EMERGENCE OF SUGARBEETS PLANTED WITH DIFFERENT PLANTER CONFIGURATIONS

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Typical sugarbeet production practice in much of the Western United States sugarbeet growing area prior to the late 1980's was to plant excess seed and then thin the resulting plants to a desired population. There were several perceived reasons for this practice, including low and unpredictable emergence, seed and thinning were relatively inexpensive, good profit margins, inability of planters to singulate seed and to space seed accurately in the furrow, and inconsistent stands with planting to stand.

Several researchers have documented low emergence of sugarbeet seed in field situations. Fornstrom (1980) found a 51 percent average emergence rate at several locations in Wyoming during a three year period. Winter (1980) reported an average emergence of 46 percent and a range of 31 to 63 percent in a four year study in Texas. Fornstrom and Miller (1989) observed an average emergence of 69 percent in Wyoming, with variations caused by year, planter model, seeding depth and variety.

As United States sugarbeet producers move into the 1990's, there is increasing pressure to be able to successfully plant to stand. Crop input costs are increasing while the price paid to growers for a ton of sugarbeets is not increasing, and some fear it may decrease. It is desirable, perhaps necessary, to eliminate the escalating input costs of excess seed and of thinning. Almost all of the British sugarbeet crop is planted to stand (Gummerson, 1989) as is most of the Western European crop. The motivation for planting to stand in Europe has been to reduce production costs and the unavailability of labor for thinning.

Although planting sugarbeets to stand in the United States is attractive and an obvious goal, it will require grower education, changes in cultural practices, and perhaps new production technology. It will not be as simple as changing the seed spacing adjustment on the planter. Higher and more consistent plant emergence must be achieved. Research in England on planting to stand has shown that at least 70 percent of seeds planted must develop into harvestable plants so that potential yield is not lost to gaps in the plant canopy (Jaggard, 1979). If this applies to the United States, then we need to strive for a minimum emergence of no less than 70 percent for plant to stand to provide yields comparable to thinned crops.

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Sugarbeet seedling emergence can be limited by many factors, including soil moisture, disease, chemicals applied to the soil, soil temperature, soil physical impedance, seedbed preparation, insects, and seed quality and vigor. Another factor which can influence emergence but has had only limited evaluation, is planter configuration. Barmington (1961) studied seven basic sugarbeet planters for seedling emergence using bare and coated monogerm sugarbeet seed. He found differences in emergence among planters and between the two seed preparations. Fornstrom and Miller (1989) compared three sugarbeet planters and two versions of the same planter. They found differences of as much as 10 percent emergence among basic models and also within the same basic model equipped with different accessories. Planter performance tests in Britain (Thomson, 1987) have shown that different planter models can contribute to differences of as much as 20 percent emergence. The difference of 10 or 20 percent final emergence between planters could be the difference between successful and unsuccessful plant to stand. Further assessment of final emergence from different planter models or variations of the same model is needed to assist growers in selecting the best planter for their operation.

The objective of this study was to compare the percent final emergence from sugarbeet seeds when planted with different basic sugarbeet planter models and with variations of the same model.

Procedure

Four base sugarbeet planter models were compared for differences in percent final emergence of sugarbeet seedlings using three types of seed coatings in eight planting sites during two years. Three of the planters had six different row configurations, while the fourth planter had two different row configurations, for a total of 20 different planter row setups.

Planters

The four base planters used in this study were the Deere 71 Flexi-Planter, the Milton planter, The Stanhay Webb Rallye 590 planter, and the Deere MaxEmerge 2 planter. The Deere 71 and Milton planters have been two of the most popular sugarbeet planters in much of the sugarbeet growing area of the United States for at least the past three decades. The Rallye 590 planter was recently designed in England, specifically for sugarbeets, and has been introduced into the United States. The MaxEmerge 2 planter is a general purpose planter, designed especially for corn and soybeans, but adapted for many other crops, including sugarbeets.

