Improvement of Sugar Beet Seedling Emergence by Planter Development

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Improvement of the percentage and uniformity of sugar beet seedling emergence in the field is at present one of the most important needs in mechanization of spring operations in sugar beet production. As long as the percentage of potential emergence on commercial plantings continues to vary from 10 to 60 percent, sometimes even outside that range, it is impossible to approach planting to a stand and it is hazardous to reduce seeding rates to the point where very little thinning is needed. Furthermore, as long as the percentage of emergence varies 200 or 300 percent on different parts of a field, as it occasionally does or even sometimes from count to count down a row, mechanical thinning with any equipment set-up is bound to give erratic and spotty field stands. The low percentage, or lack of uniformity of emergence, may result from several causes, including seedbed fitting, planter, planting job, seed, seedbed moisture, insect damage, and others of which some at least are unknown.

One of the major objectives of the sugar beet machinery project of the United States Department of Agriculture, during the last 2 or 3 years, has been the development of planters to improve the percentage and uniformity of seedling emergence. This project is cooperative with the Colorado and Michigan Agricultural Experiment Stations, but the information on only the seedling emergence work at the Colorado Station at Fort Collins is included in this report. This research has also included a study of seedbed preparation to a limited extent, but is largely with planting equipment. The Colorado Station also has been cooperating with the Beet Sugar Development Foundation on beet machinery development and they too have been carrying on work to further investigate seedling emergence characteristics of planting equipment. The results of their work are being presented in a separate report.

Two sets of beet-planter study plots were put in at Fort Collins in 1947 in continuation of this phase of our project. They were planted on the College Agronomy Farm with the cooperation of the Division of Sugar Plant Investigations of the United States Department of Agriculture, particularly in the matters of seedbed preparation and carrying the crop through harvest. The plantings included one early in the season (mid-April) when seedbed moisture conditions were good and one late in the season (mid-June) when soil moisture was expected to be low and perhaps a limiting factor in seedling emergence.

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The first planting was started on April 14, but was interrupted when one fourth done by a snow storm of .13 inch precipitation on April 15. The planting was resumed on April 17 and replications of all treatments were put in. This planting was followed by several days of light rain every day or so with an accumulated precipitation by April 28 of .84 inch and traces of precipitation intermittently for the next 10 days. There was, therefore, plenty of moisture for seed germination without soil crusts forming. The seedling emergence was very good. It averaged 75 percent for the check planting.

The second planting was delayed until June 17 in order to get a seedbed somewhat on the dry side. However, this planting was followed by rains as follows: .50 inch on the night of June 17, .08 inch on the 18th, .97 inch on the 20th to 22nd, traces on the 24th and 26th and .11 inch on the 29th. There was, therefore, plenty of moisture for germination. Moderate soil crusts were formed during that period by the rain and soil drying which were mechanically broken with small rotary-hoe-type units on June 20 and 24 before the rain fell. Seedling emergence was good in spite of soil crusts and some losses from crust breaking because the check planting averaged 47 percent.

The equipment used consisted of thirty different modifications or combinations of the furrow opener or press wheels. Most of them were used mounted on a John Deere No. 55 beet-planter chassis equipped with the new No. 64 planter seed plates and cut-offs. Special false plates and 5/8-inch O.D. by 17/32-inch I.D., smooth, slightly curved seed tubes leading below the opener-disk centers were used. Pressed-steel seed plates of .128-inch thickness and with .168-inch diameter seed cells were used. The seed was 7/64- to 10/64-inch, segmented, American Crystal Sugar Company variety No. 3 and had a germination percentage of 81 with 1.59 sprouts per viable segment. The seeding rates used were 3.16 pounds per acre for the first planting and 1.85 pounds per acre for the second. The planter drives used gave 2.83 inches per cell or 4.25 cells per foot on the first planting and 4.91 inches per cell or 2.45 cells per foot for the second.

The measure of effectiveness of each opener set-up was the percentage of potential seedling emergence obtained with that set-up. Twenty 100-inch seedling stand-counts were taken on replicated plots for each set-up. The average stand was reduced to a percentage of the potential emergence determined from the seeding rate, the seed segments per pound, and the sprouts per hundred segments. The percentages of emergence for all set-ups are directly comparable.

One of the most striking results of the tests is the importance indicated for depth of planting on seedling emergence. This is not new information and merely confirms data obtained last year on similar tests. In fact, every sugar company fieldman is aware of the influence of planting depth on emergence. However, I think many of us have taken this matter too much for granted and have been more or less ignoring it.

