PLANT SPACING ACCURACY OF SUGARBEET PLANTER MODELS AND OF OPTIONS WITHIN PLANTER MODELS

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ABSTRACT

Correct plant population and consistent spacing between plants are necessary to optimize sugarbeet yield, to minimize weed competition, and to minimize harvest loss. Selection, adjustment, and options of the sugarbeet planter influence plant population and plant spacing accuracy. The objectives of this study were to compare plant spacing accuracy of several U.S. and European sugarbeet planters, and to examine the influence of seed tube options on the Deere MaxEmerge model planter popular in the U.S. The plant spacing comparisons included two field speeds, 4.8 and 8 km/h, and two seed coating types, 4M pellet and partial coating. The Kleine Unicorn 3 planter had better plant spacing accuracy than a second group of planters including the Monosem Meca 2000, the Case-IH ASM, the Monosem NG Plus II, and the Deere MaxEmerge Plus. Six seed tube options available with the Deere MaxEmerge Plus planter were compared in a followup study. Differences in seed spacing accuracy were found among the seed tube options, but observations suggest seed tube choice with this planter must also be based on seed depth control.

INTRODUCTION

The planter is one of the foundational elements that determine sugarbeet yield. Planter performance is directly responsible for seed population, seed depth, and accuracy of spacing between seeds. Relationship of established or harvested plant populations with sugarbeet yield has been well described (Yonts and Smith, 1997; Eckhoff *et al.*, 1991; Hills, 1972; and Nelson, 1968). Generally these studies have shown that plant populations in the range of 33,000 to 38,000 plants/A at harvest time will produce maximum sugar yield in most U.S. growing areas. The effect of plant spacing accuracy on sugar yield within this range of plant populations has not been as easy to define. Studies have shown that relatively minor inconsistencies in plant spacing accuracy do not measurably influence sugarbeet yield but that large differences in plant spacings within the row do reduce yield (Harrigan, 2001; Smith and Palm, 1999; Smith *et al.*, 1990; Fornstrom and Becker, 1972; Becker, 1968; and Ririe and Hills, 1957). In addition to any influence on sugar yield that may be caused by lack of accurate plant spacing, harvest efficiency and harvest loss must be considered. Relatively close spaced plants alternating with wide spaced plants within the correct plant population will create a range of root size and range of root crown height above the soil surface. This will create problems with defoliating, scalping, and lifting the roots from the soil (Smith *et al.*, 1999). Wide gaps between plants will reduce competition between crop and weeds, encouraging weed development. Thus there are several reasons to strive for accurately spaced plants within the target plant population range.

Planter models used for planting sugarbeets in the U.S. have transitioned from three or four popular planter models in the early 1980's to one primary model and two or three secondary models by the year 2000. The Deere and Co. (Moline, IL) MaxEmerge planter model in several versions is currently used to plant an estimated 70% of the sugarbeets produced in the U.S. This planter is used for a wide variety of crops in a range of field conditions, requiring a number of options, including optional seed tubes (Fig. 1) that deliver the seed from the metering mechanism to the seed furrow, a distance of 66 cm. Case-IH (Racine, WI) introduced a new planter model in 2000, the Model 1200 with ASM metering unit. Monosem (A.T.I., Inc., Lenexa, KS) has offered the model NG Plus for sugarbeet planting and recently introduced the NG Plus II version, which includes an optional large diameter in-furrow seed press wheel. In contrast to these three multi-crop planters which use pneumatic seed metering for planting sugarbeets in the U.S., European sugarbeet producers typically use precision planters designed specifically for pelleted sugarbeet seed. Planters representing these European designs include the German Kleine Unicorn 3 (Franz Kleine, Saltzkotten, Germany) and the French Monosem Meca 2000 (A. T.I., Inc., Lenexa, KS) — both with mechanical metering systems. Researchers have compared performance of several planters (Harrigan, 2001; Panning *et al.*, 2000; Smith *et al.*, 1991; Fornstrom and Miller, 1989; and Giles and Cattenach, 1988), but all three of the current multi-crop planters have not been compared for sugarbeet plant spacing accuracy.