The combinations of soil engaging components---soil presswheels, seed firming wheels, seed furrow openers, and advance soil engaging devices---were configured differently for each row of the planters tested. The specific configuration for each row of each planter is

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To simplify technical terminology, trade names of products or equipment sometimes are used. No endorsement of products is intended nor is criticism implied of products not mentioned.

described in Table 1. These particular combinations were chosen primarily on the basis of manufacturer's options, or combinations that sugarbeet growers are using or have tried. Emphasis was placed on different presswheel designs, amount of down force on the presswheel, and devices ahead of the seed furrow opener. All rows of each planter were adjusted to place seeds 2 to 3 cm deep at planting time, and 8 to 10 cm apart within the row. Planter components and adjustments such as seed plates and vacuum levels, other than those listed in Table 1, were selected according to the operator's manuals for the specific sugarbeet seed coating types. All planters were operated at 4 km/h.

Seed Coatings

Three seed coating types were included in the study to determine if the planter row-emergence response was influenced by seed coating. The three seed coating types used are generally described as uncoated, coated, and pelleted. The base seed for each coating type was Monohikari variety of industry size medium (3.2-3.6 mm diameter). A seed sample was selected from a seed lot and divided into thirds for each seed treatment so each seed coating used equivalent base seed. The uncoated seed was drenched with seed fungicide, but had no further coating. The coated seed was partially coated with a process termed "Encrusting" which added approximately 15 percent additional mass to the seed. This type of partial coating was the most popular form of sugarbeet seed used in the United States in 1989-90. The pelleted seed was the standard 4.4 mm diameter size. The coated and pelleted seed treatments both contained seed fungicide, while the seed in the pelleted coating was also steeped. All three seed coatings were prepared by Germains, Inc. with materials and processes used for sugarbeet seed sold to producers in the United States during 1989-90. Laboratory germination for the test seed was 91 percent in 1989 and 88 percent in 1990.

Sites

Four planting sites were used in 1989 and four in 1990 to include a range of planting conditions that might influence seedling emergence. All eight sites were at the University of Nebraska Panhandle Research and Extension Center near Scottsbluff, NE. The soil type at this location is a Tripp sandy loam (Typic Haplustoll) with pH 8.3 and 0.8 percent organic matter content. The average annual precipitation is 38 cm for this Scottsbluff location. Soil conditions at planting and during emergence, including soil moisture, soil temperature, and seedbed preparation, were varied among sites by differences in planting date, seedbed tillage, natural precipitation, and sprinkler irrigation. No attempt was made to measure soil conditions at seed depth for each site and planting treatment. Instead, the goal was to include enough planting situations to provide an average emergence response representative of what sugarbeet growers actually experience among planting dates, years, and fields. Planting dates ranged from mid-April to early-May for all eight sites. Moisture in the top 5 cm of soil was very low, incapable of initiating germination, in three sites and remained low for up to two weeks after planting until natural precipitation occurred. A combination of natural precipitation and sprinkler irrigation was used in the other five sites to provide adequate soil moisture at seed depth at planting time and during the emergence period, to accommodate seedling emergence.

Seedbed preparation for all eight sites included moldboard plowing in late March, followed by two passes with a roller harrow prior to planting, typical for sugarbeet producers. To avoid any suppression of emergence by pesticides, no herbicides or other pesticides were used. There were no field operations between planting and final emergence counts.

A two factor, randomized complete block, experimental design was used within each site, with seed coatings as one factor and planter row as the other factor. With the planter design, it was not practical to completely randomize individual planter rows within the planter row factor. However, the four basic planter models and direction of travel were randomized among plots to provide a partial randomization of planter rows. Each treatment (combination of planter row and seed coating) was replicated six times within a site. Plots were 7.5 m long and row spacing was 56 cm.