Plantings were put in on both early and late plantings with regular double-disk openers with the depth bands set for 1-, 1½-, and 2-inch planting depths. Bevel-rim press wheels set about ¾ inch apart were used on the openers. The results, shown in table 1., show that the shallower, 1-inch, planting is the best for the early plantings where there is usually plenty of moisture, because the soil is colder and germination is slower. The difference between 1- and 1½-inch depths is not quite significant, but last year was very significant as the 1-inch was 50.3 percent and the 1½-inch was 40.4 percent with 5.2 percent needed for significance. For the later planting the 1½-inch depth was significantly better than for the 1-inch and this was equally true last year when the averages showed 20.9 and 35.0 percents for 1- and 1½-inch depths respectively. For these later plantings, moisture may be limited at the 1-inch depth. As the soil is warmer, the 1½-inch depth seed germinates better.

Table 1.—Effect of planting depth on seedling emergence.

Depth of Planting	Percentage seedling emergence	
	Planted 4/17/47	Planted 6/17/47
1 inch	75.15	34.75
1½ inches	70.05	46.95
2 inches	65.80	43.10
Difference for significance (5% level)	8.50	9.57

Many beet growers have a habit of using one planter set-up for all of their plantings. If the planter has depth bands on the disk openers set for 1½-inch depth of planting, it is likely to be used that way even if the planting is being done in late March or early April. I believe the average percentage of seedling emergence in nearly every district can be improved if the growers are impressed with the advantage of setting the planter for the desired planting depth. It is quite a job to change a set of the old-type depth bands to give a different planting depth, but with the new pressed-steel depth bands, such as are being used by John Deere or International, the change can be made in a few minutes. In most cases a lower seeding rate can be used to get the desired stand.

The seedling-emergence data for the different equipment tested to investigate this planter characteristic and the differences needed for statistical significance are shown in table 2. The planting depth used for all the equipment was 1 inch on April 17 and 1½ inches on June 17, based on the previous years' tests at different planting depths and dates. All of the openers and press wheels were John Deere equipment unless otherwise noted. The disk openers were all of the double-disk type. The press wheels were of the flat, bevel-rim type and both bevel-rim and deep-concavity types were used with about ¾-inch space between the wheels unless otherwise noted. Other manufacturers build similar openers and press wheels.

Table 2. Beet planter seedling emergence data.

Line No.	Equipment used	Percent emergence Planted 4/17/47	Planted 6/17/47	Average
1	Disk opener with bevel-rim press wheels	75.2	47.0	61.1
2	Disk opener with deep-concavity press wheels	62.1	53.7	57.9
3	Disk opener, deep concavity press wheels together	77.3	45.8	61.5
4	Disk opener, sprocket between concave press wheels	81.4	58.4	69.9
5	Disk opener with 2 cultipacker press wheels	70.4	49.3	59.8
6	Disk opener with 2 Sishc press wheels	42.6	50.7	46.6
7	Disk opener with 2-1 Sishc press wheels	66.9	49.4	58.1
8	Disk opener with 2 cultipacker and 2 Sishc press wheels	78.2	52.0	65.1
9	Disk opener with 2 pairs sharp-edged press wheels	64.1	42.9	53.5
10	Disk opener with fertilizer boot normal position	68.2	37.0	52.6
11	Disk opener with fertilizer boot offset	81.1	45.2	63.1
12	Disk opener with scraper bar between disks	62.2	44.4	53.3
13	Disk opener with seed coverer between disks	69.7	45.4	57.6
14	Disk opener with bar and coverer between disks	68.1	38.3	53.2
15	Disk opener with runner type shoe between disks	56.3	46.2	51.2
16	Disk opener with shoe and coverer between disks	70.9	34.7	52.8
17	Disk opener with small shoe on seed tube	70.5	43.6	57.0
18	Disk opener with round bottom shoe between disks	71.4	51.0	61.2
19	Runner opener with bevel-rim press wheels	69.3	52.7	61.0
20	Runner opener with concave wheels together	70.8	49.7	60.2
	Difference for significance (5% level)	8.5	9.6	6.4

A regular double-disk opener with flat, bevel-rim press wheels set with about ¾-inch between the wheels was used for a check or comparison. The results are shown in line 1 of table 2. It was the regular equipment combination which we had previously found to give the best emergence under most conditions. Lines 2 and 3 show comparisons with the deep-concavity type press wheels more commonly supplied on beet planters. When set close together the deep-concavity press wheels gave practically the same emergence as the bevel-rim press wheels set apart, but when the deep-concavity press wheels were set apart, as they usually are, the emergence averaged poorer. This confirmed the previous year's experience.

