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Effect of Set up Parameters for a Dual Tine and Presswheel Seeding Module on Seed Placement and Germination

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Abstract: The objective of this study was to compare the effect of different types of furrow openers, seeding tine depth and seed discharge settings on seed placement and germination rates. This work was undertaken using a direct drill, Precision Seeding System (PSS), made in South Australia that consists of a front fertilizer tine and a rear (seed) tine fitted with presswheel, all made into a single module. The front tine was designed to work deeper than the seeding tine and uses a presswheel to press the soil over the seed. The Precision Seeding System (PSS) has multi setting options that allows fitting of different types of fertilizer and seed openers and presswheels, and allows use of a range of seed delivery tube and seeding tine settings. According to research results, for the combined dual tine and presswheel module, the fertilizer tine and height of seeding tine above presswheel significantly affected the measured parameters of lateral seed spread and position, vertical seed scatter and position. The lateral seed position and lateral seed scatter were found to be near the centre at no presswheel while using presswheel spread far from the centre. There was no difference, in final percentage of plants emerged, among the treatments but the shallow seed opener and seed boot position gave faster emergence than deeper seed opener and seed boot position.

Key words: Direct drill, seed placement, seedling emergence, narrow tine

INTRODUCTION

No-tillage practices that promote soil and water conservation and reduce input costs have become an increasingly accepted alternative to conventional tillage systems in South Australia.

This work examines a no-tillage drill, Precision Seeding System (PSS), made in South Australia that consists of a front fertilizer tine and a rear (seed) tine fitted with presswheel, all made into a single module. The front tine was designed to work deeper than the seed tine and uses a presswheel to press the soil over the seed. As a result, this design aims to increase water infiltration from rainfall, use sub-soil moisture reserves for earlier germination, reduce fertilizer toxicity effects, reduce weed germination by lower soil disturbance and hence improve plant growth.

The Precision Seedling System (PSS) has multi setting options such as different types of fertilizer and seeding openers and presswheels, a range of seeding tine and seeding boot discharge settings.

The objective of this study was to compare the effect of different types of furrow openers, seeding tine depth and seed discharge settings on soil profile, seed placement, fertilizer placement, separation of seed and fertilizer and seed germination rates.

MATERIALS and METHODS

Precision Seedling Systems

The Horwood Bagshaw company has designed and markets a Precision Seedling System module, which consists of the front (fertilizer) tine, parallelogram, the rear (seed) tine and the presswheel (Fig. 1).

The front (fertilizer) tine

The front tine of the module was designed to dig and place fertilizer deeper than the rear (seed) tine.

The fertilizer tine can be fitted with a range of soil openers. In this experiment a narrow (15 mm) and a wide inverted T opener (65 mm) were compared (Fig. 2).

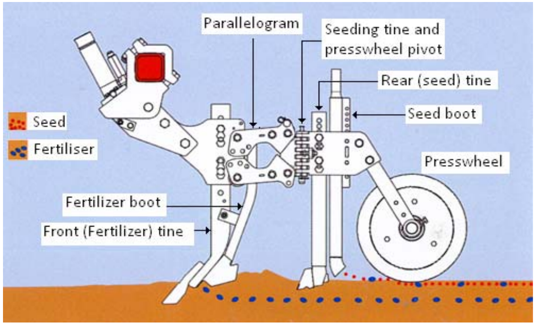
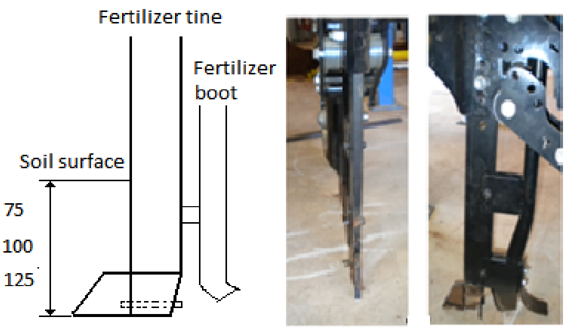
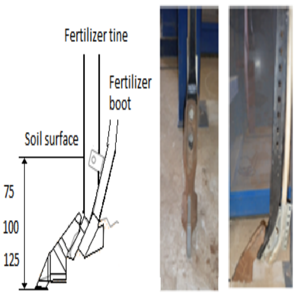


Figure 1. Precision Seedling Systems (PSS)



(a)



(b)

Figure 2. Two style of fertilizer tine narrow (a) and wide (b)

For the experiment the front tine was set to operate at depths of 75 mm, 100 mm and 125 below the original ground level.

