Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2018, 5(12):40-47**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Determination of Seed Boot Position for a Dual Tine and Presswheel Seeding Module on Soil Disturbance and Emerged Seedling

Yilmaz BAYHAN[1]*, John FIELKE[2]

[1]University of Namik Kemal, Department of Biosystems Engineering, Faculty of Agricultural, 59030-Tekirdag, Turkey
*Corresponding author: ybayhan@nku.edu.tr
[2]University of South Australia, Barbara Hardi Institute, School of Advanced Manufacturing and Mechanical Engineering, Mawson Lakes, 5095, South Australia

Abstract The objective of this study was to compare the narrow and wide types of furrow openers, seed discharge settings on seed placement and germination rates. This study 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, the depth of the furrow did not change with the different opener widths. As the depth of the leading tine increased the furrow and the soil throw became wider. As expected the seed boot discharge height had no significant effect on any of the furrow parameters as it had minimal physical interaction with the soil. 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.

Keywords Seed Boot, Presswheel, Soil

1. Introduction

No-till farming is a system which relies on placing seeds into undisturbed soil, where the furrow opener typically loosens a narrow slot of sufficient depth to obtain desired seed placement and soil coverage, with no other soil tillage operations. No-till seeding is often arbitrarily defined as a technique which must keep soil surface disturbance area below 50% [1,2], while the method of quantifying soil disturbance is often poorly described. Australian no-till farmers often use narrow point openers to create furrows for seed and fertilizer placement. However, operational speeds are limited due to excessive lateral soil throw reducing furrow backfill and causing interactions between adjacent furrows [2].

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 [3].

The aim of this study was to evaluate the effect of different types of furrow openers, and seed discharge settings on soil disturbance, seed position and seed germination.

2. Materyal and Methods

2.1. Description 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 (Figure-1).

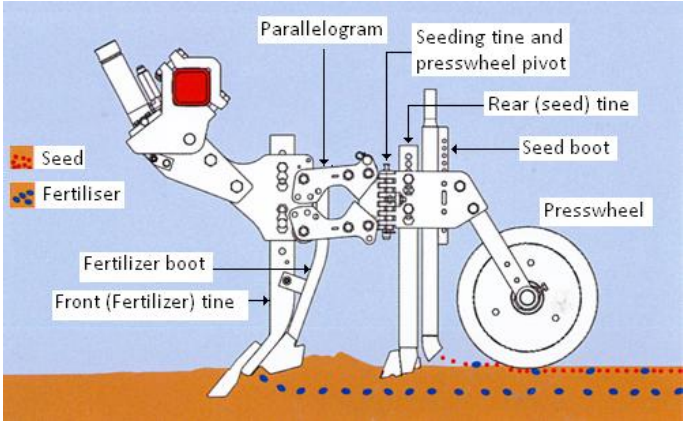
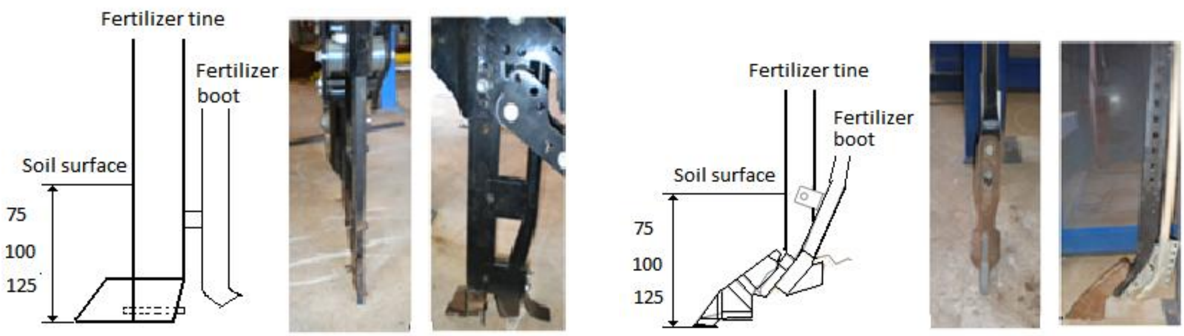


Figure 1: Precision Seedling Systems (PSS)

2.1.1. 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 (Figure-2). For the experiment the front tine was set to operate at depths of 75 mm, 100 mm and 125 below the original ground level [3].



a-Narrow tine b-Wide tine

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

2.1.2. The rear (seed) tine

The rear section of the parallelogram is fitted to, and pivots on, the front 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.

2.1.3. 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. It was selected as previous tests [4], showed it to provide the fastest emergence [3]. 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.

2.2. 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.

2.2.1. 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-3.

