An Attempt to Improve Uniformity of a Gaspardo Precision Seeder

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ADDITIONAL INDEX WORDS. seeder, planter, precision seeding, vacuum seeder, seeding uniformity

SUMMARY. Prior studies have demonstrated that a Gaspardo vacuum seeder provides less uniform seed spacing than a Stanhay belt seeder. It was hypothesized that the difference was primarily because of the greater seed drop height on the Gaspardo seeder. A Gaspardo metering unit was modified by adding a slide or an enclosed tube to guide the seeds from the release point (seed plate) to 1.0 inch (25 mm) above the bottom of the seed furrow. Seed uniformity tests were conducted with cabbage (*Brassica oleracea*), onion (*Allium cepa*) , and mustard (*Brassica juncea*) seeds. The modified planter unit was compared with an unmodified unit. No improvement in seeding uniformity was noted with either the slide or the tube. In fact, seed placement uniformity was degraded with the addition of the slide and tube. Although it is probable that the seed spacing nonuniformity was caused by drop height, attempts to control the seed trajectory were unsuccessful.

Precision seeders are often used for direct-seeding small-seeded vegetable crops. The authors have conducted a series of studies of belt-type and vacuum-type precision vegetable seeders. In the first study, Parish et al. (1991) found that a Stanhay belt seeder (Hestair Farm Equipment, Suffolk, England) spaced spherical seed (cabbage) more uniformly than a Gaspardo vacuum seeder (Gaspardo, Pordenone, Italy), and the Gaspardo seeder gave better uniformity than the Stanhay with nonspherical seeds [cucumber (*Cucumis sativus*)]. Bracy and Parish (1998) used the methods of Kachman and Smith (1995) to reanalyze the data from Parish et al. (1991) and found the Stanhay seeder to be more precise with spherical or nearly spherical seeds than was the Gaspardo. Parish and Bracy (1998) reported that precision of seed spacing with turnip (*Brassica rapa*) was better with a Stanhay seeder than with a Gaspardo seeder. Bracy and Parish (1999, 2001) compared precision vegetable seeders with typical agronomic seeders and found that the Stanhay belt seeder had the best uniformity. The Gaspardo vacuum seeder had seeding uniformity equivalent to a John Deere agronomic seeder (Deere and Company, Moline, Ill.).

Bracy et al. (1999) evaluated the seeding uniformity of a Stanhay belt seeder and a Gaspardo vacuum seeder at different nominal seed spacings. They found that seeding uniformity of the Stanhay seeder was better than that of the Gaspardo seeder. They also found that seeding uniformity of the Stanhay seeder was not affected by nominal seed spacing, but seeding uniformity of the Gaspardo seeder was affected by nominal seed spacing. The greater the nominal seed spacing with the Gaspardo, the better the uniformity. The nonuniformity at different spacings decreased percentage-wise with greater nominal seed spacing. Based on these findings, they hypothesized that the greater seed drop height of the Gaspardo was responsible for much of the nonuniformity with that seeder since basic singulation of seeds by the metering plate appeared to be very uniform. The Gaspardo seeder releases seeds from the metering plate about 7 inches (17.8 cm) above the bottom of the seed furrow, and the Stanhay seeder releases seeds from the metering belt less than 1 inch (2.5 cm) above the bottom of the seed furrow. As seeds free-fall after release from the metering mechanism, they can take many trajectories; some will fall straight down, others will fall forward or backward, others may bounce along the walls of the drop zone and opener. This variability in trajectory introduces variability in seed spacing when the seeds finally reach the bottom of the seed furrow.

There is support in the literature for this theory. Wanjura and Hudspeth (1969) found that a 3-inch (7.6-cm) seed drop height consistently produced a better seed pattern than a 6-inch (15.2-cm) drop height with a cotton (*Gossypium hirsutum*) vacuum seeder. They recommended that the metering device on a planter should be located as low as practical, and seed should fall freely to the bottom of the soil trench.

Breece et al. (1981) stated that irregular seed placement in the row is often blamed on the seed metering mechanism when it is actually caused by the seed placement mechanism. They also speculated that the effect of seed bounce in a seed tube caused what appears to be skips and doubles, since the bouncing of seeds while falling through the seed tubes can cause seeds to be displaced by as much as a full normal seed spacing increment.

The objective of this study was to modify a Gaspardo seeder by adding a sloping slide or a tube into the seed drop zone and opener to try to guide the released seeds down a common trajectory or path and thus reduce variability in spacing in the furrow.

