A Comparison of Seeding Uniformity of Agronomic and Vegetable Seeders

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Summary. **Manufacturers of certain vegetable seeders have promoted their products as precision seeders and implied that their products are more accurate at seeding uniformity than typical agronomic seeders. A comparison of the seeding uniformity of several vegetable seeders and agronomic seeders was made to evaluate this assumption. Two vegetable seeders and two agronomic seeders were evaluated for seeding uniformity and precision using soybean seed. The Stanhay S870 (belt-type) vegetable seeder had the best seeding uniformity and precision spacing of all the seeders tested. The Gaspardo SV255 (vacuum) vegetable seeder and the John Deere 7200 MaxEmerge (fingermeter) agronomic seeder were comparable in seeding uniformity and precision, although fewer skips were noted with the John Deere. The Great Plains 8030 (brushmeter) agronomic seeder had a large number of skips and multiples and poor seeding precision.**

An important feature of a precision seeder's performance is its ability to place seeds singularly a given distance apart. Recent studies evaluating seeding uniformity of vacuum and belt vegetable seeders (Bracy and Parish, 1998; Parish and Bracy, 1998) detected inconsistencies in the metering uniformity of vegetable seeders previously assumed to be very uniform (Parish et al., 1991). Bracy and Parish (1998) determined a belt seeder was as effective at singulating spherical seeds [cabbage (*Brassica oleracea* var. *capitata*)] and nearly spherical seeds [onion (*Allium cepa* var. cepa)] as the most precise vacuum seeder, but seeding uniformity of all seeders with elongated [carrot (*Daucus carota*) and cucumber (*Cucumis sativus*)] or angular [spinach (*Spinacia oleracea*)] seeds was inadequate for precision seeding. The belt seeder was also more effective than the vacuum seeders at spacing the seeds uniformly within the target area when outliers (missed and multiple seed drops) were removed.

Parish and Bracy (1998) assessed the uniformity of metering size-graded and ungraded turnip (*Brassica rapa* var. *rapifera*) seeds with belt and vacuum vegetable seeders. They concluded that neither the belt nor the vacuum seeder gave the singulation and uniformity a grower would expect from a precision seeder.

Wanjura and Hudspeth (1969) found that a 3-inch (8-mm) seed drop height consistently produced a better seed pattern than a 6-inch (15-mm) 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 but is really poor seed-to-seed spacing.

Kachman and Smith (1995) compared alternative measures of accuracy in seed placement for planters and, based on the theoretical seed spacing, recommended using four measures for evaluating seeding uniformity. Their recommended measures (based on a seeder standard issued by the International Organization for Standardization, 1984) included multiple index, miss index, quality of feed index, and precision. Multiple index (MULT) indicated multiple seed drops and was the percentage of seed spacings that were less than or equal to one-half of the theoretical seed spacing. Miss index (MISS) indicated missed seed locations or skips and was the percentage of spacings greater than 1.5 times the theoretical spacing. Quality of feed index (QFI) indicated single seed drops and was the percentage of spacings that were more than half but no more than 1.5 times the theoretical spacing. QFI was an alternative way of presenting the information contained in MISS and MULT. Precision (PREC) was the coefficient of variation of the spacings after omitting the missed and multiple seed drops (outliers). PREC was a measure of the uniformity of spacings classified as singles, whereas MULT, MISS, and QFI were measures of singulation or lack thereof. A more complete discussion of these terms and examples of calculations was given by Kachman and Smith (1995).

Although the mean (MEAN) and coefficient of variation (CV) have been used in research publications to describe spacing uniformity (Hudspeth and Wanjura, 1970; Parish, 1972; Parish et al., 1991; Wilkins et al., 1992), Kachman and Smith (1995) judged MEAN and CV as inappropriate measures of seeder accuracy. MEAN does not reflect variation in spacing, and CV does not identify the types of nonuniformity (e.g., misses, multiples, or nonuniform basic spacing).

Materials and methods

Spacing measurements of soybean (*Glycine max*) seed from two precision-drill vegetable seeders [belt-type Stanhay model S870 (Hestair Farm Equipment, Suffolk, England) and vacuum-type Gaspardo SV255 (Gaspardo, Pordenone, Italy)] and two agronomic seeders [fingermeter John Deere 7200 MaxEmerge (John Deere, Moline, Ill.) and brushmeter Great Plain 8030 (Great Plains Manufacturing, Saline, Kans.)] were used in this study. The seeders were operated over a 20-ft (6-m) long greased board at a ground speed of 1.5 miles/h (2.4 km·h^{-1}), with seed spacing measurements recorded over a center distance of 10 ft (3 m). The ground speed was based on the manufacturer recommendations for vegetable seeders

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(to minimize skips that can result at higher plate or belt speeds). Although the ground speed was slower than typically used for most agronomic seeders, all seeders were operated at this speed for consistency in the testing procedure and to accommodate the accurate placement of the equipment over the greased board. The board was coated with grease to prevent seed from bouncing and to retain exact placement of the seed. All seeder operations were conducted in dry, fair weather conditions and usually on the same day.

Soybean seed was selected to evaluate the seeders due to its spherical (nearly round) shape and medium size. Better seeding uniformity is expected with spherical seeds (Bracy and Parish, 1998; Parish et al., 1991). Mean diameter of the soybean seed used in these experiments was 0.25 inches (6.4 mm). The agronomic seeders tested have metering components sized for agronomic crops such as corn, cotton, and soybean seeds and would not realistically meter small vegetable seeds.