The equipment which gave the best emergence of all was a special plate-type sprocket or toothed wheel used between the deep-concavity press wheels as pictured in figure 1. The points of the teeth were not quite as high as the edge of the wheel rim and the base of the points was about even with the center of the concave rim. The emergence with this equipment, given in line 4 of table 2, was significantly better than the check planting shown in line 1. In fact, it was the only equipment which was consistently much better than the check. The cooperative planter test plots of the Colorado Agricultural Experiment Station and the Beet Sugar Development Foundation showed similar improved seedling emergence with this type of equipment. This press-wheel modification seems to be one of the better and most consistent improvements in press wheels so far developed. The wheels might ball up with soil in moist seedbeds so two sprocket-type wheels of half the thickness with one larger and with a larger center than the other might be a better combination.

The data in lines 5, 6, 7, and 8 are for four different combinations of special press wheels. Figure 2 shows the equipment used for line 8 and consists of two regular cultipacker wheels followed by two special Sishc wheels. The two cultipacker wheels alone were used in line 5. Figure 3 shows the tandem use of Sishc press wheels, on which data are reported in line 7, and for the data in line 6 the single rear wheel was removed. Only the heavy and awkward tandem combination of the two pairs of each type of wheels showed consistent improvement and this was not significant.

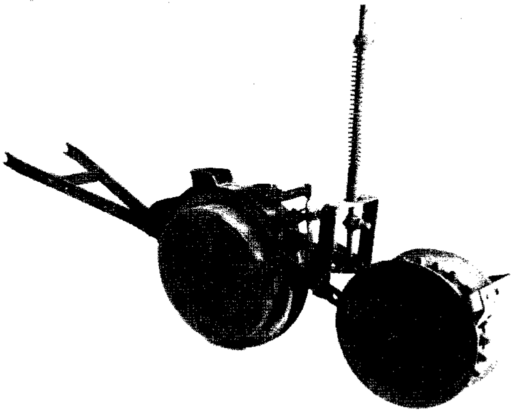

Figure 1.—The use of a plate-type sprocket or toothed wheel between the press wheels consistently improved seedling emergence as compared to press wheels without the special wheel between.

A special set of press wheels consisting of two tandem overlapping pairs of heavy cast-iron wheels with steep-angled rims were tested again this year. This set of wheels, which is shown in figure 4, weighed 70 pounds. The emergence data tabulated in line 9 showed these wheels to give a significantly poorer emergence than the check. In two plantings a year ago these wheels gave somewhat better emergence than the check, but on a loose, dry seedbed they continually caused trouble because of cutting in too much and failure to turn. These press wheels seem to be like several other types of planting equipment tested for improved seedling emergence. The results are erratic, being better than the check one year or one planting and poorer the next.

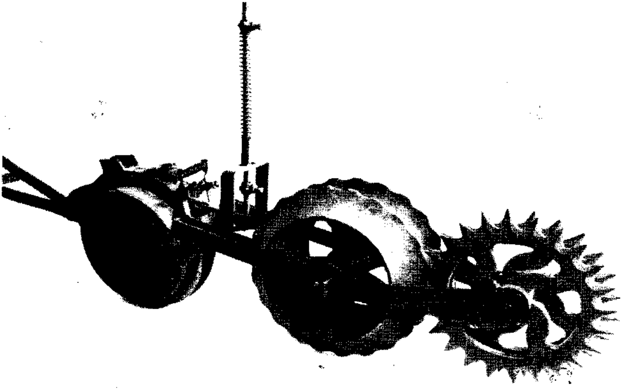

Figure 2.- A press-wheel combination of two cultipacker and two Sishc wheels gave some consistent improvement in seedling emergence, but the improvement was not significant and the equipment was heavy and awkward.

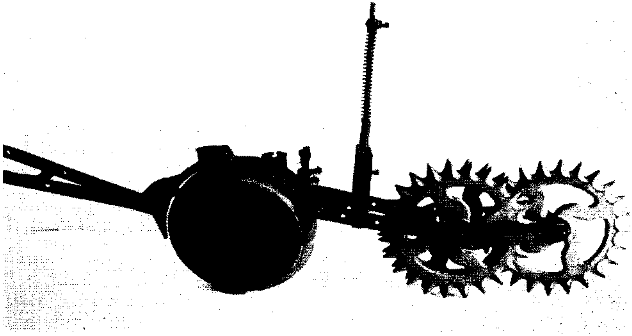

Figure 3. The Sishc press-wheel combination gave no improvement and with a damp soil surface was poor as it picked up soil.