Materials and methods

A Gaspardo model SV255 vacuum seeder was modified first by adding a diagonal slide with a V-shaped cross section to the seed drop tube and opener as shown in Fig. 1. The end of the slide was about 1.0 inch (25.4 mm) from the bottom of the furrow. The second modification tested was a seed drop tube (Fig. 2.). This tube directed the seeds from within 0.25 inch (6.35 mm) of the release point from the metering plate and guided them down to about 1.0 inch from the bottom of the seed furrow (simulated by a greased board in this study). This provided a uniform trajectory to within 1.0 inch of the bottom of the furrow (or greased board). The tube had an internal diameter of 0.25 inch. The third treatment was the standard, nonmodified seeder that dropped the seeds from a height of 7.0 inches. One unit of the Gaspardo seeder was tested with and without these modifications.

The seeder was mounted on a tractor and tested using the method described by Parish et al. (1991). The seeder was operated at 1.5 miles/h (2.4 km·h^{-1}) over a greased board 20 ft (6.1 m) long. Seeds falling on the board could not bounce because they were trapped in the grease; therefore, the

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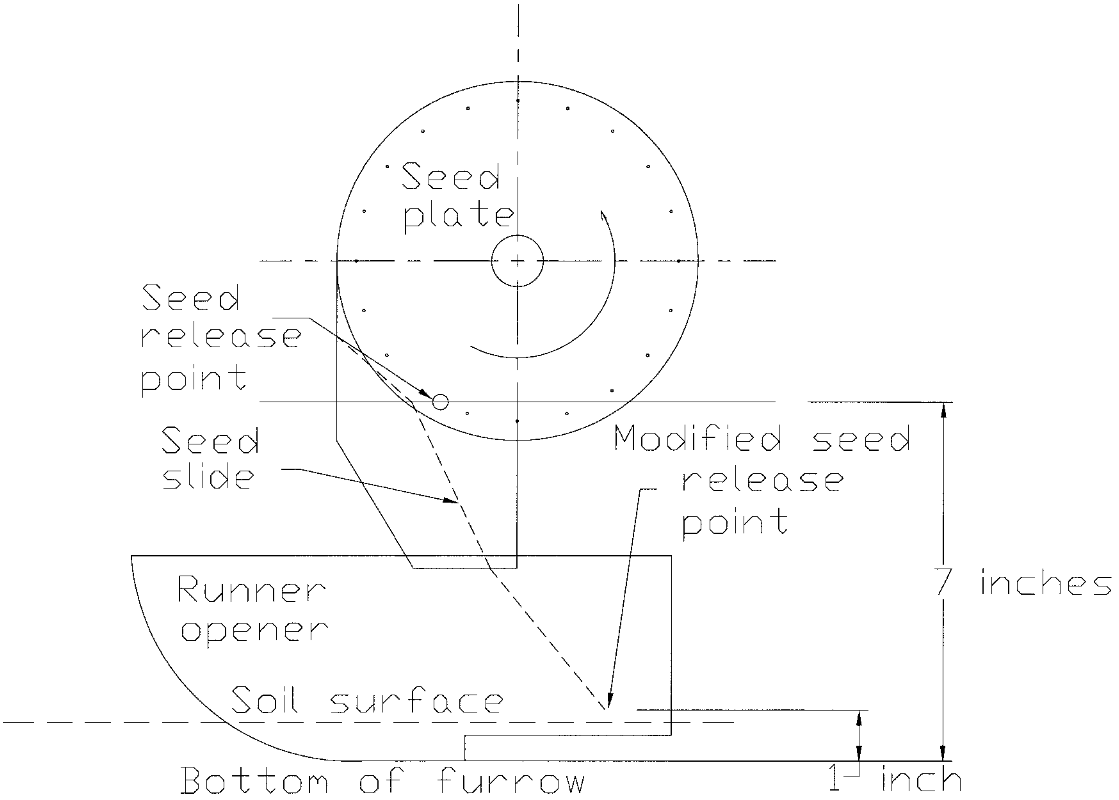

Fig. 1. Diagram of seeder unit showing the location of the prototype seed slide. The slide received the seed immediately after it was released from the seed plate and guided it down within about 1 inch of the bottom of the seed furrow (1 inch = 25.4 mm).

seed spacing could be measured reliably. The greased board was placed at the approximate location of the bottom of the seed furrow. Seed spacing measurements were recorded over a distance of 10 ft (3.0 m). Six replications were made with the standard seeder and with each modification to the standard seeder. Cabbage, onion, and mustard were tested with each drop apparatus.