Measurements

Measurements included those necessary to determine the number of seeds planted per unit length of row by each row of each planter for each seed coating; and the number of seedlings emerged per defined row length when emergence was complete. A mechanical counter was attached to each drive wheel (common drive wheel or individual presswheel, depending on the planter design) of each row of each planter. In the laboratory, the drive wheel was driven by a mechanical drive mechanism at the chosen field speed (4 km/h) to determine the number of seeds dropped for a given number of revolutions of the drive wheel. The procedure was replicated six times for each row of each planter for each seed coating type each year. Any variation in the number of seeds dropped per drive wheel revolution, was considered part of the variability in emergence of the plot. When the plots were planted, the number of drive wheel revolutions and corresponding distance were measured for each drive wheel within each plot. From this information, the average number of seeds dropped per unit length of row was calculated for each row of each plot. Percent final emergence was found by dividing the number of plants present in 4.5 m of row when emergence was complete, by the calculated number of seeds dropped for the equivalent length of row in the respective row of each plot.

Results and Discussion

The first planted site of 1990 received a moderate frost when approximately 20 percent of the plants had emerged. Since it was unclear how much plant damage had occurred and whether all treatments had equal damage, the data from this site was discarded and not included in the final analysis.

Final seedling emergence when combined over all factors was 53 percent and generally ranged from 40 to 70 percent. This was typical emergence performance in the Nebraska-Wyoming growing region as experienced by producers and as measured by Fornstrom (1980).

An analysis of variance was computed for final emergence of the data set which includes seven sites, three seed coatings, and 20 planter rows. This analysis was computed as a randomized complete block, two factor (seed coatings and planter rows) experimental design, combined over sites. This overall analysis indicates that there were statistically significant ($p = 0.05$) differences in final emergence among sites, among seed coatings, and among planter rows. There were also significant interactions among all combinations of the factors of sites, seed coatings and planter rows.

Differences in final emergence among sites were expected and intended because of differences in environmental conditions and seedbed management. The emergence period during 1989 was generally dry, warm and windy. Even after irrigation, for those sites that were irrigated, the soil surface dried rapidly. Soil temperatures were cooler and natural soil moisture was generally better in the 1990 sites. It was not the purpose of this study to project reasons for differences in final emergence among sites, but rather to treat sites as a producer might experience different fields and years. Weather and soil conditions after planting are difficult or impossible to predict at planting time. Even with irrigation available, not all soil conditions can be controlled. An "average" emergence response over a range of conditions is a more useful criteria to manage the selection and operation of a sugarbeet planter, than is trying to match a particular planter configuration with predicted seedbed conditions. Thus, if the conditions of the sites are considered somewhat random or at least not completely controllable by the producer, then it seems appropriate to combine the data over sites to further examine the main factors of seed coatings and planter row. Table 2 contains final emergence of each planter row within the three seed coatings, and the means of final emergence for the seed coatings and planter rows, combined over all seven sites.

Planter Row

Final percent seedling emergence ranged from a maximum of 59 percent for row number 4, to a minimum of 41 percent for row number 7, when averaged over all sites and all seed coatings. Observations during the emergence period of each site suggest several possible reasons for the disparity of emergence performance of these two rows. Emergence of row number 4 was statistically higher than the emergence of the five other Deere 71 planter rows. The feature of row 4 that was different from the other rows of the same basic planter model, was the presswheel design. Row 4 included a presswheel with an indented center section that left a ridge approximately 1 cm high and 2 cm wide directly over the seed row. It appeared that this presswheel design provided adequate seed-soil contact without excessive firming of the soil directly over the seed. Row 2 was the same as row 4 except the indented center section of the presswheel was wider and deeper, and exterted less pressure against the soil. Row 2 left a taller ridge of soil directly over the seed, and appeared to achieve less adequate seed-soil contact.

The reason for the poor performance of row number 7 is unclear and was unexpected. One difference between this row and other Milton planter rows was the double disk row cleaner attachment prior to the seed opener. This row cleaner moved between 1 and 2 cm of dry, loose, and sometimes cloddy soil from the row area. The remaining surface was smoother, more firm, had fewer clods, and more soil moisture. It was more difficult to close the seed furrow and attain good seed-soil contact in the firm, moist soil exposed by the row cleaning device than in the soil situation where the row cleaners were not used. In most sites, seedling emergence began sooner in row 7 than in any other row.

