Agronomic Studies Related to Mechanization of Sugar Beet Culture

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In the search for methods of mechanization in the growing of sugar beets, Spring cultural operations are largely interdependent in that each operation has a critical influence upon those to follow. **For** the purposes of study, however, we usually attempt to break down the Spring tasks into parts, to permit of more careful scrutiny. **This** report, therefore, will follow as much as possible the above principle of segregation of subjects.

Planter Studies

Planter investigations, in comparison with those undertaken by other investigators, have been on a rather limited scale. Six different drills were tested at Windsor, Colo. Of these six, three were also tested at Billings, Mont. The comparative results are presented for both locations in table 1.

Tab> 1. Planter studies. 1945. Windsor, Colo., and Billings, Mont.

Germination stand data						
Drill	location	Total seedlings	Percentage[1] singles	Percentage of potential germination	Percentage stand	Max. gap, inches
J. D. smooth tube—low can	Windsor	47.4	38.4	78.8	30.6	11.2
J. I). smooth tube—high can	Windsor	34.4	42.5	49.1	23.3	**16.7**
J. D. experimental drill	Windsor	32.0	47.6	62.5	22.8	**16.7**
I. IT. C. drill No. 40	Windsor	31.7	42.1	70.3	21.4	16.4
Cobbley unit drill	Windsor	31.7	51.4	71.5	23.2	14.8
Ford Experimental Drill	Windsor	24.4	48.0	30.8	17.2	24.7
J. L). smooth tube—high can	Billings	21.4	71.5	G3.8	18.1	15.2
I. H. C. drill No. 40	Billings	25.6	74.6	74.0	22.2	14.6
Cobbley unit drill	Billings	27.5	02.2	81.9	22.1	12.5

All counts based on 100 inches of row.
[1]Percent of seedlings as singles, i. e., only 1 seedling per inch.
Plots: 4 rows x field length at Billings and 8 rows x field length at Windsor.
Replications at each location=l.
No harvest data.

The percentage of single plants is considerably higher for Billings in the three comparisons where the same drill was used at both places. This difference is probably accounted for by the lighter rate of seeding at the Billings location which was 3 pounds of seed per acre as compared with 4 to b' at the Windsor location.

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Type of Planting

Three methods of seed coverage were used at three locations, combined with seeding rates and dates of planting. The comparisons are (1) flat or standard method and depth of seed placement; (2) furrow planting, in which the seed was placed at a depth of 2 to $2^{1}/2$. inches (the object being; to place the seed into moist soil) with immediate removal of approximately the top inch of dry soil, thus permitting seedling emergence in the usual length of time; and (3) ridge-cover, an operation whereby a ridge of soil several inches in depth was thrown over the planted seed and removed 4 to 5 days later after the seed had germinated. The principal object of this last type of planting was to hold soil moisture at a higher level immediately around the seed until germination was accomplished.

The results of these trials are summarized in table 2.

The wide variations and sometimes reversals between dates at the same location are explained by changing soil moisture conditions. One difficulty encountered with the "furrow" type of planting was in closing the seed furrow after the disk-furrow opener; this open furrow permitted drying out of the soil moisture immediately adjacent to the seed with consequent reduction in seedling emergence.

One advantage of the ridge-cover type of planting, other than moisture considerations, is weed control. It was found at Longmont that those plots in which the rows were ridged and later harrowed off were much more free of weeds than either of the other types of planting.

In removing the ridges of the ridge-cover treatments at Longmont, the operation was conducted by placing a 1-inch by 3-inch board in front of the front row of harrow teeth, the implement being driven lengthwise of the rows; by this method at this location, insufficient soil was removed from about the seed. An excess of moisture, as rain, for all cases except June 20 and 26 at Longmont was not conducive 1o success with either the furrow or ridge-cover methods of planting since the principal objective for either of these methods is to place or hold the seed in moist soil for germination when soil moisture might be insufficient for the usual flat method of planting.

Row Width and Spacing

Increasing the distance between roAvs would result in a rapid and positive saving in labor. Two widths of row wider than commonly employed, combined with two spacings within the rows, were compared with standard widths at each of three locations. These treatments consisted of (1) alternating narrow and wide rows with 8- and 12-inch spacings within the row, and (2) wide rows with 6- and

Table 2.—Coverage and rate of planting study. Germination stand counts, Billings, Longmont, and Windsor, 1945.