Multiple index (MULT), miss index (MISS), quality of feed index (QFI), and precision (PREC) were calculated using the method described by Kachman and Smith (1995), which is based on an International Organization for Standardization (ISO) standard (ISO, 1984). MULT is the percentage of spacings that were less than or equal to half of the theoretical spacing and indicates the percentage of multiple seed drops. MISS is the percentage of spacings more than 1.5 times the theoretical spacing and indicates the percentage of missed seed locations or skips. QFI is the percentage of spacings that were more than half but no more than 1.5 times the theoretical spacing. QFI is 100% minus MISS and MULT and indicates the percentage of single seed drops. PREC is the coefficient of variation of the spacings that are classified as singles after omitting the outliers, consisting of misses and multiples. PREC is much smaller than sample coefficient of variation (CV) and is a measure of the uniformity of spacings classified as singles. MISS, MULT, and QFI are measures of singulation or lack thereof. The mean spacing (MEAN) and CV are composite measures that reflect both singulation and variation in spacing.

Kachman and Smith (1995) recommended using MISS, MULT, QFI, and PREC for summarizing the uniformity of seeder metering rather than MEAN and CV. They concluded that several measures are needed to give a true picture of seeder uniformity. For the current work, all six measures are reported, but PREC is the measure of most importance, since PREC reflects variability in seed spacing on the ground after singulation.

MISS, MULT, QFI, and PREC were analyzed using the GLM statistical procedure (SAS, 1995). MEAN was calculated using PROC MEAN procedure (SAS, 1995).

Results

Seed spacing uniformity data for all of the tests are shown in Table 1. Neither the slide nor the tube improved seed spacing uniformity; in fact, in most cases seed uniformity was degraded by the slide or tube. There were significant differences in most of the parameters evaluated, although in no case was the seed spacing uniformity good. All of the PREC results (the most important factor in this study) were very poor in all cases. A PREC value of 10% is desirable. The metering efficacy of the seeder unit was visually monitored, and very few misses or doubles were observed on the seed plates during the tests, so the nonuniformity was caused by seed placement, not seed metering.

Conclusions

Addition of a seed slide or a seed tube to guide the seeds from the release point down to the seed furrow was not effective at improving seed spacing uniformity. Although it is probable that the poor seed spacing uniformity was caused by the height of the seed release point above the furrow, neither the slide nor the tube improved the seed spacing uniformity. Regardless of studies (Wanjura and Hudspeth, 1969; Breece, et al., 1981) that indicated seed fall distance af-