To improve plant spacing accuracy, and to make wise decisions on planter selection, U.S. sugarbeet growers need data on plant spacing accuracy performance of current U.S. planters, planter options, and how these compare to typical European precision sugarbeet planters. The objective of this study is to compare plant spacing accuracy of three current U.S. sugarbeet planters and offered options, with two European sugarbeet planters.

MATERIALS AND METHODS

Field comparisons of planter models and options within models for plant spacing accuracy were conducted at the University of Nebraska Panhandle Research and Extension Center near Scottsbluff, Nebraska. The soil type at this location is generally classified as a very fine sandy loam. The plot area was sprinkler irrigated prior to secondary tillage to provide good soil water content in the soil profile. When the soil surface had dried sufficient for secondary tillage, the seedbed was prepared with a European-style seedbed conditioner which left the soil surface smooth, firm, and free of large clods or ridges. At planting time, the top 1 cm of soil was dry and loose, but the soil below 1 cm had sufficient soil water to maintain an open seed furrow.

Immediately after planting, furrows were created between the planted rows and the plots were furrow irrigated. Irrigation was repeated as necessary to maintain good soil water content at seed depth until emergence was complete. When the sugarbeet plants were in the cotyledon to two true leaf stage, plant spacing measurements were made between 126 consecutive plants within each treatment row. The measuring instrumentation (Panning, 1997) was developed at the University of Nebraska and is based on the calibrated output of a rotary encoder contained in one axle of a four wheeled push cart. The cart was advanced along the crop row until a pointer was adjacent to a sugarbeet seedling. A "record" key was pushed and the output from the encoder system was saved in a portable data recorder. The output information from the rotary encoder was then converted to linear field distance using a calibration factor developed for the particular field.

Tab. 1 lists the seed plate used for each planter model, and for pneumatic models, the vacuum and singulator settings. Each row of each planter was tested on a planter test stand, and then observed in the field, to determine optimum adjustments for best seed singulation. The planter manufacturers were consulted to confirm best settings.

Tab. 1. Seed plate, vacuum setting, and singulator position for planters used in this study.

Planter Model	Field Speed (km/h)	Seed Coating	Seed Plate No.	Vacuum (cm water)	Singulator-Position
Case-IH	Both	Reg. Pellet	8020	53	2
		Med. Encrusted*	80175*	30*	1.5*
MaxEmerge	Both	Reg. Pellet	A51713	13	---
		Med. Encrusted	H136445	4.4	---
Monosem NG	4.8 km/h	Reg. Pellet	4020	56	+2
		Med. Encrusted	4016	41	0
	8 km/h	Reg. Pellet	4020	56	+5
		Med. Encrusted	4016	41	0
Kleine	Both	Reg. Pellet	8Z	---	---
Monosem Meca	Both	Reg. Pellet	5.5A5	---	---

**Case-IH currently does not recommend unpelleted seed with this planter.*

The seed for these planter comparisons was Seedex variety Charger in medium Encrusted and 4M pellet coating type designations. Both seed coatings contained seed from the same seed lot. The Encrusted seed had 10-15% coating buildup. The target seed depth was 2 cm, with 13 cm spacing between seeds.

Two plant spacing accuracy studies were conducted — the first in 2001 to compare five planter models, several equipped with options; and the second in 2002 to specifically compare seed tube options available with the Deere MaxEmerge Plus model.

PLANTER MODEL COMPARISON

The planter models and options within each model included:

> Case-IH ASM model 1200, new, 6 row

-- standard seed tube

-- new design seed tube supplied by Case-IH

-- two modified tubes supplied by the University of Nebraska

> Deere MaxEmerge Plus, approx 100 ha planted, 6 row

-- straight seed tube, without ramp

-- straight seed tube, without ramp, with insert

-- curved seed tube, without ramp

-- curved seed tube, without ramp, with insert

-- sugarbeet seed tube and accompanying runner

-- curved seed tube, without ramp, with ACRA Plant runner (Shield Industries, Hutchinson, KS), and with Rebounder (Schaffert Mfg. Co., Indianola, NE)

> Monosem NG Plus II, two row, new

-- no in-furrow seed press wheel

-- large in-furrow seed press wheel

> Kleine Unicorn 3, six row, approximately 300 ha planted. 1993 year model.

