Plant Population Experiments with Sugar Beets at Fort Collins, Colorado[2]

G. W. DEMING[3]

The relation of sugar beet stand, or plant population, to acre yield of sugar beet roots and sugar has been studied in the period 1937-1949 in the agronomic experimental work of the writer at Fort Collins, Colorado. This paper reviews briefly the older experiments which have been previously reported in some detail and gives additional information from the experiments of 1948 and 1949.

The experiments have been conducted on Fort Collins Clay Loam soils of the agronomy farm at the Colorado A & M College Agricultural Experiment Station. The sugar beet seed used has been the standard commercial variety currently issued to growers of the Fort Collins district by the Great Western Sugar Company. With the exception of experiments involving different row widths as a variable, the standard row width used was 20 inches. Various plant populations have been attained by differential basic spacings of hills in the row and by varying the proportions of skips, 1-, 2-, and multiple-plant hills in the stands. Distribution of the different types of hills in a stand has been at random, usually as determined by drawing random numbers. In general the attained stands have approximated very closely the stands as planned. All the experiments have been of randomized block or Latin square design with a minimum of 5 replications.

The 1937-39 series of experiments compared spacings of single plants at 8, 12 and 16 inches with 100, 70 and 40 percent stands of each spacing. The conclusions reached were: (1) With approximately equal yields from full stands of all three spacings the 12-inch spacing appeared to be the optimum. (2) As stands were reduced yields declined, but the declines in yield were not proportional to the reductions in stand. In general a 70 percent stand could be expected to produce about nine-tenths as much as a full stand, a 50 percent stand three-fourths and a 30 to 40 percent stand two-thirds of a normal crop. (3) Percentage sucrose declined as stands were reduced, but marked reductions in quality of the roots did not occur until stands dropped below about 60 plants per 100 feet of row (1, 2, 3, 5) .*

In 1941-43 beets planted in the first half of April with 100, 70, 50, and 30 percent stands of single plant hills were compared with a full stand of beets planted in mid-May. The conclusions were: (1) That it would usually be more profitable for a grower to save as little as a half stand of timely planted

[1] Agronomic investigations of the Division of Sugar Plant Investigations at Fort Collins, Colo., are cooperative with the Agronomy Section of the Colorado A & M Agricultural Experiment Station and are conducted on its Agronomy farm.

[2] Scientific Journal Series No. 325. Colorado A & M College Agricultural Experiment Station.

[3] Agronomist, Division of Sugar Plant Investigations, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.

[4] Numbers in parentheses refer to literature cited.

beets than to replant in May. (2) The conclusions reached from the 1937-39 tests as to the proportion of a full crop which could be expected from 70, 50 and 30 percent stands and the poorer quality of beets from reduced stands were confirmed (1, 2, 3).

A study of yields from thin stands *in* rate of planting tests in 1944-45 and a plant population experiment in 1945 in which full and reduced stands in which 25 percent of the plant-containing hills (15, 25 and 35 percent in the case of the 70 percent stands) had two or more plants per hill were compared with a full stand of single plant hills led to the conclusion that the hill was the unit of stand which determined sugar beet yields (4). This conclusion was the basis for the following recommendation:

> "The thinned stand of sugar beets, by whatever method it is obtained, should consist of as high a proportion of single-plant hills as can be obtained from the initial stand of seedlings without reducing the total stand of well distributed hills below the maximum number obtainable up to a full stand."

In 1946 full and reduced (70, 50 and 30 percent) stands of single-plant hills were compared with similar stands in which 25 percent of the plant-containing hills were 2-plant and multiple-plant hills. This experiment confirmed the conclusion that the hill, irrespective of the number of plants it contained, was the unit of stand which determined sugar beet yields (5). Consideration of the relation of this concept to machine thinning of sugar beets led to the following conclusions and recommendations:

> "In machine thinning of the sugar beet crop the aim should be to leave as full a stand of hills as is obtainable from the initial stand being worked. Few roots of marketable size are likely to be produced in hills containing more than a maximum of 3 plants. Therefore, precision planting of high quality sheared seed on a clean and well prepared seedbed must be the foundation for the thin, uniform initial stand from which an approximately full stand of predominantly 1- and 2-plant hills can be saved by the appropriate machine operation."