Location	Date planted	Rate of planting Pounds per A.	Total No. seedlings per 100 in. Flat	Furrow	Ridge-cover	No. singles per 100 in. Flat	Furrow	Ridge-cover	" Maximum gap—inches Flat	Furrow	Ridge-cover
Billings	April 12	3.24	18.70	7.80	13.50	11.50	5.00	9.60	18.20	47.10	25.80
Billings	May 1	3.24	28.00	17.00	31.80	20.06	11.40	18.50	19.20	23.80	8.70
Billings	June 21	3.24	15.50	22.00	18.00	11.00	15.80	15.20	26.00	18.80	19.00
Billings	July 3	3.24	12.10	8.80	12.10	8.80	6.80	9.60	22.50	28.80	27.50
Longmont	May 4	2.91	46.58	50.00	40.31	20.00	20.94	17.81	11.17	11.31	13.75
Longmont	May 8	2.91	31.06	43.19	12.63	17.56	19.25	9.44	13.94	11.00	27.81
Longmont	June 13	1.88	22.88	19.41	17.25	11.94	11.07	10.06	19.00	23.07	20.81
Longmont	June 13	2.91	34.50	24.25	22.81	16.38	16.53	13.94	14.06	18.75	20.75
Longmont	June 13	4.38	40.81	27.88	24.19	21.25	16.31	13.81	18.75	19.44	23.13
Longmont	June 20	1.88	2.25	3.81	1.50	1.44	2.44	1.13	77.56	69.38	81.69
Longmont	June 20	2.91	2.44	5.75	2.03	1.94	3.00	2.13	77.81	54.31	73.56
Longmont	June 20	4.38	3.44	10.69	5.50	2.88	6.62	4.06	77.38	54.56	69.44
Longmont	June 26	2.91	0.00	2.31	0.00	0.00	1.94	0.00	100.00	72.94	100.00
Windsor	May 3	5.00	49.56	33.88	38.13	17.38	17.88	14.69	11.94	14.81	16.56
Windsor	May 3	5.00	23.69	18.38	19.50	13.63	10.94	9.25	15.38	19.94	24.38
Windsor	May 7	5.00	31.00	34.13	25.38	18.13	14.13	12.88	10.88	16.04	20.50
Windsor	May 18	5.00	20.88	18.75	18.88	12.94	14.44	13.13	22.88	21.50	21.44
Average		3.53	23.72	20.46	17.83	12.28	11.31	10.30	32.42	30.94	34.78

Design of experiment:

Single four-row plot of each treatment, each date or replicate.
Windsor—300 feet in length
Longinont—380 feet in length
Billings—450 feet in length
No harvest data

10-inch spacings within the row. The above treatments were compared with narrow rows with 12-inch spaeings as standard. These comparisons are presented in table 3.

Table 3.—Summarized resulted for width of row and spacing presented as averages for three locations, viz., Billings, Longmont, and Windsor, 1945.

Treatment[1]	Tons beets per A.	Percentage sugar	Pounds sugar per A.	No. beets per 100 feet of row
Narrow row, 12-inch spacing	17.95	16.52	5931	109.8
Narrow-wide alternate row, 12-inch spacing	15.79	16.12	5091	105.5
Narrow-wide alternate row, 8-inch spacing	15.35	16.15	4961	120.1
Wide row, 10-inch spacing	14.74	15.00	4687	116.2
Wide row, 6-inch spacing	14.06	15.94	4482	151.1
General mean	15.68	16.13	5026	119.9
CV (percent)	4.02	1.78	4.09	–
LSD 5 percent pt.	1.15	.35	381	–
LSD 1 percent pt.	1.60	.50	532	..

Hand work at Longmont and Windsor with rows 20 inches (narrow) and 40 inches (wide) in width long-handled hoe at Billings with rows 22 inches (narrow) and 44 inches (wide) in width.

Design of experiment:

3 replications at each of three locations.

Plot lengths—Longmont—380 feet
Windsor—300 feet
Billings—450 feet

Rows per plot—Longmont'and Windsor—8 rows for 20-inch, and alternate 20-ineh-40-inch rows; 6 rows for 40-inch rows.
Billings—6 rows for 22-inch rows.
4 rows for alternate 22-inch-44-ineh rows.
3 rows for 44-inch rows.

Harvest—10 samples of 10 feet of row for each plot at Longmont and Windsor; entire plot yields at Billings.

It should be pointed out that in these tests increasing the population in the wider rows by closer spacing within the row did not result in an increase in acre yield ; the difference, while not amounting to significance, is pointedly in favor of wider spacing.

