The Influence of Planting Rate and Thinning Method On Sugarbeet Stand[1]

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The importance of sugar beet stand on the basis of number and spacing has been reported by several investigators. Friehauf, *et al.* (1)[3] reported that percent stand showed a positive effect on yield with maximum yields obtained from approximately 150 beets per 100 feet of row. Herron, *et al.* (3) indicated that the highest yield in Kansas occurred with approximately 25,000 sugarbeet plants per acre. Figure 1 shows the relationship between the number of beets harvested per 100 feet of 22-inch row and yield for each contract in the Worland-Riverton factory district of Wyoming during 1966. The linear regression line indicates an average increase in yield of 0.2 ton per acre for any increase in plant population of one beet per 100 feet of row, within the range of 30 to 120 beets per 100 feet of row.

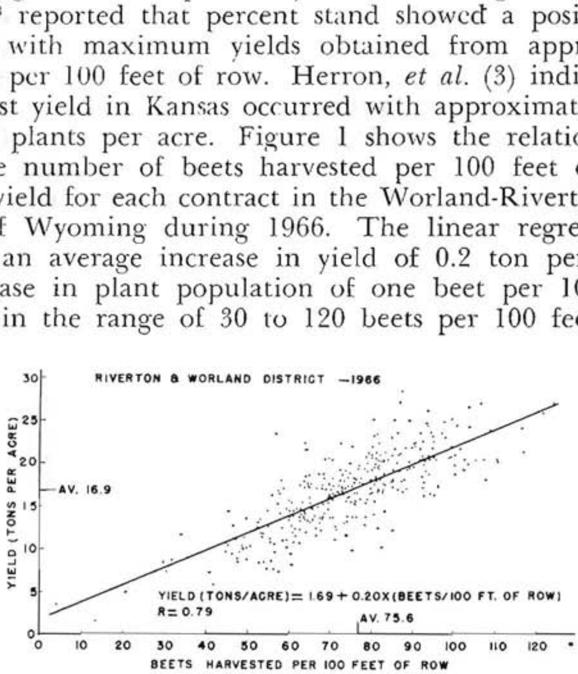

Figure 1.—Relationship between yield and number of beets harvested per 100 feet of row spaced 22 inches.

The average number of beets harvested was much lower than the recommended stand of 100 to 120 beets per 100 feet of row. Average yield could potentially have been greater with

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[3] Numbers in parentheses refer to literature cited.

increased stands. Even though growers who harvested 60 beets had yields as high or higher than others who harvested 100 beets per 100 feet of row, more than one half of the variation among yields for the Riverton-Worland factory district was explained by differences in the number of beets harvested. Variation in other important cultural and production factors such as tillage, fertility, irrigation, weed control, planting date, etc. accounted for the remainder of the yield differences.

It is common to plant excess sugarbeet seeds and then thin the emerged plants to the desired stand. Planting directly to stand has many advantages and will be practiced when good weed control and a relatively high and predictable emergence rate becomes the rule. Seedlings with increased vigor and reduction and control of hazards such as soil crusting, insect damage, toxicity from herbicides, etc. would allow planting directly to stand. Overplanting with subsequent plant thinning allows some insurance against unpredictable factors affecting emergence rate and stand reduction associated with mechanical weed control operations.

Plant Spacing

If for theoretical considerations we assume a uniform seed spacing of (s) inches in the row and seed that is 100% monogerm, plants spaced (s) inches will account for (e) portion of the total, where (e) is the emergence rate. Since the probability of a combination of independent events is the product of the independent probabilities, (1 - e)e of the plants will be spaced 2s, $(1 - e)^2$ of the plants 3s, etc., or:

$$\overline{x} = es + e(1 - e)2s \ . \ . \ . \ e(1 - e)^{n-1} ns = \frac{s}{e} \qquad [1]$$

where: $\overline{x}$ = average plant spacing after emergence

Down the row random mechanical thinning has been practiced many years. Machines used for this operation cut out plants occupying fixed (but adjustable) portions of blocks of plants in the row. The theoretical portion of the total plants removed is equal to the ratio between the length of block cut out and the center distance between blocks.