> Monosem Meca 2000, three rows of a 12 row planter that had approximately 150 ha planted. 1998 year model.

The ACRA Plant runner was included on one row of the MaxEmerge planter to hold open the seed furrow behind the curved seed tube because the curved seed tube delivers the seed farther behind where the furrow is opened compared to sugarbeet or straight seed tubes. The Rebounder was added to this same row. The Rebounder is a flexible device attached to the seed tube and extends behind the tube opening to direct any seeds into the furrow that deflect horizontally or upward from the opening of the seed tube. This device does not contact the soil.

The planter model study was conducted two times in 2001, with plantings on June 28 and August 28. The experimental design within each planting date was a three factor, split plot, incomplete randomized block, with six replications of each treatment. The factors were field speed (4.8 km/h and 8 km/h), seed coating (Encrusted and pellet), and planter row. The planter row factor was split within the factors of field speed and seed coating. The Kleine Unicorn 3 and Monosem Meca 2000 planter models only operate with pelleted seed, so the seed coating factor was incomplete. The row options were randomized on the planter for planters with more than one row tested. Planter direction in the field was also randomized. Seed hoppers were randomly assigned to planter rows for each plot.

SEED TUBE COMPARISON WITHIN THE DEER MAXEMERGE PLANTER MODEL

The six seed tube combinations evaluated in the 2002 study were:

- -- curved seed tube with ramp
- -- curved seed tube without ramp
- -- curved seed tube with ramp and with insert
- -- sugarbeet seed tube with associated furrow opener
- -- straight seed tube with ramp
- -- straight seed tube without ramp

Fig. 1. Deere MaxEmerge seed tube options. From left to right: Insert for curved tube, curved tube, insert for straight tube, straight tube, and sugarbeet tube with runner which replaces the rock guard. Seed tubes with and without the internal ramp feature appear the same externally.

The seed tube study was conducted three times in 2002, with plantings on April 26, June 27 and August 19. The experimental design within each planting date was a three factor, split plot, randomized complete block, with six replications of each treatment. The factors were field speed (4.8 km/h and 8 km/h), seed coating (Encrusted and pellet), and seed tube. Seed tubes were randomly assigned to one row of the six-row planter. The planter row factor (seed tube) was split within the factors of field speed and seed coating. The planter hoppers including the metering mechanisms, were randomly assigned to planter row position for each plot to avoid any confounding of the effect of the metering system and the seed tube on plant spacing accuracy. Planter direction in the field was also randomized for each plot.

PARAMETER USED TO COMPARE SEED SPACING ACCURACY

The parameter "Precise Spacings" was used to measure and compare seed spacing accuracy (Panning *et al.*, 2000). This parameter is defined as the percentage of spacings that were within a 3 cm range centered on the mode spacing, and excludes any spacings greater than 1.5 times the mode and less than 0.5 times the mode spacing. "Precise spacings" represents the percentage of those spacings very close to the mode spacing and are the most desirable spacings. The spacings greater than 1.5 times the mode or less than 0.5 times the mode are spacings that might be the result of seeds dropped but did not emerge, or seeds that produced more than one seedling—neither caused by the planter. Test stand evaluation of the planters indicated that seed metering was very good for all combination of planters, seed coatings, and field speeds so it is probable that any short or long spacings were not caused by the planter.

RESULTS

PLANTER MODEL COMPARISON

Field emergence was 92% for the June 28 planting date and 90% for the August 28 planting date, averaged over all treatment factors. When planting dates were combined, there was no statistical ($p<0.05$) difference between final emergence of pelleted seed (90.5%) and unpelleted seed (91.8%). There were no statistically significant plant spacing accuracy interactions of planting date with planting treatments, thus results from the two planting dates have been combined.

Plant spacing accuracy of pelleted seed (57% precise spacings) was statistically higher than plant spacing accuracy of Encrusted seed (47% precise spacings) when averaged over both field speeds and the three planter models that used Encrusted seed. Plant spacing accuracy of 4.8 km/h field speed (66% precise spacings) was higher than that of 8 km/h (55% precise spacings) when averaged over all five planter models for pelleted seed only.