Row 8 of the Milton planter, like row 7, had lower final emergence than rows 9-12. It seems unlikely that the method of depth control would have contributed to poor performance of row 8 relative to the typical setup of row 10. The other difference between row 8 and row 10 is that row 8 used the close spaced MaxEmerge type presswheels, as did row 7. Although it appeared that the close spaced presswheels provided better seed furrow closing than the standard MaxEmerge presswheels of rows 19 and 20, plant emergence may have been hampered by firmer soil directly over the seed with rows 7 and 8.

Final emergence of all rows of the Stanhay Webb Rallye 590 planter was lower than the best rows of the other three planter types. This was surprising since this planter was recently developed in England specifically for sugarbeets and has had good acceptance with British sugarbeet growers. One notable difference between all rows of this planter and all other rows tested except rows 3 and 20, is that the Rallye 590 planter utilizes a runner-type seed furrow opener whereas the other planter rows use a double disk opener. Row 3, which included the manufacturer's optional sugarbeet shoe opener in addition to the double disk opener, produced statistically lower final emergence than the other five rows of the Deere 71 planter. As compared to the best Deere 71 rows, all rows of the Rallye 590 planter had lower final emergence in six of the seven sites. Observation of the sites during emergence did not suggest a reason why a shoe or runner opener would cause lower final emergence than a double disk opener. The shoe and runner openers should provide a more consistent furrow bottom to accept the seed and more uniform seed depth.

Rows 17 and 18 provided the highest final emergence of the six Rallye 590 rows. These two rows had the least soil engaging devices, as described in Table 1.

Final emergence of row 19 of the Deere MaxEmerge 2 planter compared favorably with the best performing rows of the traditional Deere 71 and Milton planters. Row 20 of the MaxEmerge 2 planter included a shoe furrow opener (not manufactured by Deere) in addition to the double disk opener. Row 20 had statistically lower final emergence than row 19, further suggesting that shoe or runner type openers are not beneficial for sugarbeet planting, at least as used with these planters in these planting conditions. This apparent difference in emergence between opener types deserves further investigation.

Based on results of this study, sugarbeet growers who use "typical" setups for the Deere 71 and Stanhay Webb Rallye 590 planters should consider alternate configurations to attain a small improvement in percent final emergence. "Typical" configurations of the Milton and Deere MaxEmerge 2 planters provided final emergence as high as or better than the other row options tested.

Seed Coatings

Final percent seedling emergence for coated and pelleted seed was statistically higher than uncoated seed when averaged over all sites and all planter rows, although only by two percent. Final emergence was statistically different among seed coatings in only six of 20 rows when compared within individual planter rows. In five of those six planter rows, pelleted seed provided higher emergence than uncoated seed. In only one planter row, row number 6, did uncoated or coated seed provide statistically higher final emergence than pelleted seed. There was no obvious reason for the interaction between seed coatings and planter row.

In general, the differences in emergence between seed coatings within a planter row were relatively small compared to differences between planter rows. Within most planter rows, the performance of seed coatings was similar to the performance averaged over all rows. Thus there seems little risk to average over seed coatings to compare planter rows.

Emergence Variability vs. Emergence Magnitude

Maximum percent final seedling emergence is an important sugarbeet planter performance factor. Perhaps just as important for a sugarbeet producer is consistency from field to field and year to year. As an attempt to compare the consistency or variability of the planter rows tested, Table 3 contains the standard deviations of final emergence for combinations of seed coatings and planter rows, as averaged over the seven sites and six replications. The standard deviation listed for a particular seed coating and planter row reflects the variability of final emergence among sites and replications. The standard deviations of final emergence combined over all three seed types include the variability of seed coating in addition to variability from sites and replications. Similarly, standard deviations of final emergence combined over planter rows include variability of planters in addition to sites and replications. When final emergence is combined over planter rows, the standard deviations of the three seed coatings are numerically the same. When averaged over seed coatings, the standard deviations are substantially different among planter rows. This suggests that final emergence of certain planter row configurations was more consistent among replications and sites than of other rows. Planter rows with highest final emergence, such as row 4, also tended to have lowest standard deviations when data was combined over replications, sites and seed coatings.