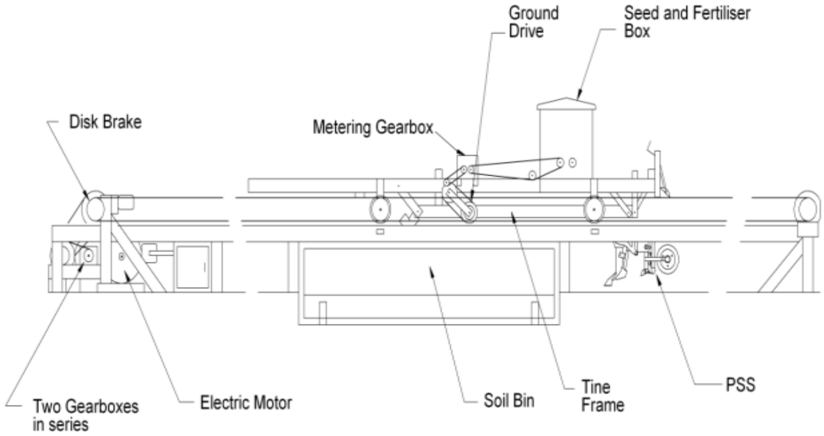


Figure 3: Soil bin seed placement test rig

2.2.2. 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 [5]. 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.

2.3. Seed locations and soil profile development

The system developed at the University of South Australia uses a manual excavation method to find the seed (Figure-4). 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 4: Seed locations and soil profile measuring system

2.4. 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. Seed and fertilizer location was defined as the average lateral seed, fertilizer position from the centre of the fertilizer tine, lateral seed, fertilizer spread, average vertical seed and fertilizer position from the original soil level and the vertical seed and fertilizer spread, as shown in Figure-5, [3].

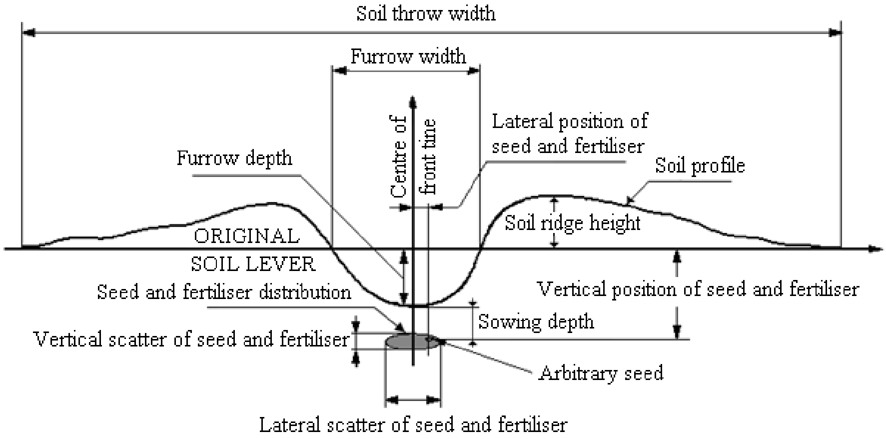


Figure 5: Definition of measurements and dimensions referred to in seed and fertilizer placement analysis [3]

2.5. 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 [6].

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

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

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.

2.6. 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 with two fertilizer tines, three seeding tine depths above base of presswheel, two height of seed discharge seeding tine and three replications. The experiment varied the fertilizer opener between a narrow and a wide inverted T. The experiment varied the seed boot position (a and b shown in Figure 6) with the parameters used being a=0 and 30 mm, b=10 mm and 70 mm (Figure-6). 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. The seeding rate along the row was set at 100 seeds/m.

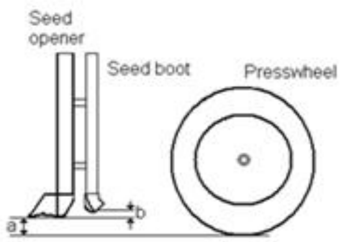


Figure 6: Position of seed opener, seed boot and presswheel

A randomized complete block design was selected for the experiment. Each treatment was replicated three times. Analysis of variance was determined using the MSTAT statistical package to examine the effects of treatments [7]. Duncan's multiple range tests were used to identify significantly different means within dependent variables at P≤ 0.05.

3. Result and Discussion

3.1. Effect of seeding unit on soil profile parameters

The average of the 3 replications of the furrow profiles produced by the seeding module is shown in Figures-7, along with the location of all of the seeds from the 3 replications. The analysis of variance (Tables-1-2) indicated that there were significant differences associated with the type of opener and seeding depth. The furrow with the wider leading tine was 14 mm wider, the ridge height 5 mm higher and the mean soil throw 19 mm wider. The depth of the furrow did not change with the different opener widths. As the depth of the leading tine increased the furrow and the soil throw became wider. As expected the seed boot discharge height had no significant effect on any of the furrow parameters as it had minimal physical interaction with the soil.

