EVALUATING GROWERS' SUGARBEET PLANTER METERING UNITS AND SEED DROP TUBES ON THE UNIVERSITY OF NEBRASKA PLANTER TEST STAND

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Introduction

Pre-season planter clinics have been commonly conducted in the local sugarbeet growing areas of Nebraska and other states to help assure correct seed population and uniform seed spacing necessary for high yields and efficient production of sugarbeets. Traditionally these planter clinics are based on a grease belt test stand. The sugarbeet growers bring their planter metering units (hoppers) to the clinic site, the units are dismantled, inspected, any replacement parts added, and the unit is tested with seed on what is commonly called a 'grease belt test stand'. This test stand employs a moving belt, coated with oil, to simulate the relative motion of the planter and the soil. The oil on the belt captures the seed as it leaves the metering mechanism to prevent the seed from rolling or bouncing, which would occur on an otherwise dry surface. The operator observes the spacing of the seed and, based on experience, subjectively decides if the planter metering mechanism is functioning satisfactorily.

The grease belt test stand has served the sugarbeet production industry very well for many years. It has a number of positive attributes. It is simple and trouble free. It is visual and allows the operator and grower to directly observe seed spacing performance. However, in its traditional form, it has several limitations. First, there is no numerical output measure of seed spacing performance to provide a consistent and precise comparison with a reference performance of a properly operating planter unit and the one being tested. Serious seed spacing performance problems are obvious but minor seed spacing performance problems are difficult to visually detect, even by an experienced test stand operator. Second, at realistic field speeds, the belt must be stopped to carefully examine seed spacing on the grease belt. This limits the number of seed spacings that can be studied within the short testing time. It is sometimes necessary to observe 500 or more seed spacings to detect certain problems. Third, at operating speeds of four or five mph there is concern that some seeds, particularly the heavier seed coating types, can slide in the oil, giving inaccurate spacing results. Fourth, typically the growers' planter seed drop tubes are not included in the evaluation. Seed tubes do become physically damaged and worn and perhaps should be tested with the planter metering unit.

The University of Nebraska has developed an electronic sensing system to measure the seed spacing output of a planter to supplement and to address some of the shortcomings of the traditional grease belt. The accompanying planter test stand will also accommodate the seed drop tube. This test stand system has been used for several years in a series of sugarbeet planter clinics in Nebraska and adjoining states.

Objectives

1. Compare seed spacing performance of growers' planter row units as delivered to the planter clinic with seed spacing performance after inspection and any repair parts are added.

2. Determine the influence of worn seed drop tubes on the seed spacing performance of growers' sugarbeet planter row units.

Methods

The tests were conducted on the University of Nebraska electronic planter test stand. The test stand design was specified by the University of Nebraska and constructed by Schlagel Mfg., Inc. of Torrington, WY. This test stand accommodates metering units and seed tubes of several planter models common to Nebraska, including the Deere 71 Flexi-Planter, Deere MaxEmerge series, and the Case-NH ASM planter units. The belt has an observation length of 9 ft. Oil is applied to the belt with an oil pump to maintain a consistent oil supply at higher belt speeds. The belt surface speed can be varied from 0 to 6 mph. The planter metering unit drive speed can be varied to provide different seed spacings but is connected to the grease belt to deliver a consistent seed spacing when belt speed is varied.

The electronic measuring system consists of components and software developed at the University of Nebraska. The core of the system is a 'photogate' placed below the seed drop tube in the seed path. This photogate has a square opening, 3 ¾ in. on a side, through which the seed passes. The photogate is positioned vertically to duplicate the distance between the bottom of the seed tube and the bottom of the seed furrow when operating in the field. The photo gate has an array of 24 alternating photo sensors and photo emitters on each side of the photogate that is parallel to the direction of travel. As a seed passes through the photogate, the light from the emitter is blocked from the sensor. Information about which sensor pair was blocked, and the time between successive seeds, are transferred to a computer equipped with a commercially available digital I/O board. Other sensors detect the rotational speed of the grease belt drive. The operator provides input constants that enable the computer software to calculate belt surface speed and to convert the time between seeds to horizontal distance between seeds, calibrated to be equivalent to the seed spacing observed on the grease belt. A unique, and necessary feature of the software is that seed spacings reported by the electronic system account for both the time between seeds as they pass through the photogate and the position through the photogate (the reason for 24 sensor pairs instead of only one). Details of the design, verification, and operation of this electronic seed sensing system are provided by Kocher, et al (1998); Lan, et al (1999); and Panning, et al (2000).

