An Evaluation of Mechanical Thinning of Sugar Beets in California

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In recent years the practice of complete mechanical thinning of sugar beets has increased greatly in several sugar beet growing areas of the United States (5)[2] (6). Hand thinning is a tedious task, a major item of expense in the culture of the sugar beet crop and is the last remaining obstacle to complete mechanization. Any procedure which holds promise of eliminating some of this task deserves prompt consideration. As with any new practice, however, it is important that its use be carefully evaluated to be sure that its adoption will result in an improvement in production efficiency. For this purpose, several field trials were conducted from 1952 through 1955 to determine the effect of down-the-row type mechanical thinners on sugar beet production in California.

Eleven field trials were conducted. Individual plots in all trials consisted of four-row strips through the field or experimental area. Each treatment in each trial was replicated from 3 to 7 times. The eight trials conducted in commercial fields were harvested by machine, usually of the Marbeet type. Beets from each individual plot were loaded in a separate truck. Each truck load was handled at a sugar company loading station in the usual manner with the exception that 4 or 5 samples were taken from each instead of the usual one. The average of these samples was used for determining average plot sucrose and tare percentages.

The three trials at the Experiment Station at Davis, California, were harvested by hand. Plots were at least 150 feet in length and four rows wide. One-hundred and fifty, 180, and 60 feet of all four rows were harvested in 1953, 1954, and 1955 respectively. Four, 20-beet samples were taken from each plot for sugar and tare determinations. Beets less than two inches in diameter were discarded.

Thinning machines used were the Silver "GW" Beet Thinner or the machine manufactured by the Dixie Implement Manufacturing Company.

In all trials, beets were thinned mechanically according to the procedure outlined by the machine manufacturer. Thinning heads were selected to leave at least 137 beet containing inches per 100 feet of row.

Stand counts were made before and after thinning at two locations across the area selected for each trial. All four rows of each plot were counted for each measurement taken. Thus each plot was represented by at least eight determinations for each measurement.

Final stand determinations were made two to four weeks after thinning. An objective was to select a stand evaluation procedure that would reflect yield differences. Previous experiments had indicated that a four-inch spacing between single beets is about as close as can be tolerated without reducing yields appreciably (4). A four-inch space, therefore, was selected

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[2] Numbers in parentheses refer to literature cited.

as the criterion for determining single, double, and multiple plant hills. If two beets occurred within a four-inch space, it was a "double"; if three or more, a "multiple." Plants separated by four inches or more were "singles." These determinations were made in six of the trials.

To measure the effect of gaps between plants, a procedure outlined by the late G. W. Deming was followed (2). Each gap in excess of 16 inches was measured and the distance in excess of 16 inches considered as "row unoccupied." Such unoccupied spaces were totaled per 100 feet of row to develop the measure "percent row unoccupied."

Results and Discussion

Harvest results for all trials are given in Tables 2 and 3. Highly significant differences in root yield occurred in 8 of the 11 trials with hand thinned plots yielding from 0.7 to 6.5 tons per acre more than plots thinned entirely by machine. When long-handled hoes were used to trim machine thinned beets, root yields were usually increased compared to beets thinned completely by machine.

There was a significant difference in percent sugar in only one trial. This was a 0.5 percentage point increase in favor of machine thinned beets. Coefficients of variation for sugar percentage in the various trials were low, indicating that possible differences in sucrose percent could be measured with a high degree of precision. Failure to consistently measure differences indicates that mechanical thinning had very little effect on sugar percent.

Tare dirt, which includes small beets removed by screens at loading stations, was significantly higher for machine-thinned plots in two trials. Differences in tare dirt between the two thinning methods in terms of tons of waste material per acre was not great.

Laboratory tare percentage tended to be higher for machine-thinned beets in most of the trials and significantly higher in two. Differences in laboratory and beet-dump tare in favor of hand-thinned beets can account for some of the differences in root yield of clean beets. In most cases, however, the differences in laboratory and beet-dump tare are not great enough to explain the major portion of differences in clean root yields.

If a new practice contributes to farming efficiency, it should increase, or at least not decrease, net income. Under present economic conditions in California, a grower cannot afford a yield reduction of much more than one ton per acre by thinning mechanically as compared to hand thinning without reducing his net income from sugar beets. The economic effects of mechanical thinning have been reported elsewhere (3).