The parallelogram

The parallelogram provides the rear seeding tine's ground-following; leading to more consistent seeding depth. Seed depth control leads to more accurate seed placement, which produces more even crop development.

The rear (seed) tine

The rear section of the module is fitted to, and pivots on, the rear section of the parallelogram. Generally, seed should be placed approximately 12 mm-37 mm below the soil surface. The setting of the seeding boot relative to the seeding tine point and presswheel controls the depth of seed placement. The rear tine was evaluated using a range of height settings of the seed boot, seed opener relative to the base of the presswheel to evaluate if it could achieve vertical separation with the seed and be above the fertilizer so as to separate the placement of the seed and fertilizer and hence minimize fertilizer toxicity.

The presswheel

The presswheel was designed to press the soil over the seeds and act as a depth setting mechanism for the sowing tine. In this experiment the presswheel used was of semi-pneumatic construction and 55 mm wedge design. A sketch of the presswheel profile is shown in Figure 3. It was selected as previous tests (Fielke et al., 2009) showed it to provide the fastest emergence. The presswheel had an outside diameter of 380 mm. The presswheel was set up for the experiment to run in-line with the seeding tine.

The Seed Placement Test Facility

This experiment was conducted using the University of South Australia's seed placement soil bin test facility. The indoor facility was developed to provide a controlled environment to evaluate seeder related factors influencing distribution and depth of seed in the soil.

Test carriage

The test carriage had a length of 4.7 m and a width of 1.3 m. With a weight of 1 tonne, the test carriage can accelerate up to 16 km/h in 3.8 m prior to reaching the soil bin and stop in 2.0 m after leaving the soil bin. Two conveyor chains are used to drive the carriage back and forth. The seeding module was mounted in a height adjustable frame 1.1 m wide x 2.4 mm long. A sketch of the equipment is shown in Figure 4.

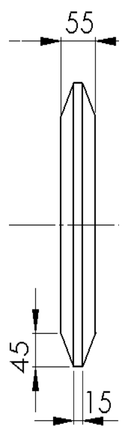


Figure 3. Wedge 55 mm presswheel profiles

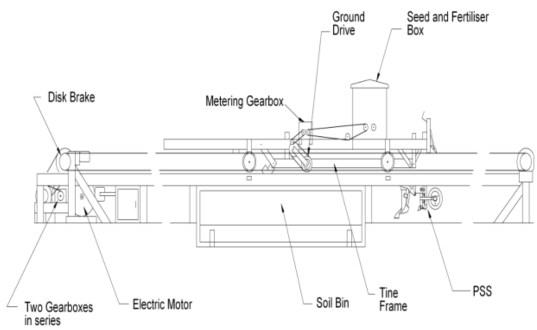


Figure 4. Soil bin seed placement test rig.

Soil bins

The soil was composed of 16.10% clay, 11.80% silt and 72.10% sand. It was classified as a sandy-loam soil (Klute et al., 1986). Soil moisture of 10.5% at the time of sowing was used. The average bulk density for the depth of 0 to 100 mm was 1.4 g/cm^3. Average soil penetration resistance was 1.4 MPa in the depth range of 0–50 mm, 1.5 MPa in the depth range of 50–100 mm, 1.6 MPa in the depth range of 100–150 mm.

The facility holds four soil bins. Each soil bin is 1.5 m wide and 3 m long and can be indexed and locked into place beneath the test carriage rails. The central 2 m length of the bin (steady state seeding) was used for seed and soil profile recording purposes. Removable plastic covers were fitted to the soil bins to provide an enclosed environment that conserves the moisture in the soil and provided protection from vermin.

Seed locations and soil profile development

The system developed at the University of South Australia uses a manual excavation method to find the seed (Fig. 5). The soil was excavated after germination was completed by spoon and the location of each of the the seeds recorded. A three dimensional digitizer with a moveable pointer within a fixed reference frame was used to record the individual seed locations and soil profile. The measuring frame made of aluminum was constructed to locate accurately on the test carriage rails to provide an accurate and repeatable measurement reference

Figure 5. Seed locations and soil profile measuring system

Methods

Experimental design

Each soil bin was partitioned into two blocks along the length of the bin. Each block was 2 m long by 750 mm wide and contained one row of seeding. For the experiment, a total of 36 plots were arranged in a randomized complete block design. Three replications were undertaken. The experiment varied the fertilizer opener between a narrow and a wide inverted T opener. The experiment varied the seeding parameters (a and b shown in Figure 6) with the parameters used being the seeding opener position above the base of the presswheel, a=0 and 30 mm; and the height of the seed boot discharge above the tip of the seeding opener, b=10 mm and 70 mm. The speed of tillage for the all tests was 8 km/h. The working depth of the front fertilizer tine was 75mm, 100 mm and 125 mm (Figure 2). The seeding rate along the row was set at 100 seeds/m.