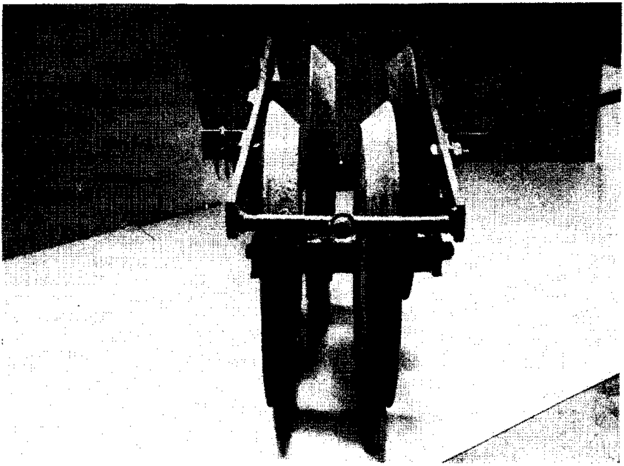

Figure 4.—This special set of heavy, steeply beveled-rim press wheels was significantly poorer than the regular press wheels.

The effect of the use of a safety fertilizer boot on both emergence and seed distribution has been frequently questioned. The boot on a John Deere disk opener is normally used between the disks. This equipment set-up and a special set-up with the boot offset just outside of the disk, as shown in figure 5, were both tested, but no fertilizer was used. The blade on the boot has a slight angle with the line of travel, thus giving a side pressure against the soil as the opener is pulled forward. The boot was offset in the direction to give this side pressure against the seed or toward the right as seen in figure 5. The purpose of offsetting the boot was two-fold. First, it removed the blade from between the disks where the seed had been dropped and thereby reduced the tendency to disturb the placement of the seed. Second, it gave this side pressure against the seed which was thought might close the furrow with moist soil around the seed and give better firming of the soil and thus improve germination and seedling emergence.

Lines 10 and 11 give the emergence data when using the fertilizer boot in normal and offset positions respectively. It will be noted that in normal position it significantly reduced seedling emergence as compared to the check, line 1. This probably resulted from loosening of the soil around the seed and leaving air spaces that permitted a drying-out action. On the other hand, on the first planting, when the boot was offset, it improved emergence over the check. The second planting, with the offset boot, went in poorly because of improper setting of the boot, and wedging which frequently stopped the disk. Consequently, plowing in of the opener resulted. The boot blade must be set largely behind the disk, as shown in figure 5, to prevent soil wedging between the two and stopping the disk. If the second planting with the offset boot had gone in smoothly—as smoothly as the first one—I believe the emergence would have been better. Even with the poor operation on the second planting, it gave practically the same emergence as the check planting.

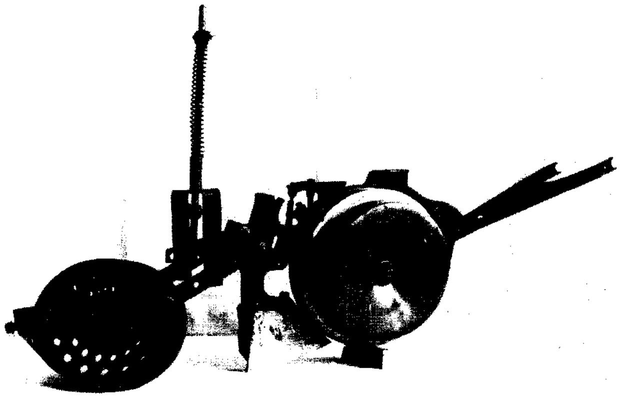

Figure 5.—Offsetting the safety fertilizer boot on this opener very significantly improved the seedling emergence as compared with the boot in normal position.

Seedling distribution comparisons were also made between tests with the fertilizer boot and the check planting. For some unknown reason the uniformity of seedling distribution was practically the same when the boot was offset and when it ran between the disks, on or against the seed, even though it was expected to be better when offset. In both cases it was considerably poorer than the check, but not quite significantly so. The fertilizer boots were used only for the set-ups reported in lines 10 and 11.

The equipment used for trials reported in lines 12, 13, 14, 15, 17 and 18 has all been used in the last 2 years and has shown improvement or promise at one time or another. This year's tests showed all of it to be poorer or no better than the check in obtaining increased seedling emergence. For line 12 an angled bar, extending back and down between the disks, was used to flatten the bottom of the opened furrow. For line 13 a small plowlike device, mounted between the disks, was used to move a small amount of moist soil from the side of the bottom of the opened furrow over the seed. A combination of these two attachments was used in line 14. A small, sharp edged, runnerlike shoe to divide and flatten the bottom of the opened furrow was used for line 15. A small, wedge-shaped, flat-bottom shoe mounted on the front side of the seed tube was used for line 17. This seed tube came down the rear or fertilizer spout in the disk opener. A round-bottom shoe to press down and flatten the furrow bottom was used for line 18.