Conclusions

There were statistical differences in percent final seedling emergence among 20 planter rows, configured differently, when emergence data was combined over three seed coating types and over seven planting sites during two years. Final emergence ranged from 41 percent to 59 percent for planter rows when data was combined over sites and seed coating types. Planter configurations which provided highest final emergence included the Deere 71 with optional presswheel, and the typical Milton and typical Deere MaxEmerge 2 setups. Among the Stanhay Webb Rallye 590 planter rows, two with the least soil engaging components produced the highest final emergence. Planter units with double disk seed furrow openers appeared to provide higher final emergence than units with shoe or runner type furrow openers. Planter units with highest final emergence generally had the least variability of emergence when data was combined over sites and seed coatings.

There were differences in final emergence among planting sites but data was combined over sites to include various field conditions experienced by growers over different years, fields, and planting dates. Pelleted seed and coated seed provided slightly higher final emergence than uncoated seed when data was combined over all planting sites and all 20 planter rows.

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Table 1. Description of configuration of each row of the four base planters.

Deere 71 Flexi-Planter

Typical setup for sugarbeets includes Deere's chevron tread presswheel option, double disk seed furrow opener, and spring load on presswheel set between the middle and maximum adjustment.

Row	Description of Individual Row Relative to Typical Setup
1	Spring load on presswheel set to maximum force. This is a typical setup.
2	Deere's floatation type, wide groove, zero pressure, presswheel option.
3	Deere's beet shoe option which fits between the double disk furrow opener, and long seed drop tube.
4	Deere's double-tread, concave center, presswheel option.
5	Same as row 1 except no spring load on presswheel, only weight of presswheel assembly itself.
6	Deere's concave, smooth, zero pressure, presswheel.

Milton Planter

Typical configuration includes double disk seed furrow opener, singulation mechanism between openers eliminating need for seed drop tube, metal depth bands on furrow openers for seed depth control, and two smooth, vertically positioned, rubber tired presswheels, 1 cm apart. Presswheels spring loaded with approx. 5 kg vertical force.

Row	Description of Individual Row Relative to Typical Setup
7	Prototype H & H Precision Planter - Frame and depth gage wheels similar to Deere MaxEmerge planter. Milton singulation mechanism positioned between the double disk seed furrow openers. Presswheels same as MaxEmerge except modified so bottom of wheels closer together for shallow planted crop. ACRA-Plant double disk row cleaner assembly mounted to parallel bar linkage of planter.
8	Non-standard, Milton unit. Two rubber tired gage wheels near front of seed furrow opening disks for seed depth control, no depth bands. Close spaced Deere MaxEmerge style presswheels.
9	Typical Milton setup except 35 kg mass mounted directly over the standard Milton narrow spaced, dual, rubber presswheels to increase presswheel down force.
10	Typical Milton setup.
11	Typical setup except no spring loading on presswheels.
12	Typical setup except Milton optional, single, wide, smooth, zero pressure, rubber presswheel.

(continued on next page)

Table 1. Description of configuration of each row of the four base planters. (cont.)