Analysis of variance was determined using the MSTAT statistical package to examine the effects of treatments. Duncan's multiple range tests were used to identify significantly different means within dependent variables at $P \leq 0.05$.

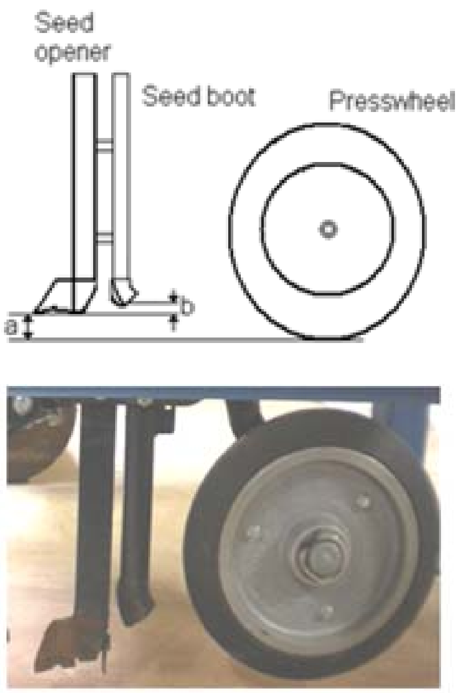


Figure 6. Position of seed opener, seed boot and presswheel

Determining Soil Profile, Seed and Fertilizer Location

The performance of the seeding module for its various settings was compared in terms of furrow profile, seed and fertilizer location, as shown in Figure 7.

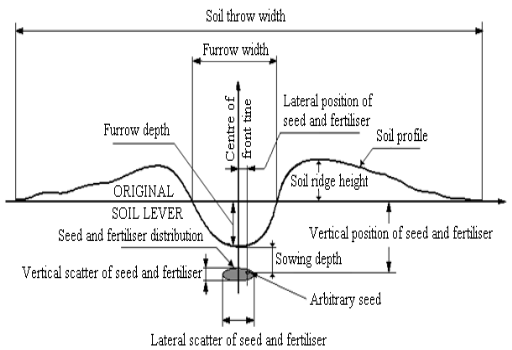


Figure 7. Definition of measurements and dimensions referred to in seed and fertilizer placement analysis

Mean emergence dates and percentage of emergence

Seedling counts were made in 2 m of row per treatment every day during the emergence period. From these counts the mean emergence time (MET) and percentage of emerged seedlings (PES) were calculated using Equations 1 and 2, respectively (Bilbro and Wanjura, 1982).

$$MET = \frac{N_1D_1 + N_2D_2 + \cdots ... + N_nD_n}{N_1 + N_2 + \cdots ... + N_n} \qquad (1)$$

$$PES = \left(\frac{TES}{n}\right)x100 \qquad (2)$$

Where $N_1, . . ., n$ is the number of seedlings emerging since the time of previous count; $D_1, . . ., n$ is the number of days after sowing; TES is the number of total emerged seedlings per meter; n is the number of seeds sown per meter.

3. RESULTS and DISCUSSION

The results showed many significant effects from the parameters investigated with a complex range of interactions. The average of the 3 replications of the furrow profiles is shown in Figures 8 along with the location of all of the seeds from the 3 replications.

Effect of seeding unit on soil profile parameters

The analysis of variance showed that there were significant differences in lateral seed scatter associated with the type of opener, seeding depth and seed boot discharging (Tables 1, 2 3).

The lateral seed position had a significant statistical effect from seed boot discharging height but not from the type of opener and seeding depth. The interactions between the parameters were not important. The type of opener indicated a non-significant effect on the vertical seed scatter and position, but seeding depth and seed boot discharging had a significant statistical effect on vertical seed scatter and position. The seed lateral position and lateral seed scatter were found to be near the centre at the narrow tine while the wide tine spread far from the centre. The vertical seed position, lateral seed scatter were found to be near the centered at the narrow tine while the wide tine broadcasted far from the centre.