The 2002 and 2003 sugarbeet planter clinics were planned and conducted by a cooperative effort of the Western Sugar Cooperative Agriculture staff, regional sugarbeet seed sales staff, local Deere dealerships, and the University of Nebraska. The clinics were located at local Deere dealerships or Western Sugar Cooperative facilities. Growers signed up for a specific day and time of day to bring their planter metering units. It was suggested that they bring both their metering units and seed tubes for testing.

At the planter clinics, the metering units and seed tubes (a new seed tube was used if the grower did not bring his own seed tubes) were tested on the University of Nebraska test stand before any inspection or repairs were made, and the basic 'before inspection' seed spacing data was recorded. The metering units were then inspected and repaired as needed and run on a standard grease belt to look for any obvious problems. When the metering unit was observed to be operating satisfactorily and ready to be returned to the grower, it was tested again on the University of Nebraska planter test stand. If the row unit did not perform as expected, it was returned for further inspection and repair and tested again on the University of Nebraska test stand. This was repeated if necessary until the row unit performed satisfactorily.

All planter row units were operated at 3 mph equivalent field speed and 4.5 in. seed spacing for consistent comparison. The seed tube (for Deere MaxEmerge models only) and seed type (size and coating) were chosen to match the growers' practices. Each test measured the spacings between 800 seeds. This number of spacings was found necessary to provide repeatable results for the same planter unit and would identify any random or pattern seed spacing problems.

An example of the output from the seed spacing instrumentation is shown in Figure 1. This is an output from the 2004 version of the system which includes two-dimensional seed spacing performance. Since most properly operating sugarbeet planters can singulate most seed with very few 'skips' or 'multiples', the primary seed spacing concern is accuracy (repeatability) of seed spacing. The parameter used in this report to quantify seed spacing accuracy will be 'CP3'. CP3 is defined as the percentage of all spacings that are ±1.5 cm (~½ in.) of the target seed spacing. The planter unit reported in Figure 1 achieved a CP3 of 94.2% at a target seed spacing of 4.56 in. Thus, 94.2% of the 799 measured spacings were between approximately 4 and 5 in.

In relative terms, seed spacing with a CP3 of 90% appears as very good seed spacing on a grease belt. A CP3 of 75% will be noticeably irregular in comparison but will still appear as a good seed spacing. A seed spacing with a CP3 of 45% or less appears as very irregular seed spacing.

Results

In 2002, a total of 44 planters composed of 446 individual rows were tested at four sites in Nebraska and 3 sites in Colorado. In 2003, 69 planters comprised of 724 individual rows were tested at four sites in Nebraska, three sites in Colorado, two sites in Wyoming, and one site in Montana. Information on the planter models tested is shown in Table 1, number of rows per planter is shown in Table 2, and the size and type of seed coating are listed in Table 3. Table 4 provides information on which type of seed tube the growers used in the Deere MaxEmerge planters tested, if the seed tube included an insert, and if the seed tube was a version with the 'ramp' feature. The trend in Nebraska and the adjacent growing areas is to not use the seed tube insert. The insert was initially useful to improve performance of the seed sensor but that is no