Plant spacing accuracy comparison of the planter models, each with the options that provided the best plant spacing accuracy, is shown in Tab. 2.

Tab. 2. Comparison of planter models for plant spacing accuracy, using the best row (row with the highest plant spacing accuracy) of each planter where more than one row was included, averaged over both planting dates and both field speeds.

	Plant Spacing Accuracy (Precise Spacings, %)	
Planter Model	**Regular Pellet Seed Coating**	**Medium Encrusted Seed Coating**
Case-IH, with std seed tube	59.5	50.5
Monosem NG Plus II, without seed press wheel	61.0	47.8
Deere MaxEmerge Plus, with curved seed tube, without	51.9*	43.0*
Kleine Unicorn 3	72.1	------
Monosem Meca 2000	59.8	------
lsd (p=0.05)	*5.0*	*3.9*

**Note: These results are with the older style seed tube without internal ramp.*

With the Case-IH planter there was no statistical difference in plant spacing accuracy between the standard seed tube and the new design seed tube furnished by Case-IH. Both seed tubes furnished by Case-IH had better plant spacing accuracy than the modified seed tubes provided by the University of Nebraska. There was no statistical difference in plant spacing accuracy between the Monosem NG Plus II with and without the large in-furrow seed press wheel. Comparison of the seed tube options with the Deere planter is shown in Tab. 3. Inserts decreased plant spacing accuracy with both the curved and straight seed tubes. The beet seed tube had lower plant spacing accuracy than either the curved or straight tube, but field observations suggest the beet seed tube has better seed depth control than the curved and straight seed tubes. The curved seed tube with ACRA-Plant shoe and Rebounder had lower seed spacing accuracy than the same tube without the ACRA-Plant shoe and Rebounder. Our explanation, is that to mount the ACRA-Plant shoe, the bottom of the seed tube was repositioned nearly 3 cm further rearward with the furnished tube extender, causing more contact of the seed with the seed tube during the path of the seed down the seed tube.

Tab. 3. Effect of seed tube option on plant spacing accuracy on the Deere MaxEmerge Plus planter, averaged over two field speeds, two planting dates, and two seed coating types.

Row Unit Configuration	Plant Spacing Accuracy (Precise Spacings, %)
Curved seed tube, without ramp	47.4
Curved seed tube, without ramp, with insert	35.4
Straight seed tube, without ramp	47.3
Straight seed tube, without ramp, with insert	38.8
Beet Seed tube with beet runner	41.0
Curved seed tube (without ramp) with ACRA-Plant shoe and Rebounder	43.5
lsd (p=0.05)	*2.8*

Upon completion of the 2001 project, we learned that Deere has new versions of the curved and straight seed tubes. This change occurred in the mid-1990's and was included on new planters assembled at the factory but dealer inventory still contained some of the earlier seed tube versions — the source of the seed tubes used in this study. The change was the addition of a "ramp" on the internal, front surface, starting at the top of the seed tube and increasing in thickness to the opening for the seed sensor, where this ramp-like feature stops. The intent of this change is to cause the seed to "ramp over" the rough section where the seed sensor extends into the opening of the seed tube. Thus, the results shown in Tab. 2 and 3 for the Deere MaxEmerge model planter do not reflect the most recent curved and straight seed tubes. This is the reason for the 2002 study which compared seed tubes with and without the ramp feature.

SEED TUBE COMPARISON WITHIN THE DEERE MAXEMERGE PLANTER MODEL

A total of 43,200 spacings between plants were measured in the 2002 study which compared six different seed tube configurations of the Deere MaxEmerge planter at two field speeds, with two seed coating types, in three field planting dates. Field speed of 4.8 km/h (48.8% precise spacings) had statistically ($p<0.05$) better plant spacing accuracy than 8 km/h (40.4% precise spacings) when averaged over all three planting dates, both seed coating types, and all six planter seed tubes. Pelleted seed (46.7% precise spacings) had statistically better plant spacing accuracy than Encrusted seed (42.5% precise spacings) when averaged over all three planting dates, both field speeds, and all six planter seed tubes. Seed spacing accuracy comparison of the six seed tube configurations is shown in Tab. 4. The relationship of the curved seed tube without ramp, straight seed tube without ramp, and the sugarbeet seed tube was very similar to that obtained in the 2001 study (Tab. 3). The ramp feature improved seed spacing accuracy of both the curved and straight seed tubes. Applying the benefit of the ramp feature to the curved tube without ramp used in the 2001 study, suggests that the seed spacing accuracy performance of the Deere MaxEmerge planter is similar to the Monosem NG Plus and the Case-IH ASM model 1200 planters.