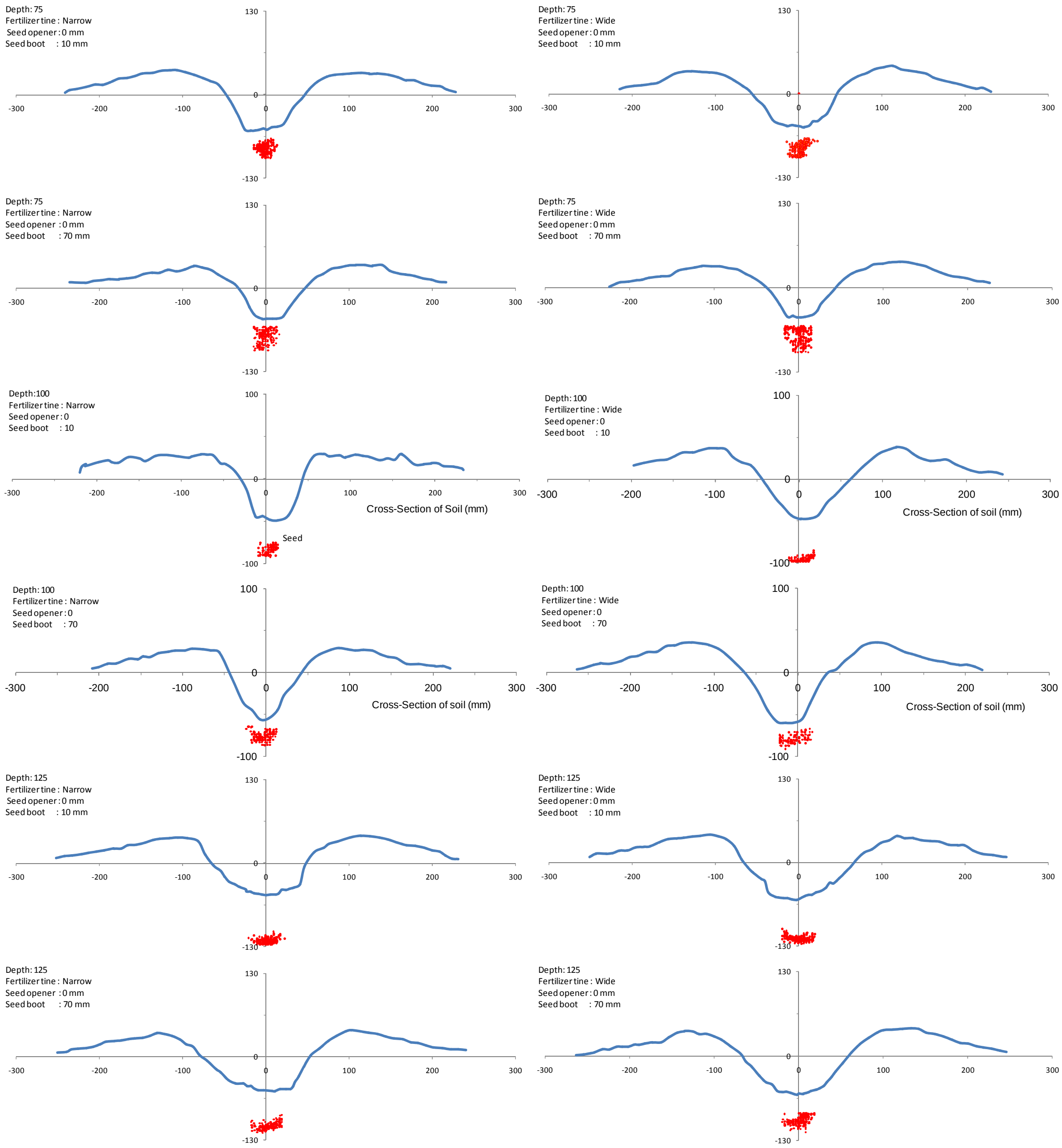


Figure 8. Effect of seeding unit on soil profile and seed placement

Table 1. Effect of seeding depth on seed placement parameters

	75 mm	100 mm	125 mm	$S_{\bar{x}}$	F_{cal}
Seed placement parameters					
Mean lateral seed position (mm)	0.3	0.8	1.8	----	0.97^{ns}
Mean vertical seed position (mm)	79^{b}	83^{b}	11^{a}	1.348	175.01**
Lateral seed scatter (mm)	28^{b}	32^{a}	33^{a}	0.826	10.08**
Vertical seed scatter (mm)	23^{a}	20^{b}	20^{b}	0.853	4.38*
Mean depth of sowing (mm)	28^{c}	32^{b}	59^{a}	0.736	521.37**

Unlike letters in column denote significant differences (P<0.05), * Significant (P<0.05), **Highly significant (P<0.01) and ns= non-sig
nificant

Significant differences were found among opener types in relation to their seed distribution patterns. Darmora and Pandey (1995) evaluated the performance of seven openers. Opener type had a significant effect on the depth of seed placement. In the case of shoe and shovel openers, placement was about 10 mm higher than the target depth of 40 mm under both soil conditions, whereas the observed depth was close to the target depth for the hoe openers. Narrow opener width (with flat lift wings where present), at lower rake angles, set to operate at shallower depths, and fitted onto narrow, forward leaning shank tines should be targeted for minimum soil throw (Desbiolles, 2003).