Stanhay Webb Rallye 590 Planter

The Rallye 590 planter, manufactured in England, is available with many options. A typical arrangement as used in England includes, from front to rear, a clod deflector; a zero pressure rubber tire centered on the seed furrow and which serves as a furrow depth control; a narrow, ceramic, runner-type seed furrow opener with side plates; a seed firming wheel; a seed coverer; and a soil presswheel. The six rows were configured as follows:

Row	Soil Tines	Crumbler	Clod Deflector	Seed Firming Wheel	Seed Coverer	Soil Presswheel
13	none	none	yes	yes	yes	split SST
14	none	none	yes	yes	yes	single rubber
15	yes	yes	yes	yes	yes	single rubber
16	none	yes	yes	yes	yes	single rubber
17	none	none	none	yes	yes	single rubber
18	none	none	none	none	yes	single rubber

Deere MaxEmerge 2 Planter

Planter with Vacuum Seed Metering Mechanism

Row	Description of Row
19	Typical setup used in Nebraska for sugarbeets. Configuration recommended by Deere for sugarbeets except the insert in the "straight" sugarbeet tube was not used. Presswheel was in the first notch.
20	Same as row 19 except ACRA-Plant shoe mounted between double disk seed openers, and insert used in "straight" sugarbeet seed tube.

Table 2. Final percent seedling emergence for the twenty planter rows and three seed coatings averaged over seven planting sites in 1989 and 1990.

Planter Row No.	Uncoated Seed	Coated Seed	Pelleted Seed	LSD (p=0.05)	Mean
	Final Seedling Emergence (Percent of seeds planted)				
	- - - - - - - - - Deere 71 Flexi-Planter - - - - - - - - -				
1	56	56	53	N.S.	55
2	55	60	56	N.S.	57
3	52	52	51	N.S.	52
4	61	59	58	N.S.	59
5	53	51	49	N.S.	51
6	55	60	54	4	57
	- - - - - - - - - - - Milton Planter - - - - - - - - - - -				
7	40	40	44	4	41
8	46	45	46	N.S.	45
9	57	57	59	N.S.	58
10	59	57	57	N.S.	58
11	48	56	53	5	52
12	55	57	59	N.S.	57
	- - - - - - Stanhay Webb Rallye 590 Planter - - - - - -				
13	45	45	50	N.S.	47
14	44	47	50	5	47
15	45	47	50	N.S.	47
16	44	46	47	N.S.	46
17	46	50	54	4	50
18	49	53	55	4	52
	- - - - - - - Deere MaxEmerge 2 Planter - - - - - - -				
19	58	60	57	N.S.	58
20	56	57	55	N.S.	56
LSD (p=0.05)	4	4	4		2
Mean	51	53	53	1	52

Table 3. Standard deviation of final percent seedling emergence combined over seven planting sites and six treatment replications.

	Standard Deviation of Final Percent Seedling Emergence			
Planter Row No.	Uncoated Seed*	Coated Seed*	Pelleted Seed*	All Seeds†
- - - - - - - - Deere 71 Flexi-Planter - - - - - - - -				
1	16	16	17	16
2	13	10	13	12
3	18	19	18	18
4	13	12	10	11
5	22	21	22	21
6	13	11	13	13
- - - - - - - - - - Milton Planter - - - - - - - - - -				
7	13	9	20	15
8	15	14	18	16
9	15	11	16	14
10	12	13	15	13
11	15	14	15	15
12	12	15	13	13
- - - - Stanhay Webb Rallye 590 Planter - - - -				
13	14	18	16	16
14	17	16	20	18
15	14	17	19	17
16	17	21	18	18
17	13	13	14	14
18	12	12	13	13
- - - - - - - Deere MaxEmerge 2 Planter - - - - - - -				
19	14	15	12	14
20	14	16	13	14
All Planters‡	16	16	16	16§

*Standard deviation of final percent seedling emergence data combined over six replications and seven planting sites for the respective planter row unit and seed coating.

†Standard deviation of final percent seedling emergence data combined over six replications, seven planting sites, and three seed coatings for the respective planter row unit.

‡Standard deviation of final percent seedling emergence data combined over six replications, seven planting sites and twenty planter row units for the respective seed coating.

§Standard deviation of final percent seedling emergence for complete data set of six replications, seven planting sites, three seed coatings and twenty planter row units.