Each seeder was operated at its smallest possible spacing for soybean seeds. Nominal spacing was based on the manufacturer's calibration for the Gaspardo, John Deere 7200 (JD), and Great Plains 8030 (GP) seeders. The Gaspardo, JD, and GP seeders were operated with theoretical spacings of 3.0 inches (76 mm), 3.8 inches (97 mm), and 1.0 inches (25 mm), respectively. A seed belt with 48 holes, 22/64 inches (8.7 mm) in diameter, was used in the Stanhay seeder to obtain theoretical spacing of 1.9 inches (48 mm). Six replications of seed spacing measurements were recorded for each seeder.

All data for seed spacings were analyzed using the methods (MULT, MISS, QFI, and PREC) described by Kachman and Smith (1995). Acceptable QFI values were established at 85% or greater, indicating that 85 or more of every 100 drops were singulated seed. Researchers have demonstrated greater than 95% accuracy with agronomic planters, indicating the metering accuracy (ACCU) to be within 5% of the theoretical seeding population (Bateman, 1972; Halderson, 1983; Snyder and Hummel, 1985). ACCU, like MEAN, gives an indication of total seed metering but does not measure singulation. The Prairie Agricultural Machinery Institute (1984) indicated a QFI of 95%, or better, was considered to be excellent.

Kachman and Smith (1995) reported a practical upper limit of 29% for the value of PREC, since a 29% value would be obtained with any random scattering of seeds within the target range. An acceptable PREC for seed measurements taken in the lab should fall below 10%, which would mean that the standard deviation of spacings within the target region would be 10% or less of the theoretical spacing.

Although not considered a valid measure of uniformity by Kachman and Smith (1995), MEAN is the only measure that a grower can readily obtain to determine seeder performance. MEAN was included to illustrate fallibility of the typical seeder calibration checks (catching the seed while the drive tire is rotated) used by growers for determining seeding uniformity of the seeder.

Data were analyzed using the GLM statistical procedure (SAS, 1995). MEAN was calculated using the PROC MEAN procedure (SAS, 1995).

Results and discussion

Means for Stanhay, Gaspardo, and GP seeders were very close to the theoretical spacing (Table 1). The mean for the JD seeder was within 80% of the theoretical spacing. The mean, however, was not indicative of the uniformity and precision of the seeders.

Skips (MISS) were lowest with the Stanhay vegetable seeder. The Stanhay seeder also had the lowest MULT value of all the seeders, with only 5% of the drops being multiple seeds. QFI was greater with the Stanhay than the other seeders as 90% of the drops with the Stanhay were single seed. Although the greatest PREC occurred with the Stanhay seeder (22%), PREC was not considered acceptable for any seeder tested.

The Gaspardo vegetable seeder had greater MISS than either the Stanhay or JD seeder. Multiple seed drop (MULT) was lower with the Gaspardo than with the agronomic seeders but almost five times greater than with the Stanhay. Mediocre seed singulation occurred with the Gaspardo, but the QFI was similar to that of the JD seeder. Precision within the target range (PREC) was unacceptable with the Gaspardo and did not differ significantly from that of the agronomic seeders.

MISS with the JD was significantly smaller than with the Gaspardo and GP seeders. Although MISS with the JD was nominal (8%), this was still twice the amount of skips with the Stanhay. Multiple seed drop (MULT) with the JD was less than with the GP but greater than with the Gaspardo. The JD had almost six times more multiple seed drops than with the Stanhay. This high MULT value is the reason the mean [3.1 inches (79 mm)] reflects a smaller seed spacing than indicated in the theoretical seed spacing [3.8 inches (97 mm)]. Seed singulation (QFI) and PREC with the JD were poor and similar to those recorded with the Gaspardo seeder.

The GP seeder had greater MISS and MULT values than any of the seeders tested. The mean seed spacing is identical to the theoretical spacing and does not reflect the nonuniformity of MISS and MULT. Seed singulation (QFI) with this seeder was

Table 1. Seeding uniformity of selected agronomic and vegetable seeders using soybean seeds.

Seeder	Theoretical spacing inches (mm)[y]	Measure[z]				
		MEAN inches (mm)	MISS (%)	MULT (%)	QFI (%)	PREC (%)
Stanhay	1.9 (48)	1.8 (46)	4 a[x]	5 a	90 a	22 a
Gaspardo	3.0 (76)	2.8 (71)	14 c	23 b	62 b	28 b
John Deere	3.8 (97)	3.1 (79)	8 b	29 c	63 b	26 b
Great Plains	1.0 (25)	1.0 (25)	23 d	38 d	38 c	28 b

[z]MISS = missed seed locations (skips), MULT = multiple seed drops, QFI = quality of feed index (single seed drops), PREC = precision (variation of the spacings within target range).
[y]Smallest possible spacing for soybean seeds based on manufacturer's recommended setting.
[x]Means within a group followed by same letter are not significantly different at $P = 0.05$ by Duncan's multiple range test.

significantly less than with the other seeders. Precision was similar among the GP and JD agronomic seeders and the Gaspardo vegetable seeder.

Conclusion

The Stanhay vegetable seeder had the best seeding uniformity and precision spacing of all the seeders tested for spherical seeds. The Gaspardo vegetable seeder and the JD agronomic seeder were comparable in seeding uniformity and precision, although fewer skips were noted with the JD seeder. The GP agronomic seeder had a high number of skips and multiple seed drops and had poor seeding precision.

Parish and Bracy (1998) reported wide variation in seeding uniformity and precision among precision vegetable seeders. Results of this study indicated that variation occurred in the seeding uniformity of the two agronomic seeders tested. From this evaluation of agronomic and vegetable seeders using spherical seed, only the Stanhay vegetable seeder can be promoted as having seeding uniformity and precision greater than the agronomic seeders tested.

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