Table 2. Effect of opener on parameters of seed

Seed placement Parameters	Narrow	Wide	F_{cal}
Mean lateral seed position (mm)	1	1	0.87^{ns}
Mean vertical seed position (mm)	91	92	0.50^{ns}
Lateral seeds scatter (mm)	29	39	15.22**
Vertical seeds scatter (mm)	21	21	0.0001^{ns}
Mean depth of sowing (mm)	41	38	9.42**

* Significant (P<0.05), **Highly significant (P<0.01) and ^{ns}= non-significant

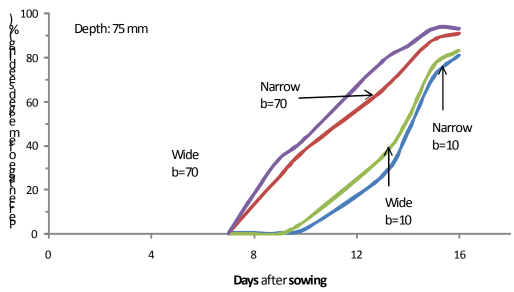
Table 3. Effect of seed boot discharging on seed placement parameters

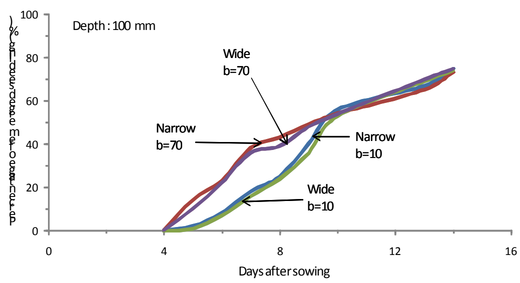
Seed placement parameters	Narrow	Wide	F_{cal}
Mean lateral seed position (mm)	2	0	7.25*
Mean vertical seed position (mm)	98	85	65.03**
Lateral seeds scatter (mm)	29	33	18.07**
Vertical seeds scatter (mm)	18	24	47.30**
Mean depth of sowing (mm)	46	33	219.78**

* Significant (P<0.05), **Highly significant (P<0.01) and ^{ns}= non-significant

Effect of seeding unit on emerged seedlings

There was no difference in final percentage of plants emerged, among the treatments but the seed boot position (b=70) which planted the seeds shallower gave faster emergence than the seed boot position (b=10). The deeper seed placement was seen to slow emergence. The depth of 75mm, 100 mm and 125 mm of the percentage of emergence is shown in Figure 9 for the travel speeds of 8 km/h. Collins and Fowler (1996) conducted effect of soil characteristics, seeding depth, operating speed, and opener design on draft force during direct seeding. Shallow seed placement is recommended for most crops that are direct seeded in western Canada. Deep seed placement delays emergence, results in weak spindly plants that are more susceptible to winter damage, delays crop maturity, and reduces yield potential. Iqbal et al. (1998) evaluated seed furrow smearing. Deeper seed placement probably slowed emergence and offset any effects of reduced compaction in the seed zone and less smearing of the furrow sidewall. Lower emergence rate values at greater moisture might be due to more smearing and poorer seed-to-soil contact. There were no significant differences, in final percentage of plants emerged, among the three coulter treatments or among soil moisture levels.





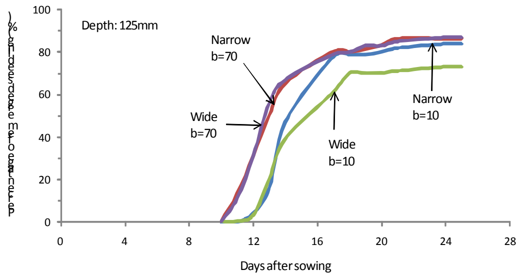


Figure 9. The effects of depth on emergence

CONCLUSIONS

According to research results, for the combined dual tine and presswheel module, the fertilizer tine and height of seeding tine above presswheel significantly affected the measured parameters of lateral seed spread and position, vertical seed scatter and position. The lateral seed position and lateral seed scatter were found to be near the centre at no presswheel while using presswheel spread far from the centre. There was no difference, in final percentage of plants emerged, among the treatments but the shallow seed opener and seed boot position gave faster emergence than deeper seed opener and seed boot position. Use narrow points to bring moisture up into a shallower seed zone and control moisture loss at seeding with minimal soil and stubble disturbance and reduced soil throw.

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