Since the conventional 20-inch beet row seems somewhat narrow for the best operation of large-tired tractors and some beet harvesters an experiment was conducted in 1947 to determine the effect of width of row on yields of sugar beet roots and sugar. Row widths of 22, 24, and 30 inches and alternate rows of 20- and 40-inch widths were compared with the standard 20-inch row. Total plant populations were varied by holding the row spacing of single plant hills constant at 12 inches for all row widths. In other treatments populations were held at approximately 26,000 plants per acre, the normal stand at 20x12-inch spacing, by varying the spacing in the row or the inclusion of a portion of 2- and multiple-plant hills according to the row widths. In general, yields declined as row widths increased. Increasing the number of plants in the row had little effect on yields; row width was the determining factor (6). The conclusion was that since reductions in yield were relatively small in the case of small increases in row width, the greater convenience of operating machinery might justify the use of 22-inch, or possibly 24-inch, rows.

Plant Population Experiment, 1948-49

It is obvious that some of the sugar beet plants in multiple-plant hills

will not produce roots of sufficient size to be saved at harvest. It would seem that this condition would result in somewhat lower recorded yields from stands in which part of the hills contained two or more plants than from comparable stands of single-plant hills. In the experiments conducted from 1944 to 1947 the differences in yields from such stands were usually small and could not with certainty be considered significantly different. However, the small differences observed in yields of roots were often in favor of the single-plant stands. Sometimes a slightly higher percentage sucrose in the roots from the stands containing multiple-plant hills compensated for the slightly

TABLE I. Detail of treatments included in sugar beet populations experiment, Fort Collins, Colo., 1948-49.

Basic spacing	Hills per 100 feet of row				Total plants per 100' row
	Blank	1-plant	2-plant	3-plant	
(inches)					
12x20	0	100	0	0	100
8x20	0	150	0	0	150
8x20	50	60	80	10	150
12x20	0	70	25	5	135
12x20	20	56	20	4	108
12x20	30	49	18	3	94
12x20	40	42	15	3	81
12x20	50	35	13	2	67

smaller yield of roots and calculated yields of gross sugar were almost identical. To obtain additional evidence on this point an experiment was conducted in 1948 and repeated in 1949. The treatments included in this experiment are given in table 1. The test was planted as a Latin square. The plots were 8 rows 6 feet in length, of which the four inside rows were harvested. Distribution of the various types of hills was determined by drawing numbers for each plot. In 1948 the attained thinned stands were with a few exceptions in fair agreement with the planned stands and in 1949 all stands were in excellent agreement. Planting was timely in both years but in both years thinning was slightly late because of weather conditions. Acre yields of gross sugar and roots and percentage sucrose for both experiments are summarized in table 2. In the second portion of this table the data are experessed as percentages of the check (treatment 1) .

In these experiments none of the treatments equalled the check in yields. However, the yields of the full stand of single-plant hills spaced 8x20 inches was, as usual, only slightly, and not significantly, lower than the check.

The evidence from these experiments as to percentage sucrose in the beets from the different treatments is in reasonable agreement with the evidence from earlier experiments. The conclusion is that under the conditions at Fort Collins there is no marked decline in quality of the roots produced in reduced stands until the stands fall below about 70 hills per 100 feet of row.

In general the harvest crew did not save beets which were less than about 1 inch in diameter at the crown. Such beets were rare in the check

plots, but were found in appreciable numbers in the other treatments; particularly treatments 2, 3 and 4. Treatment 4 with a full stand of hills, 30 percent of which had one or two additional plants, produced appreciably lower yields than the check; the differences being significant in 1949 and for the average of the two experiments. The reduction of approximately 7 percent in yield of roots from this treatment seems too large to be attributed entirely to non-harvest of small beets. In this full stand of hills the additional plants may have had an overall adverse competitive effect.

TABLE 2.—Sugar Beet Population experiment Fort Collins, Colo., 1948 and 1949. Acre yields of gross sugar and roots and percentage sucrose. Data given as 8-plot averages and 2-year average of averages.