If we assume that the remaining blocks after thinning contain plants in the same proportion that existed in the field prior to thinning and that the length of block skipped is small enough to contain one plant, the random thinner then leaves a minimum plant spacing of L. Applying the same theory used in equation [1]:

$$\overline{x}_r = pL + p(1 - p)2L \ . \ . \ . \ . \ p(1 - p)^{n-1} nL = \frac{L\,s}{L_s\,e} \qquad [2]$$

where: $\overline{x}_r$ = average spacing of plants after thinning
L = center distance between blocks
L_s = length of block skipped

$$p = e^{\frac{L_s}{s}}$$

Selective thinning, whether it be the man with the hoe or a machine which cuts out portions of the row only after the presence of a plant has been detected, can be utilized. If the length of block skipped (L_s) after detection of the plant is small enough to contain one plant, the probability that a plant will exist in a block of L inches is p. Another group of plants will be spaced ($L + L_s$) with a probability of (1 -p)p etc. Utilizing an equation derived by Garret (2):

$$\overline{x}_s = pL + p(1-p)(L + L_s) + p(1-p)^2 (L + 2L_s) \ldots p(1-p)^{n-1} [L + (n-1) L_s] = L + L_s \left[\frac{1-p}{p}\right] \qquad [3]$$

where $\overline{x}_s$ = average spacing of plants after selective thinning.

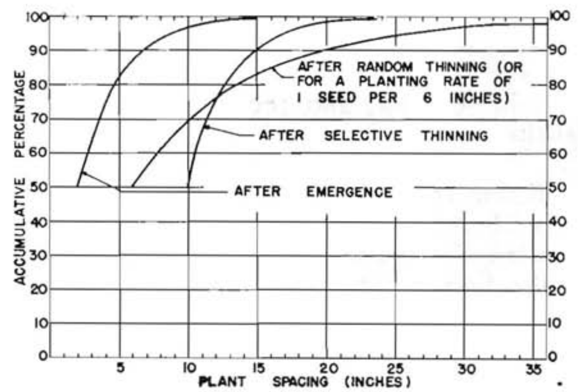

Figure 2.—Theoretical plant spacings before and after thinning for a seed spacing of 2 inches, emergence rate of 0.5 and a final plant population of one per foot of row.

Figure 2 shows the theoretical accumulative percentage of plants at various spacings before and after selective and random thinning for a uniform seed spacing of 2 inches, emergence rate of 0.5 and a final plant population of one per foot of row. Comparisons show that the use of a selective thinner should theoretically result in less variation of the plant spacing from the desired average when the emergence rate is less than 100%. Alternately, for a given minimum plant spacing the total plant population will be increased, i.e., if the minimum spacing or block length (L) was 8 inches, seed spacing (s) 2 inches and the emergence rate (e) 0.5, the plant population will increase by 60%.

Field Evaluation

During spring, 1967, a field evaluation of sugar beet plant spacings before and after thinning by random mechanical thinners, hand labor and an electronic selective thinner was made on 27 different 100 foot lengths of row near Lovell and Powell, Wyoming.

The electronic selective thinner used was one of a limited production model of the Eversman Selectronic Row Crop Thinner. An electric eye senses the presence of a plant in the row. After the electric eye beam is interrupted by a plant, a knife actuated by a fast-action air cylinder removes plants ahead of the sensed plant for a pre-determined distance. This distance is adjusted by coordinating forward speed with the time the knife is held in the thinning position. The longitudinal position of the eye and forward speed will affect the distance ahead of the sensed plant at which the knife begins to cut.

Tall weeds, clods of soil and other debris in the beet row will also interrupt the beam from the electric eye and cause activation of the knives. Therefore, good seedbed preparation, weed control in the row, and relatively uniform plant height are prerequisites to proper operation of the electric eye selective thinner.

Three different commercially available random thinners were used in fields where stand evaluations were made.

A 10 foot length frame with marks 0.1 foot apart was placed adjacent to the beet row to determine the spacing between the individual beet plants to the nearest 0.1 of a foot. The determination was made on the same 100 foot interval before and after thinning in order to determine which plants were removed during the thinning operation.

Results

Table 1 shows the average number of sugar beet plants spaced at various intervals before and after different methods of thinning, i.e., hand hoeing, random mechanical and electronic selective thinning. The percentage of plants before and after thinning spaced at various spacings was calculated. The observed accumulative percentages could then be compared with the theoretical (or calculated) percentages using formulas [1], [2] and [3]. The calculated or theoretical plant spacings for selective thinning can be considered the best possible for the seed spacing (assumed uniform), emergence rate and final number of beets per 100 feet of row observed.