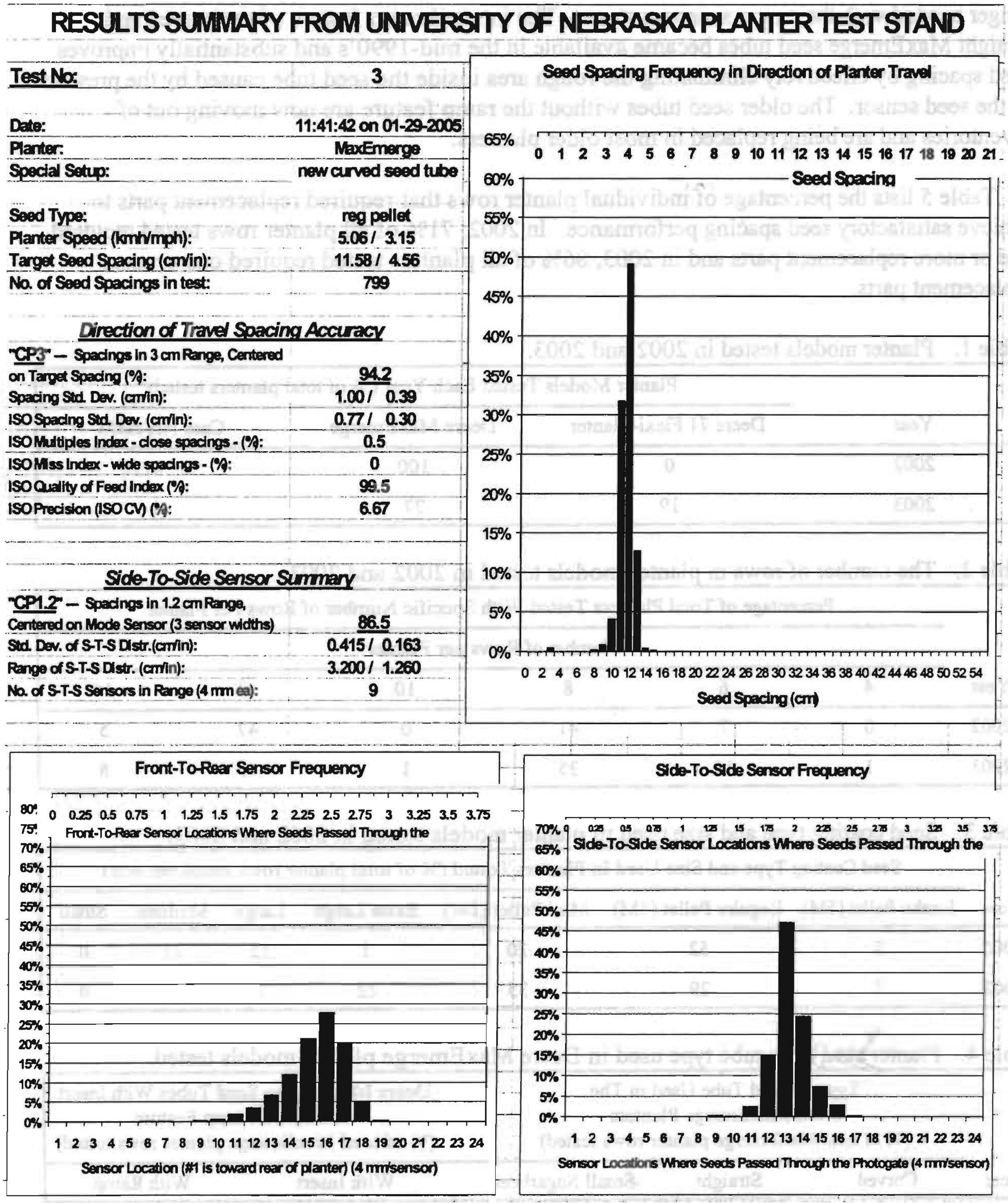

Figure 1. Example output from the University of Nebraska electronic planter test stand. This is very good seed spacing performance from a Deere MaxEmerge planter row unit with a curved seed tube, regular (4M) sugarbeet pellet, and 4 ½ in. seed spacing at 3 mph simulated field speed.

longer needed with the newer sensor systems. The internal ramp feature of the curved and straight MaxEmerge seed tubes became available in the mid-1990's and substantially improves seed spacing by effectively eliminating the rough area inside the seed tube caused by the presence of the seed sensor. The older seed tubes without the ramp feature are now moving out of inventories and are being replaced in most older planters.