Table 4 gives detailed stand determinations for the six trials in which they were made. Root yields and the results of multiple correlation analyses are also given. It can be seen from these data that two stand determinations, four-inch spaces containing three or more plants and percent row unoccupied, quite consistently show close relationship to root yield. These two measurements reflect, to some degree at least, the primary reasons for poor stands: crowding of plants and unoccupied space. A count of single plants may correlate fairly well with root yields but may not necessarily reflect either of these important reasons for yield losses. Total hills per 100 feet is obviously a very poor measure of an adequate machine-thinned stand. By this criterion, machine thinned stands in all but trial eleven in Table 4 would be considered excellent. Such counts, of course, do not reflect the very important consideration of hill distribution. When a beet containing hill is defined as one inch of row that contains one or more plants, total hills per 100 feet of row become an even more inadequate measure of stand. The employment of this latter definition of a beet hill in the blind use of mechanical thinners is, in our opinion, a principal reason for the poor results obtained with twice-over thinning. Excellent pre-thinning stands existed in the trials reported here. Thinning heads were selected to leave at least 137 beet-containing inches per 100 feet of row. In most cases row unoccupied was a principal cause of reduced yield. Had knives been selected to leave the commonly desired 100 hills per 100 feet of row, even greater yield reductions might have occurred. Table 5 shows, for two trials, the increase in row unoccupied with successive passes of the thinner.

While the stand evaluation procedure adopted for these trials is not perfect by any means, it appears to be a step in the right direction. There is a need for more work to develop a fairly simple system that can be easily used in practical field work. In particular, different space intervals should be considered, in addition to 16 inches, for determining row unoccupied. Other methods of determining multiples might also be investigated.

Summary and Conclusions

Eleven field trials were conducted to evaluate complete machine thinning in comparison with the conventional hand thinning method. An attempt was made to develop a procedure for stand evaluation that would more accurately reflect differences in root yield. Results indicated that:

1. Complete mechanical thinning reduced root yield in every trial from 0.7 to 6:5 tons per acre. Trimming mechanically thinned beets with long-handled hoes increased yields in most cases when compared to complete mechanical thinning, but in no instance equalled the yield of hand thinned beets.

2. Sucrose percentage was not affected by mechanical thinning to an important degree.

3. Mechanical thinning tended to increase the amount of tare dirt and small beets screened out at loading stations. This increase was not great.

4. Laboratory tare percentage tended to increase as a result of mechanical thinning.

5. Excellent root yields were produced by mechanically thinned beets. Under current economic conditions, however, a loss of much more than one ton per acre cannot be tolerated without reducing net income.

6. Differences in root yields were correlated quite well with stand measurements reflecting four-inch blocks containing three or more beets and percent row unoccupied.

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Table 1.—Stand Before Thinning, Thinning Heads Used, Number of Replications, and Harvest Method. Mechanical Thinning Field Trials.

	Trial Number, Location (County or Nearest Town) and Year Conducted										
	No. 1 Butte 1952	No. 2 Butte 1953	No. 3 Butte 1954	No. 4 Butte 1954	No. 5 Butte 1955	No. 6 King City 1953	No. 7 Davis 1953	No. 8 Davis 1954	No. 9 Davis 1955	No. 10 Yolo 1955	No. 11 San Benito 1954
Beet containing inches per 100 inches before thinning	31	35	33	—[1]	38	48	33	37	35	32	40
Thinning heads used— first pass	8x1	8x1½	16x⅞	—[1]	8x1¾	10—2	10—1½	10—2	10—2	10—2	8x1¾
second pass	16x⅝	none	none	—[1]	16x⅝	20L½	20L½	8L2	20L½	20L½	16x¾
Number of replications	3[2]	3	3	3	6	6	6	5	7	6	6
Harvest method[3]	M	M	M	M	M	M	H	H	H	M	M

[1] Information not available

[2] Only 2 replications of machine thinned plots

[3] M is machine harvest, H is hand harvest

Table 2.—Effect of Thinning Method on Sugar Beet Root Production and Sucrose Concentration.

Thinning Method	Trial Number											
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	Average All Trials
	Tons, Clean Beets Per Acre											
Short hoes	15.5	17.8	18.5	16.8	29.2	32.0	34.0	25.3	30.4	27.1	29.3	25.1
Machine[1]	14.7	16.5	17.8	15.3	25.8	28.6	27.5	22.5	24.1	24.7	22.8	21.8
Machine plus long hoes	15.0	16.9	17.8	15.9	—	—	30.9	24.2	26.8	—	—	
L.S.D. 19:1[2]	ns.[2]	ns.	ns.	1.7	0.9	1.1	2.3	2.1	2.4	1.6	1.7	
C.V.[2]	3.2	4.4	5.0	5.5	3.5	2.7	6.0	6.6	6.6	4.1	4.9	
	Percent Sucrose											
Short hoes	17.6	13.9	14.9	16.1	16.2	16.0	13.7	13.1	14.0	13.9	15.4	15.0
Machine	17.3	14.1	14.7	16.4	16.7	15.9	13.8	13.5	14.0	14.0	15.5	15.1
Machine plus long hoes	17.3	13.9	15.8	16.2	—	—	13.9	13.8	14.0	—	—	
L.S.D. 19:1	ns.	ns.	ns.	ns.	0.2	ns.	ns.	ns.	ns.	ns.	ns.	
C.V.	3.0	1.4	2.9	2.2	1.0	1.0	2.2	6.7	2.7	3.1	2.0	

[1] Machine refers to Silver or Dixie down-the-row type thinner.

