was known to be low in fertility, which undoubtedly was an important factor in producing a low average yield. Under these conditions, three beet hills spaced 20 by 18 inches produced a yield of sugar per acre significantly lower than the 20 by 8 inch spacing of single beets. The single beet spacing at 20 by 18 inches produced yields not significantly different from other spacings and hill populations but was significantly lower in sucrose percentage. The percentage of marketable beets per acre was unusually low for all spacings except the single beet spacing of 20 by 18 inches. From the data obtained it is apparent that high acre populations, whether in single or multiple hills, did not greatly affect yields.

A test was made at Rocky Ford, Colo., in 1945 on a field of high fertility, of beets in 20-inch and 80-inch rows. This test was in strips 12 rows wide extending the length of the field. The beets in the 20-inch rows were thinned 12 inches apart, and those in the 30-inch rows were thinned 8 inches apart, thereby obtaining equal populations per

acre for each strip. Samplings of 100 feet of row were made in adjacent areas in each strip at harvest for yield determinations. Two 10-beet samples were obtained for sucrose percentage from each 100 feet of row harvested. The results are given in table 6.

Table 6.—Yield data obtained from 20-inch and 30-inch row spacings, Rocky Ford, Colo., 1945.

Row spacing inches	Hill spacing inches	Tons beets per acre	Sucrose percent	Pounds sugar per acre
20	12	28.14	15.57	8744
30	8	25.60	15.23	7819
Approximate odds (4)		28:1	7:1	45:1

These results are in accord with earlier investigations in this area, which led to recommendation for row spacings of approximately 20 inches. Under the conditions of this test, it would appear that beets in a space pattern of 20 inches by 12 inches were better able to absorb plant food than those in the 30-inch by 8-inch pattern.

Discussion of Results

The experiments conducted at Rocky Ford, Colo., in 1943 on three areas of different fertility showed that yield of beets could be increased by use of 20-inch by 8-inch space allotments as compared to 20-inch by 20-inch space allotments. At East Grand Forks in 1944, 18-inch by 12-inch plant spacings gave very significantly higher acre yields of beets and sugar, and of sucrose percentage, than 18-inch by 18-inch spacing. These results are in accord with previous findings of other investigators.

An analysis of the data obtained at East Grand Forks in 1944 where three commercial fertilizers and no fertilizer check were used on plots planted to two varieties and thinned to three different spacings (table 2) indicated that in this area the major factor of importance was acre population. However, highly significant F values were obtained for variety effect and for the spacing-variety-fertilizer interaction. Since spacings and varieties, and fertilizers and varieties, also gave significant F values, it is apparent in this test that both varieties and fertilizers were important in the production of sugar per acre from the various spacings. At Rocky Ford, Colo., in 1945 the data obtained on the hill spacing and hill population test did not show great differences in acre yield due to population. These results were obtained on a field of low fertility where counts indicated that only beets in wide space relationships produced a high percentage of marketable beets. This would indicate further that fertility of soil may be an important factor in determining the correct acre beet population to use.

In a preliminary test at East Grand Forks it was found that higher acre populations obtained by use of two-beet hills produced a significant increase in yield. If two-beet hills continue to produce higher yields than single beets in future tests, this method of obtaining higher yields may be used, since no change in standard farming practice would have to be made.

In a test of beets planted in 20-inch rows and thinned to 12 inches in the row, as compared with beets planted in 30-inch rows and thinned to 8 inches in the row, a significant difference in sugar per acre yield in favor of the 20-inch by 12-inch space pattern was obtained.

Conclusions

Evidence has been obtained from tests conducted in two widely separated areas that yields of sugar per acre can be increased by thinning to higher acre populations of beets. This was accomplished in one test by leaving two-beet hills, and in another test by spacing single beets more closely in the row, without change of row width. Varieties as well as fertility of soil are important in the determination of the most productive acre population. In one test where a space allotment of 240 square inches was given, beets arranged in a 30-inch by 8-inch pattern gave lower yields than those in *a* 20-inch by 12-inch pattern.

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