Treatment No.	1948 Acre yields Gross sug. (pounds)	Roots (tons)	Percentage sucrose (percent)	1949 Acre yields Gross sug. (pounds)	Roots (tons)	Percentage sucrose (percent)	2-year average Acre yields Gross svig. (pounds)	Roots (tons)	Percentage sucrose (percent)
	6,198	19.63	15.67	7,173	20.60	17.41	6,686	20.12	16.54
	6,184	19.51	15.71	7,054	20.16	17.46	6,609	19.84	16.58
	5,584	17.75	15.74	6,357	18.49	17.20	5,970	18.12	16.47
	5,934	18.68	15.88	6,455	18.83	17.13	6,194	18.76	16.50
	5,845	18.90	15.46	6,543	19.22	17.02	6,194	19.06	16.24
	5,943	18.87	15.75	6,460	18.54	17.43	6,202	18.70	16.60
	5,094	16.78	15.18	5,716	17.10	16.80	5,420	16.94	15.99
	5,082	16.62	15.27	5,245	15.81	16.59	5,164	16.22	15.90
Sig.	400	1.17	0.36	502	1.25	0.54	321	0.86	0.32
	Data expressed as percent of the check treatment.								
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	99.8	99.4	100.3	98.1	97.9	100.3	98.8	98.6	100.2
	90.1	90.4	100.4	88.6	89.8	98.8	89.3	90.1	99.6
	95.7	95.2	101.3	90.0	91.4	98.4	92.6	93.2	99.8
	94.3	96.3	98.7	91.4	93.3	97.8	92.6	94.7	98.2
	95.9	96.1	100.6	90.7	90.0	101.1	92.8	92.9	100.4
	82.2	85.5	96.9	80.1	83.0	96.5	81.1	84.2	96.7
	82.0	84.7	97.4	73.1	76.7	94.9	77.2	80.6	96.1

Treatment 3, with a basic spacing of 8x20 inches, one-third of the hills blank and 40 percent of the plant-containing hills having one or two additional plants, produced about 90 percent of a full crop. This yield was approximately of the order to be expected from such a reduced stand and there seems to be no reason to believe that the multiple-plant hills had any particularly adverse effect in this treatment. Treatments 5, 6, 7, and 8 were similar to treatment 3 in that they also produced crops that, on the basis of previous tests, can be considered as approximately normal for such reduced stands of hills.

Although the results of these experiments were not entirely conclusive they suggest that additional plants present in multiple-plant hills may have some adverse effect on yields under some conditions. These experiments again confirmed the conclusion that such plants in no way compensate for skips in the stand. Therefore, as machines take the place of hand labor in thinning the sugar beet crop, the aim must be to so plant and thin the crop that there will be a high proportion of single-plant hills in adequate thinned stands. It is unlikely that even the best machine work can ever equal the

nearly perfect stands of single-plant hills that can be attained by the best hand work. However, it is certainly not too much to expect that 70 to 90 percent thinned stands of predominantly single-plant hills can be attained by the proper use of machinery alone. The evidence accumulated in the past thirteen years of experimentation with sugar beet populations at this station indicates clearly that profitable beet crops will be produced from such stands.

Literature Cited

1. DEMING,, G. W., Relative Yields of Reduced Stands of Sugar Beets Planted at a Normal Date and of Replanted Sugar Beets. Proceedings Amer. Soc. Sug. Beet Tech. 1942, 197-202.

2. _____Stands and Yields. Through the Leaves, 33 (2) ; 21-27 March-April, 1945.

3. _____Saving a Small Stand vs. Replanting. U & I Cultivator. 5 (1), 14-15; March,'l945.

4. _____Sugar Beet Populations in Relation to Yields. Proceedings Amer. Soc. Sug. Beet Tech. 474-494; 1946.

5. _____Effect of Multiple-Plant Hills on Yields and Quality of Sugar Beets. Proceedings Amer. Soc. Sug. Beet Tech. 47-53; 1947 Western Regional Meeting.

6. _____The Effect of Variations in Row Width and Plant Populations on Root Yields and Sucrose Percentage of Sugar Beets at Fort Collins, Colo. Proceedings Amer. Soc. Sug. Beet Tech. 280-281; 1948.