The attachment used between the opener disks for line 16 was a combination of the type of runnerlike shoe of line 15 and the seed coverer of line 13 which was new this year. It is shown in figure 6. In the past year or two we have frequently found that some modification of the bottom of the opened furrow, like flattening, has improved the seedling emergence obtained. Also a method of covering the seed with a small amount of moist soil before the seed furrow was filled and pressed down has been beneficial. These ideas were combined in this attachment, but the resulting seedling emergence was poorer than the check.

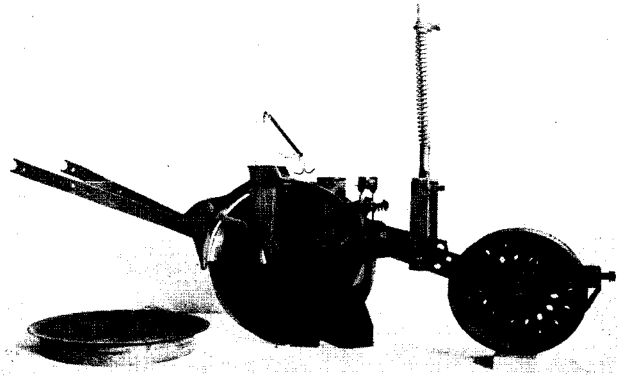

Figure 6.—This combination runner or shoe and seed coverer used between the disks did not improve seedling emergence.

A regular John Deere runner opener was used for lines 19 and 20. In the first case flat-rim press wheels were used and in the second deep concavity press wheels set close together were used. Both tests gave much the same results, confirming results with the disk opener with the same type press wheels as shown in lines 1 and 3. The runner openers gave somewhat poorer emergence on the first planting and slightly better on the second, averaging practically the same as the disk-opener tests with similar press-wheel arrangements.

In addition to the comparisons of the seedling emergence with different equipment a good comparison of the effect on emergence of two different types of seedbed preparation was obtained from this set of planter tests. The seedbed for the first planting in mid-April had been fitted for a week or so before planting and had received about .4 inch of precipitation, mostly rain, which had settled and firmed it somewhat during that time. Just before planting half of the seedbed was spike-tooth harrowed twice to loosen up the soil. As mentioned before, the planting was begun on April 14, interrupted by a snow of .13 inch precipitation on the 15th and a full set of treatments put in on the 17th. The seedling emergence counts with the different equipment were grouped and analyzed so that an emergence comparison could be made on the harrowed or looser seedbed and on the unharrowed or firmer seedbed.

The seedling emergence on the harrowed and unharrowed sections are shown in table 3. Apparently the freshly harrowed seedbed was not quite firm enough on April 14 as the seedling emergence from that day's planting was significantly better on the unharrowed seedbed. Apparently the .13 inch precipitation on the 15th settled the harrowed ground sufficiently to give a reversal of results for the emergence on the harrowed ground was significantly better on the April 17 planting. The average of the two plantings 3 days apart showed no significant difference between the harrowed and unharrowed seedbed.

Table 3.—Effect of seedbed harrowing on seedling emergence.

	Percent seedling emergence		
Treatment	Before snow	After snow	Average
Harrowed before planting	66.5	67.2	66.9
Unharrowed before planting	70.0	64.5	67.3
Difference for significance	3.92	2.25	1.95

The seedling emergence data from this year's planter plots in many instances do not substantiate the results with the same equipment in the past year or two. This variation in results from year to year and from one planting date to another bears out the experience on other sets of plots where seedling emergence is being studied. It indicates that climate, seedbed variation and other factors greatly influence the comparative seedling emergence results obtained with different planting equipment. Planter set-ups which give improved emergence one time and poorer results than regular equipment the next can be recommended only with reservations, if at all. Development to improve this planter characteristic will have to continue until consistent results are obtained.

Some equipment characteristics have been consistent and can be recommended. One of these, which should be repeatedly emphasized, is the proper depth of planting. Early plantings, in the northern Colorado districts at least, should be planted shallower to improve emergence while the later plantings should go in somewhat deeper. The seed should be well firmed in the soil. Improved seedling emergence can be obtained by using suitable press wheels, properly adjusted, or press-wheel modifications or perhaps some other device such as the offset fertilizer boot, used to improve the firming of the soil about the seed. Some modification of the bottom of the seed furrow, like flattening, smoothing or firming, seems desirable but the proper device or method to give consistent results apparently has not been developed so far.