Table 5 lists the percentage of individual planter rows that required replacement parts to achieve satisfactory seed spacing performance. In 2002, 71% of all planter rows tested required one or more replacement parts and in 2003, 86% of all planters tested required one or more replacement parts.

Table 1. Planter models tested in 2002 and 2003.

	Planter Models Tested Each Year (% of total planters tested)		
Year	Deere 71 Flexi-Planter	Deere MaxEmerge	Case NH ASM
2002	0	100	0
2003	19	77	4

Table 2. The number of rows in planter models tested in 2002 and 2003.

	Percentage of Total Planters Tested With Specific Number of Rows Per Planter					
	Number of Rows per Planter					
Year	4	6	8	10	12	16
2002	0	7	41	0	47	5
2003	1	10	35	1	45	8

Table 3. Seed coating type and size used in planter models tested in 2002 and 2003.

	Seed Coating Type and Size Used In Planters Tested (% of total planter rows tested per year)						
Year	Jumbo Pellet (5M)	Regular Pellet (4M)	Mini Pellet (2M)	Extra Large	Large	Medium	Small
2002	2	52	20	3	12	11	0
2003	7	29	35	12	1	16	0

Table 4. Planter seed drop tube type used in Deere MaxEmerge planter models tested.

	Type of Seed Tube Used in The Deere MaxEmerge Planters (% of total MaxEmerge planter rows tested)			Deere MaxEmerge Seed Tubes With Insert or Internal Ramp Feature (% of total MaxEmerge planter rows tested)	
Year	Curved	Straight	Small Sugarbeet	With Insert	With Ramp
2002	48	27	25	12	79
2003	45	32	23	8	51

Table 5. Replacement parts for the Deere MaxEmerge planter row units tested in 2002 and 2003 to achieve satisfactory seed spacing performance.

	Deere MaxEmerge Planter Row Units Requiring Specific Replacement Parts (% of total MaxEmerge planter rows tested per year)	
Replacement Part	2002	2003
One or more parts	71	86
Meter shaft bearings	5	4
Door seals	57	74
Center seal	39	68
Brush holder	5	6
Brush	39	59
Knockout wheel assembly	9	40
Meter door	5	4
Meter body	0	2
Seed plate	20	6
Seed drop tube	30	26
Drive coupling	11	13

Seed spacing accuracy of individual planter rows after inspection/repair was statistically higher than the seed spacing accuracy before inspection/repair (Table 6). Averaged over all planters within a year with both before and after inspection/repair data, the difference in seed spacing accuracy was very similar each year. The difference of nearly 10% CP3 represents a substantial difference in seed spacing accuracy, noticeable visually on a conventional grease belt, and indicates that inspection, repair, and testing of the seed meters and seed drop tubes of sugarbeet planters made a difference in planter performance.

Table 6. Seed spacing accuracy of Deere MaxEmerge planter row units before inspection/repair and after inspection/repair for 2002 and 2003.

Year	No. of Planter Row Units Tested	Seed Spacing Accuracy of All Planter Rows Tested (CP3, %)* Before Inspection/Repair	After Inspection/Repair
2002	402	60.3	70.3
2003	544	60.1	71.9

*Seed spacing accuracy was statistically different ($p<0.001$) between before inspection/repair and after inspection/repair within each year.

To examine the effect of 'worn' planter seed drop tubes on seed spacing accuracy, the data sets for each year were sorted by planter model. The rows of the Deere MaxEmerge planter were further designated as having the seed tube changed or not changed. There were more planters each year that did not have the seed tubes changed than those that had the seed tube changed.