At two locations, Longmont and Windsor, Colo., a third treatment was added to those discussed above; namely, row width of 30 inches, with 8- and 12-inch plant spacing, results for which are presented in table 4.

While the space relationship per plant in the 30-inch rows would be the same as for the alternating 20-40-inch, apparently in these two comparisons the 30-inch treatment produced more sugar per acre, but not by a significant amount.

Table 4.—Summarized results for width of row and spacing presented as averages for two locations), viz., Longmont and Windsor, 1945.

Treatment	Tons beets per A.	Percentage sugar	Pounds sugar per A.	No. beets per 100 feet of row
20-inch row, 12-inch spacing	18.83	16.35	6144	103.2
Alternate 20-inch-40-inch row, 12-inch spacing	16.21	15.48	5016	102.6
Alternate 20-inch-40-inch row, 8-inch spacing	15.64	15.75	4924	116.2
30-inch row, 12-inch spacing	17.01	15.46	5245	105.2
30-inch row, 8-inch spacing	16.30	15.56	5089	122.0
General mean	16.80	15.72	5292	109.0
CV (percent)	5.56	1.61	5.70	-
LSD 5 percent pt.	1.01	.31	330	"
LSD 1 percent pt.	3.15	.43	725	-

Design of experiment :
3 replications at each of 2 locations.
Plots—8 rows x 380 feet at Longmont
8 rows x 300 feet at Windsor
Harvest—10 samples of 10 feet of row for each plot.

Method of Mechanical Thinning

In general, two methods of reducing the beet population in the row mechanically have proved usable, viz., (a) cross blocking, or running tools perpendicular to the row direction, and (b) "down the row" machines exemplified by the Dixie Beet Thinner, used in these tests, which has a system of revolving knives. Essentially the accomplishment is the same with either machine, but conditions in any given field can make one type operate more satisfactorily than the other.

Three population levels, as left by the Dixie Beet Thinner, were compared at two locations with standard hand thinning and with long-handled-hoe thinning. The harvest results for two locations are given in table 5.

In another test cross blocking by use of cultivator tools running perpendicular to the direction of the rows was compared with conventional hand thinning and thinning by long-handled hoe only. Results for each of three locations are given in table 6.

It may be pointed out here that in each case thinning by means of a long-handled hoe only resulted in *very* moderate reductions in acre yield at any of the three locations.

In order to test out on an extensive and practical scale the possibilities of complete mechanization of thinning, an offer was made

Table 5.—Summarized results for Dixie Beet Thinner operation at two locations, viz, Longmont and Billings, 1945.

Longmont Treatment	Tons beets per acre	Percentage sugar	Pounds sugar per acre	No. beets per 100 feet of row: Harvested	No. beets per 100 feet of row: After thinning
Hand block and thin, 12-inch spacing	15.70	14.50	4553	104.1	107.0
Long handled hoe only, 12-inch sparing	15.40	14.77	4461	181.9	161.5
Dixie Beet Thinner, 150 beets per 100 feet	14.11	14.43	4072	106.0	146.0
Dixie Beet Thinner, 125 beefs per 100 feet	13.21	14.18	3746	87.9	131.2
Dixie Beet Thinner, 100 heels per 100 feet	14.21	14.75	4192	97.5	107.0
General mean	14.17	14.53	4205	105.5	130.0
CV (percentage)	5.62	2.29	6.25	....	....
LSD 5-percent pt.	.99	.41	329		
LSD 1-percent pt.	1.36	*	440	....	....
Billings					
Hand block and thin, 12 inch spacing	17.50	16.60	5840		94.8
Long handled hoe only, 12-inch spacing	16.70	16.50	5638	....	135.5
Dixie Beet Thinner, 150 heels per 100 feet	15.18	16.50	5009	....	166.5
Dixie Beet Thinner, 125 beets per 100 feet	15.02	16.80	5047	....	149.7
Dixie Beer Thinner, 100 beets per 100 feet	14.82	16.70	4950	....	121.8
General mean	15.88	16.62	5270	....	133.6
CV (percentage)	5.57	2.03	6.28	....	....
LSD 5-percent pt.	1.07	*	398	....	....
LSD 1-percent pt.	1.45	*	543	....	....