The results of these calculations are shown in Figures 3, 4 and 5 for hand, random and electronic selective thinning, respectively. Figure 5 shows the results secured with the electronic selective thinner after field adjustment.

Discussion of Results

Figures 3, 4 and 5 indicated that the observed and calculated or theoretical plant spacings after emergence compare favorably with spacing calculated using Formula [1]. However, plants spaced one inch or less are observed because some small percentage of the seed is multigerm and some seeds are spaced at intervals less than the average seed spacing due to non-uniform seed placement by the planter.

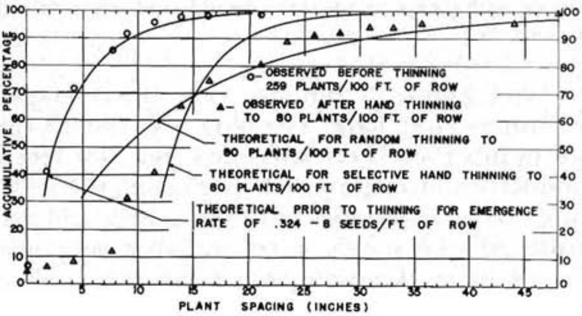

Figure 3.—Comparison between the observed and theoretical plant spacings before and after hand thinning.

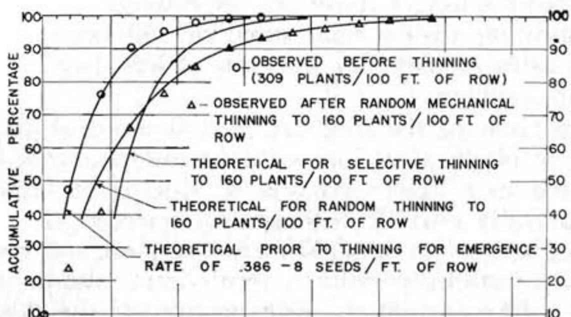

Figure 4.—Comparison between the observed and theoretical plant spacings before and after random mechanical thinning.

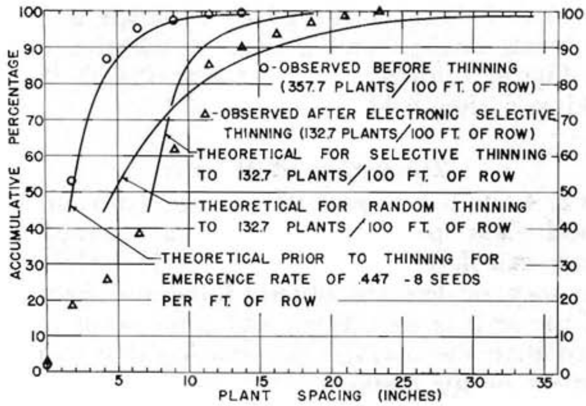

Figure 5.—Comparison between observed and theoretical plant spacings before and after selective electronic thinning. Average of three tests after field adjustment with beets at uniform height and rows relatively free of large weeds.

Table 1 and Figure 3 indicate that the average stand for seven observations after hand thinning was slightly higher than the average number of beets harvested per 100 feet of row in the Worland-Riverton factory district during 1966 (80 vs. 75.6). If the number of plants spaced less than 1 inch and some harvest loss is considered, the stands were probably very nearly equal. The results of hand thinning on the average indicated fewer and a lower percentage of plants spaced at small intervals (less than 1 or 5 inches) than for mechanical methods; however, this is probably due in part to the removal of a greater portion of the plants by hand thinning as indicated by final stands of 79 to 80 plants per 100 feet of row compared with 178 and 133 for random and selective thinning, respectively. One observation of hand thinning with a final stand of 100 beets per 100 feet of row indicates 11 plants at intervals of less than one inch and 18 less than 5 inches.

A comparison of the observed and theoretical accumulative percentage of plants at various spacings indicates that hand thinning resulted in a higher portion of spacing at large intervals than theoretically possible with perfect selective thinning. The number of plant intervals of 40 inches or more was nearly equal to that which would theoretically result from random mechanical blocking to the same stand. The portion of the plants spaced 24 to 36 inches or more was less than would have resulted with random mechanical thinning but more than would have resulted with perfect selective thinning.