There were four statistically significant interactions of the factor combinations seed by date, seed tube by date, seed tube by speed by date, and seed tube by seed by date. All four of these interactions included the factor of planting date. Part of this effect from date may have been from different amounts of talc (recommended by the planter operator's manual) added to the seed, or some influence of temperature or humidity. Each of these three factors has been observed to cause some difference in seed spacing accuracy with the MaxEmerge planter on a laboratory test stand at the University of Nebraska. Examination of seed spacing accuracy associated with each of the three factors of seed coating type, field speed, and seed tube within each of the planting dates revealed no large numerical differences involved in the statistical interactions. Thus, the data is presented as combined over the three planting dates.

Tab. 4. Plant spacing comparison of seed tube options on Deere MaxEmerge planter, averaged over two field speeds (4.8 and 8.0 km/h), two seed coating types (4M pellet and medium Encrusted), and three planting dates during 2002.

Seed Tube Description	**Plant Spacing Accuracy**
Curved seed tube with ramp	52.1
Curved seed tube without ramp	44.9
Curved seed tube with ramp and with insert	38.3
Sugarbeet seed tube with associated furrow opener	40.6
Straight seed tube with ramp	47.8
Straight seed tube without ramp	44.0
lsd (p=0.05)	*2.1*

Soil planting conditions for all three planting dates within the 2002 study were considered ideal. The soil surface was level, dry, firm, and with no soil clods larger than ½ cm. There was sufficient soil moisture at the 1 cm depth to maintain an open seed furrow. Observations in these and other less than ideal planting conditions suggest that there may be important differences in the seed depth control performance among the Deere MaxEmerge seed tubes. For example the curved seed tube delivers the seed into the furrow farther behind the point where the furrow is opened compared to the sugarbeet seed tube. Some soil may slough into the furrow before the seed reaches the furrow bottom with the curved tube if the soil is very dry and loose and if the field speed is low. The sugarbeet seed tube has a smaller opening than the curved tube which may help direct the seed into the furrow bottom. However, the runner opener which accompanies the sugarbeet seed tube may build up with soil or residue in wet, heavy soil conditions and cause the double disk furrow openers to stop turning. Thus, the operator of the Deere MaxEmerge planter must prioritize desirable operating characteristics when selecting a seed tube option for this planter.

CONCLUSIONS

Plant spacing accuracy was better for all planters tested when the planter was operated at 4.8 km/h compared to 8 km/h field speed. Pelleted sugarbeet seed, 4M size, provided better plant spacing accuracy than medium Encrusted seed for all planters tested. The Kleine Unicorn 3 planter provided excellent plant spacing accuracy, higher than plant spacing accuracy of the other four planters tested when averaged over both field speeds and using pelleted seed. The Case-IH model 1200 AMS, the Monosem NG Plus II, the Monosem Meca 2000, and the Deere MaxEmerge Plus model planters all performed similarly for plant spacing accuracy with pelleted seed, when results were averaged over the two field speeds and seed coating types, and when the best tested row configuration of each planter was compared (including the seed tube ramp feature on the Deere model).

The seed tube options for the Deere MaxEmerge Plus model planter made a large difference in plant spacing accuracy. The seed tube insert lowered plant spacing accuracy for both the curved and straight seed tube models compared to the respective seed tubes with no insert. The ramp feature included on current production of the curved and straight seed tubes, improved plant spacing accuracy compared to no ramp. The curved seed tube had better seed spacing accuracy than the straight seed tube, although the difference was small. Observations suggest that the straight seed tube may have better seed depth control in some situations than the curved tube. The sugarbeet seed tube had lower plant spacing accuracy than either the curved or straight seed tubes but, of all seed tube combinations tested, the sugarbeet seed tube was observed to have the best seed depth control in some planting conditions.

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