* Not significant

Design of experiment : Randomized block
Plots—4 rows x 195 feet at Longmont
4 rows x 700 feet at Billings
6 replicates at each location
Harvest—2 rows of each plot taken at Longmont for yield. Samples for sugar determination taken at random from these 2 rows. All 4 rows taken at Killings for yield. Two samples for sugar determination taken at factory dump from load delivered.

by the Great Western Sugar Company to reimburse for any net losses certain growers who were willing to cooperate in mechanizing one-half of a field up to 10 acres in size as compared with the other half, thinned entirely by hand. The hoeing and weeding operations were the same., on either half of the field, except that in most cases a hoe-trimming operation followed the machine blocking, while in other cases the regular hoeing was increased somewhat where the hoe-trimming was not

Table 6.—Summarized results for cross blocking and cross cultivation tests, 1935, Longmont, Billings, and Windsor.

Treatment	Tons beets per acre	Percentage sugar	Pounds sugar per acre	No. beets per 100 feet of row: Harvested	No. beets per 100 feet of row: After thinning
Longmont					
Hand block and thin	15.88	13.26	4211	84.2	88.7
Cross block and cross cultivate	15.00	12.67	3801	82.4	85.9
Long-handled-hoe thinning	15.18	13.27	4029	94.5	100.0
General mean	15.35	13.07	4011	80.4	101.5
CV (percentage)	3.14	1.66	4.27	....	....
LSD 5-percent pt.	.56	.25	200	....	....
LSD 1-percent pt.	*	.35	280	....	....
Billings					
Hand block and thin	18.80	17.20	6364	81.4	76.5
Cross block	16.20	17.30	5695	98.7	98.5
Long-handled hoe thinning	16.96	17.50	5926	114.5	91.5
General mean	17.22	17.31	5962	98.2	78.9
CV (percentage)	3.02	.67	3.00	....	....
LSD 5-percent pt.	.56	.13	797	.	.
LSD 1-percent pt.	.77	.17	274	.	..
Windsor					
Hand block and thin	14.71	17.32	5096	84.2	94.8
Cross block	13.47	17.37	4650	113.0	105.8
Long-handled hoe thinning	14.50	17.39	5074	92.0	90.2
General mean	14.24	17.36	4934	98.7	93.8
CV (percentage)	8.03	2.00	8.60	....	....
LSD 5-percent pt.	*	*	*	....	....
LSD 1-percent pt.	*	*	*	....	....

* Not significant

Design of experiment: Randomized block

Plots—20 feet x 60 rows at Longmont
22 feet x 100 rows at Windsor
20 feet x 160 feet at Billings

Replicates—Longmont=7
Windsor =8
Billings =8

Harvest—Longmont and Windsor—18 feet of row per sample, 8 samples per plot. Billings—36 feet of row per sample, 10 samples per plot.

done. A total of 41 farms were included in this test, the results being summarized to table 7 for the principal districts of the Great Western area.

In figuring the net return all regular beet labor costs were used, this figure representing the cash return to the grower for his part in growing the crop and delivering it to the factory. The actual saving

Table 7.—Summarization of yield, labor cost, and financial returns for cross blocking and hoe trimming ("Mech") as compared with hand thinning ("Hand").

District	No. farms	Yield tons roots per acre		Total labor cost per acre		Net cash return per acre	
		Hand	Mech.	Hand	Mech.	Hand	Mech.
N. Colorado	17	14.20	11.94	$35.91	$24.29	$145.59	$123.79
E. Colorado	10	12.73	10.65	33.08	25.63	120.68	102.80
Nebraska	9	11.78	10.28	31.83	22.84	101.96	93.82
Wyoming	1	9.85	7.70	30.81	10.78	104.92	88.10
Montana	4	12.20	9.95	19.63	15.38	143.86	119.29
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in hand labor amounted to 28 percent as an average of all 41 farm tests, the net cash return for the mechanized operation being 15 percent less than for hand work. This experiment needs to be considered not so much with respect to the rather small loss in return from the mechanized operation as compared with hand work, but as a first experience by 41 different growers, each of whom could, not doubt, improve their work and results for a second experience with a mechanized operation.

Summary

None of the tests here presented give a method of producing the beet crop mechanically and still maintain yields equivalent to those obtained by hand thinning of the plants. The reductions in yield in many comparisons are relatively small, demonstrating that in conditions of reduced labor supply, methods are available for continued production of the sugar beet crop.

it would seem that, without doubt, experience in mechanical thin--ing operations will result in greater proficiency on the part of growers in handling this kind of work. As such knowledge is gained, we should expect acre yields to rise toward those of conventional hand thinning. It is not inconceivable that ultimately we can surpass, by mechanical operation, the yields now obtained by hand thinning.