[2] LSD indicates least significant difference. NS means not significant. CV refers to coefficient of variation.

Table 3.—Effect of Thinning Method on Beet Dump and Laboratory Tare.

Thinning Method	Trial Number											
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	Average All Trials
	Tons Tare Dirt Per Acre Removed at Beet Dump											
Short hoes	—	0.81	0.99	5.7	0.98	1.14	—	—	—	1.1	5.8	2.36
Machine	—	1.28	0.97	5.9	1.08	1.40	—	—	—	1.2	4.3	2.30
Machine plus long hoes	—	0.87	0.94	4.6	—	—	—	—	—	—	—	—
LSD, 19:1	—	0.16	ns.	ns.	ns.	0.08	—	—	—	ns.	ns.	
	Laboratory Tare Percentage											
Short hoes	11.1	9.6	6.6	14.1	6.1	5.8	—	—	—	10.1	15.5	9.86
Machine	12.7	12.2	7.9	14.2	6.7	8.5	—	—	—	11.9	14.1	11.02
Machine plus long hoes	12.4	10.1	7.6	12.2	—	—	—	—	—	—	—	—
LSD, 19:1	ns.	1.8	ns.	ns.	ns.	1.5	—	—	—	ns.	ns.	

Table 4.—Effect of Thinning Method on Stand and Root Yield.

Thinning Method	Stand After Thinning 4-inch Beet Containing Blocks Per 100 Feet				Percent Row Unoccupied	Tons Roots Per Acre
	Singles	Doubles	Multiples	Total		
Trial No. 8, Davis, 1954						
Short hoes	102	39	10	151	0.5	25.3
Long hoes	68	29	23	120	1.8	24.7
Machine	40	29	48	117	7.3	22.5
Machine plus long hoes	48	26	20	94	8.7	24.2
Machine, tines first	45	29	44	112	7.5	21.8
Significant difference, 19:1						2.1
Partial correlation coefficients[2]			-0.314		-0.491*	
Regression equation[1]		Y = 25.270 − 0.129 Xg − 0.026 Xm				
Trial No. 9A, Davis, 1955						
Short Hoes	121	26	4	151	1.6	31.0
Machine	43	35	63	141	3.5	24.1
Significant difference, 19:1						2.6
Partial correlation coefficients			-0.870***		-0.569*	
Regression equation		Y = 32.362 − 0.567 Xg − 0.10 Xm				
Trial No. 9B, Davis, 1955						
Short hoes	119	28	4	151	0.4	29.7
Machine plus long hoes	50	33	26	109	4.7	26.8
Significant difference, 19:1						2.2
Partial correlation coefficients			-0.102		-0.499	
Regression equation		Y = 29.97 − 0.559 Xg − 0.024 Xm				
Trial No. 11, San Benito, 1954						
Short hoes	139	6	0.7	145.7	2.7	29.3
Machine	46	22	15	83	25.0	22.8
Blocker plus short hoes	89	11	2	109	7.8	27.1
Significant difference, 19:1						1.7
Partial correlation coefficients			-0.489*		-0.822***	
Regression equation		Y = 29.402 − 0.199 Xg — 0.106 Xm				
Trial No. 10, Yolo, 1955						
Short hoes	83	32	9	124	3.5	27.1
Machine	40	27	40	107	12.7	24.7
Significant difference, 19:1						1.6
Partial correlation coefficients			-0.668*		-0.231	
Regression equation		Y = 27.86 − 0.074 Xg − 0.056 Xm				

Table 4 continued on next page.

Table 4, continued.

Trial No. 5, Butte, 1955						
Short hoes	137	82	7	226	0.4	29.2
Machine	56	51	33	140	7.9	25.8
Significant difference, 19:1						0.9
Partial correlation coefficients			−0.655*		−0.565	
Regression equation	Y = 29.695 − 0.181 Xg − 0.073 Xm					

[1] Partial correlation coefficients derived from multiple correlation of tons per acre on multiples (Xm) and percent row unoccupied (Xg).

*,**,*** Significant at 5 percent and 0.1 percent levels respectively.

Table 5.—Effect of Successive Passes of Down-the-Row Thinning Machines on Unoccupied Row Space.

Thinning Operation	Percent Row Unoccupied	
	Trial No. 5[1]	Trial No .10[2]
Before thinning	0.16	0.75
After 1st pass	1.2	4.2
After 2nd pass	7.9	12.7
Hand thinning	0.4	3.5

[1] Pre-thinning count = 37.9 beet containing inches per 100 inches. Heads used: 8 x 1¾ and 16 x ⅝ to leave 146 beet containing inches per 100 feet.

[2] Pre-thinning count = 31.9. Heads used: 10-2 and 20 1½ to leave 140 beet containing inches per 100 feet.

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