The group that did not have the seed tube changed was reduced in number of rows by pairing planters in each group by test site location and by the number of row units per planter. This resulted in 142 rows and 128 rows of matching planters that had the seed tube changed and did not have the seed tube changed in 2002 and 2003, respectively. The data set was analyzed within a year as a two factor, completely random experimental design with the before and after inspection/repair factor split on the completely random factor of changed seed tube and not changed seed tube. Main effects results are shown in Table 7. When averaged over before and after inspection/repair, there was no statistical difference (and very little numerical difference) in seed spacing accuracy of planter rows that had the seed tube replaced and those units which did not have the seed tube replaced. This implies that these two sets of planter row units were very similar. There was a statistical difference in the main effect of before and after inspection/repair. There was also a significant interaction between the two main effects.

Table 7. Summary of the analysis of the main effect of seed spacing accuracy before and after inspection/repair (averaged over row units which had the seed tubes changed and those not changed), and the main effect of whether the seed tube was changed or not (averaged over before and after inspection). All row units were Deere MaxEmerge models.

		Seed Spacing Accuracy (CP3, %)*			
		Main Effect of Before and After Inspection/Repair		Main Effect of Whether the Planter Row Had the Seed Tube Changed or Not	
Year	No. of Rows Tested	Before Inspection/Repair	After Inspection/Repair	Seed Tubes Not Changed	Seed Tubes Changed
2002	142	59.1	72.3	65.1	66.3
2003	128	58.7	74.5	66.7	66.6

*There was a statistical difference ($p<0.001$) between treatments within the main effect of before and after inspection/repair within each year. There was not a statistical difference ($p=0.05$) between treatments within the main effect of whether the seed tube had been changed or not within either year. There was a significant interaction of the two main effects.

The interaction of the main effects summarized in Table 7 was examined by separately analyzing the before and after seed spacing of the rows that had the seed tubes changed and those that did not (Table 8). The before and after seed spacing was statistically different in all cases but the magnitude of the difference was greater for those row units that had the seed tube changed. This suggests that replacing the worn seed tube had a greater influence on seed spacing performance than all the seed meter repairs combined.

Table 8. Seed spacing accuracy before and after inspection/repair for those Deere MaxEmerge row units that had the seed tube changed and those that did not have the seed tube changed, for 2002 and 2003. This is a subset of the data summarized in Table 7.

	Seed Spacing Accuracy (CP3, %)*			
	Planter Rows Which Had The Seed Tube Changed		Planter Rows Which Did Not Have The Seed Tube Changed	
Year	Before Inspection/Repair	After Inspection/Repair	Before Inspection/Repair	After Inspection/Repair
2002	55.1	75.0	63.1	69.6
2003	55.1	78.3	62.3	70.8

*There was a statistical difference ($p<0.001$) between before and after inspection/repair for planter rows which did have the seed tube changed, and between before and after inspection/repair for those planter rows which did not have the seed tube changed, for each year.

Summary

The University of Nebraska electronic planter test stand was used to evaluate the row units of 113 planters consisting of 1170 individual rows in a series of planter clinics in Nebraska, Colorado, Wyoming, and Montana in 2002 and 2003. Planter models included the Deere MaxEmerge, Deere 71 Flexi-planter, and the Case NH ASM. This planter test stand system provided numerical description of the seed spacing performance to compare seed spacing accuracy before and after inspection/repair of the planter row units brought to the clinics by sugarbeet producers. There was a statistically significant improvement (CP3 = 10%) in seed spacing accuracy by the inspection, repair, and testing process used by the planter clinics when averaged over all planters tested, each year. Nearly 30% of the Deere MaxEmerge row units tested required the seed drop tube be replaced to achieve acceptable seed spacing. When the data subset of Deere MaxEmerge row units which required the seed tube to be replaced was compared to the data subset of those row units which did not require seed tube replacement, it was found that worn seed tubes contributed more (CP3 = 20%) to inaccurate seed spacing than all of the meter replacement parts combined (CP3 = 8%).

Literature Cited

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