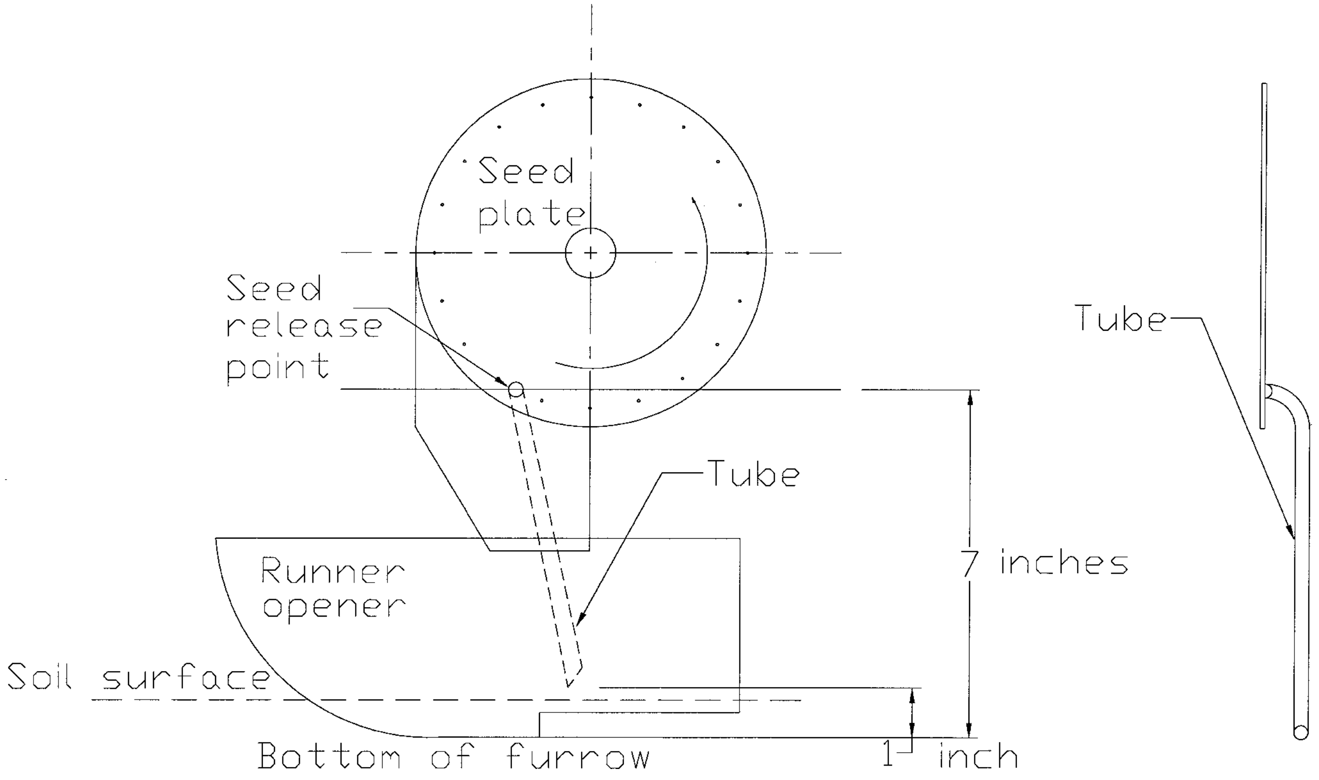

Fig. 2. Diagram of seeder unit showing the location of the prototype seed tube. The tube received the seed immediately upon release from the seed plate and guided it down within about 1 inch of the bottom of the seed furrow (1 inch = 25.4 mm).

Table 1. Uniformity of seed spacing from tests with modified and unmodified Gaspardo seeder.

	Spacing [inches (mm)]		Performance parameter (%)				
Crop	Nominal	Mean	CV[z]	MISS[y]	MULT[x]	QFI[w]	PREC[v]
Cabbage							
Standard	3.0 (76)	3.15 (80)	56.8 b[u]	21.0	19.2 b	59.8 a	22.9 b
Slide[t]	3.0 (76)	3.02 (77)	66.6 ab	21.7	30.1 a	48.2 ab	29.6 a
Tube[s]	3.0 (76)	3.26 (83)	73.1 a	29.9	29.5 a	40.6 b	30.0 a
Significance		NS	*	NS	*	*	**
Onion							
Standard	3.0 (76)	3.20 (81) a	58.4 b	22.6 a	18.7 c	58.7 a	21.9 c
Slide	3.0 (76)	2.82 (72) b	61.1 b	16.2 b	27.5 b	56.3 ab	25.7 b
Tube	3.0 (76)	2.49 (63) c	79.1 a	14.0 b	37.7 a	48.3 b	29.1 a
Significance	**	**	**	**	*	**	
Mustard							
Standard	2.0 (51)	1.99 (51)	46.5 b	10.8 b	12.9 b	76.3 a	23.2 b
Modified	2.0 (51)	2.00 (51)	54.9 b	14.9 b	19.2 b	66.0 b	25.2 b
Tube	2.0 (51)	2.04 (52)	78.3 a	21.4 a	33.5 a	45.1 c	27.5 a
Significance	NS	**	**	**	**	**	*

[z] CV = coefficient of variation.

[y] MISS = the percentage of spacings more than 1.5 times the theoretical spacing and indicates the percentage of missed seed locations or skips.

[x] MULT = the percentage of spacings that were less than or equal to half of the theoretical spacing and indicates the percentage of multiple seed drops.

[w] QFI = the percentage of spacings that were more than half but no more than 1.5 times the theoretical spacing, and indicates the percentage of single seed drops. QFI = 100% – (MISS + MULT).

[v] PREC = the coefficient of variation of the spacings that are classified as singles after omitting the outliers, consisting of misses and multiples. PREC is much smaller than sample CV and is a measure of the uniformity of spacings classified as singles.

[u] Numbers in each grouping followed by the same letter are not significantly different a the 0.95 level, Duncan's multiple range test.

[t] Slide refers to prototype with open slide to guide seed to ground (Fig. 1).

[s] Tube refers to prototype with enclosed tube to guide seed to ground (Fig. 2).

[NS,*,**] Nonsignificant or significant at $P = 0.95$ or 0.99, respectively.

fected uniformity, the modifications made in this experiment were not effective at improving uniformity. The nonuniformity observed in the slide and tube treatments was likely caused by continuing seed bounce on the slide or within the tube; in other words, the desired uniform seed trajectory was not obtained.

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