Figure 4 indicates that the observed number of plants spaced

Table 1.—Average number of sugarbeet plants spaced at various intervals before and after different methods of thinning—Theoretical planting rate of 8 seeds per foot of row.

Method		Number of observations	Average no. plants/100 ft	Less than 1	1 - 5	6 - 10	11 - 15	16 - 20	21 - 25	More than 25
Hoe	before	7	259	16	169	53	15	3	2	1
	after		79	3	3	18	28	13	6	8
Hoe (greatest stand)	before	1	247	33	131	57	21	1	3	1
	after		100	11	7	27	26	18	8	3
Hoe (least stand)	before	1	201	7	115	55	20	1	1	2
	after		46	—	—	5	8	11	3	19
Random thinner #1	before	2	309	29	206	60	12	2	—	—
	after		161	12	54	57	22	8	4	4
Random thinner #2	before	2	417	29	345	38	4	—	1	—
	after		174	9	72	63	19	5	3	3
Random thinner #3	before	2	366	28	253	45	10	—	—	—
	after		200	17	96	55	21	8	2	1
Electronic selective thinner	before	11	399	25	330	40	3	1	—	—
	after		164	8	64	50	29	8	3	2
Electronic selective thinner (after field adjustment)	before	3	358	7	304	40	6	1	—	—
	after		133	3	31	48	38	9	4	—

at various intervals after random thinning can be calculated with a reasonable degree of accuracy if the final desired stand and planting and emergence rates are known. The figure shows the results for one of the three machines studied since the performance of all three were similar. However, as with the initial stand, plants spaced 1 inch or less are observed due to the non-uniform spacing of seed in the row and multi-germ seed.

The plant spacing after thinning with the electronic selective thinner for eleven different observations, two-thirds of which were taken while the machine was being adjusted, where large weeds were present in the row, and where the beets were not of uniform size, indicated intervals similar to those expected with a random mechanical thinner. However, after adjustment, field experience and operation in fields where the beets were relatively uniform in height and free of large weeds in the row, the resulting plant spacings approached the theoretical plant spacings for selective thinning (Figure 5 and Table 1). A higher percentage and number of plants were spaced less than 1 and 5 inches than for hand thinning. On the other hand, a larger number and percentage of the plants were spaced in the desirable range of 6 to 10 inches and the maximum observed spacing was 25 inches in 300 feet of row compared to an average of eight plants spaced more than 25 inches per 100 feet of row for hand thinning.

Summary and Conclusions

1. Observed and calculated or theoretical plant spacings compare favorably except for plants spaced at small intervals (1 to 2 inches or less) due to multi-germ seed and non-uniform seed placement in the row during the planting operation.

2. The number of plants spaced at various intervals after random thinning can be calculated with a reasonable degree of accuracy for a given final stand if the planting and emergence rate are known. Plants spaced at small intervals will be observed for the same reasons mentioned in the previous paragraph. The plant spacings after thinning will theoretically be the same as they would have been if the planting rates had been reduced to give the same final stand without thinning. Although studies were not made on weed control during mechanical thinning, it is assumed that the percentage of weeds removed from the beet row will be equal to the ratio between the length of block cut out and the center distance between blocks.

3. Observation of plant spacings after use of the electronic selective thinner while it was being adjusted, where large weeds are present in the sugarbeet row and where beet size was not

uniform, indicated spacings very much the same as would be expected with a random thinner. However, after adjustment and operation in a field with beets of relatively uniform height and free of large weeds, the plant spacings approached the theoretically best possible spacing for the emergence rate observed and the seed spacing used. A higher percentage and number of plants were spaced less than 1 and 5 inches, but a larger number and percentage were spaced in the desirable range of 6 to 10 inches when compared with hand thinning. The number and percentage of plants spaced 24 inches or more was less than for hand or random thinning. Theoretically, the selective thinner would remove all weeds in the row except those in the length of block skipped for sensed plants.

4. The number of plant intervals of 40 inches or more after hand thinning was nearly equal to that which would result after random mechanical blocking to the same stand and greater than observed after selective thinning.

Hand thinning resulted in a smaller number of plants spaced at small intervals (less than 1 or 5 inches) than for mechanical methods; however, this might not have been the case if the stands had been thinned to the recommended 120 beets per 100 feet of row instead of 80.

Literature Cited

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