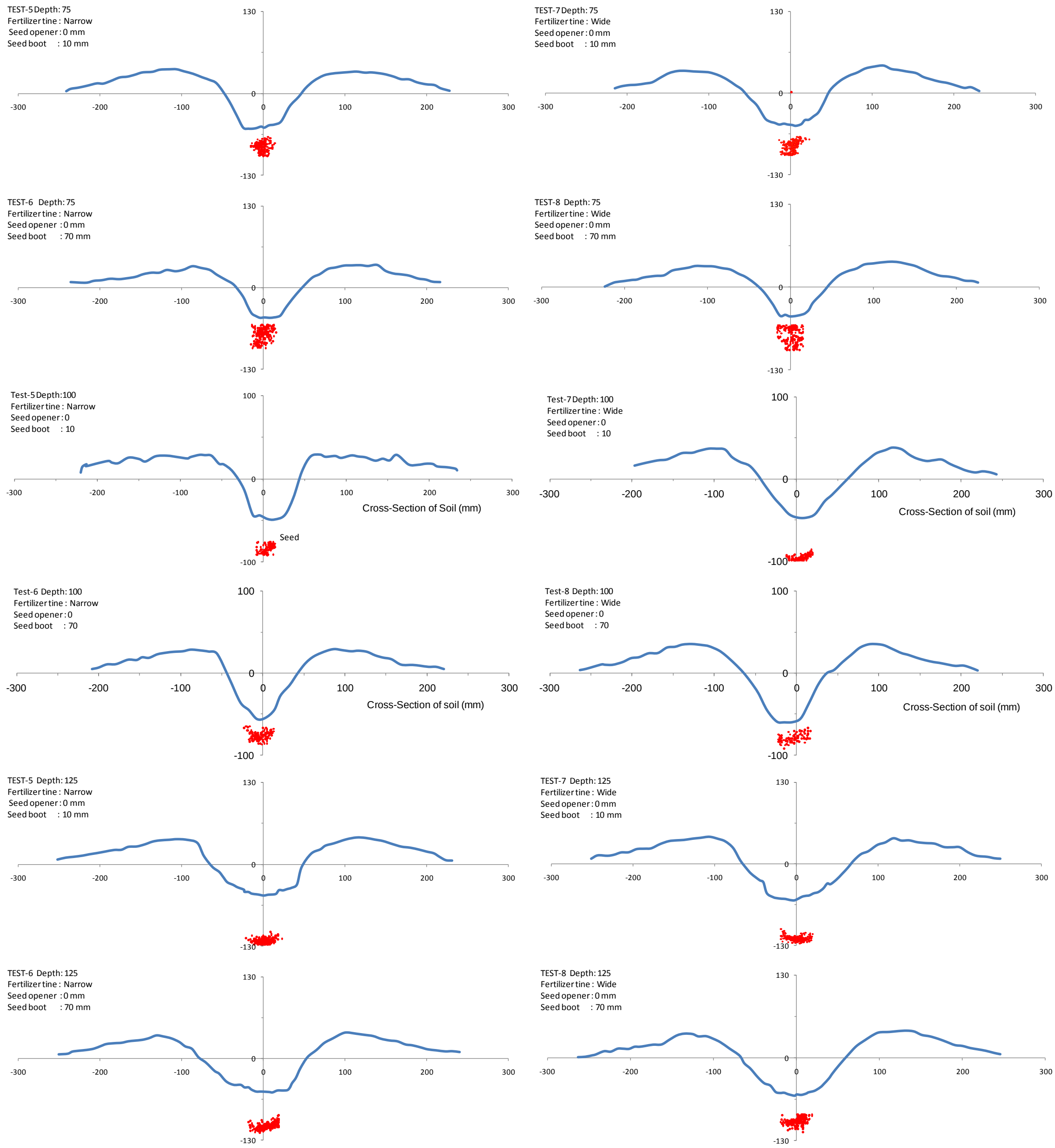


Figure 7: Effect of seeding unit on soil profile and seed placement [3].

Table 1: Effect of opener on parameters of soil throw parameters

Furrow parameters	Narrow	Wide	F_{cal}
Mean furrow width (mm)	95	109	56.29**
Mean furrow depth (mm)	54.6	55.3	0.33^{ns}
Mean soil ridge height (mm)	38	43	16.90**
Mean soil throw width (mm)	456	475	65.62**

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

Table 2: Effect of seed boot discharging on soil throw parameters

Furrow parameters	b=10	b=70	F_{cal}
Mean furrow width (mm)	103	101	1.24^{ns}
Mean furrow depth (mm)	54	56	0.87^{ns}
Mean soil ridge height (mm)	41	40	0.90^{ns}
Mean soil throw width (mm)	465	466	0.03^{ns}

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

3.2. Effect of seeding unit on seed placement parameters

The analysis of variance (Tables-3-4-5,) showed that there were significant differences in seed placement associated with the type of opener, seeding depth and seed boot discharge height. The variance analysis for all parameters was given Table-3.8. The lateral seed scatter was significantly wider for the wider fertiliser point and the narrower point placed the seeds slightly deeper. As the fertiliser tine was set deeper a deeper furrow resulted and the seeds were sown correspondingly further into the profile. A deeper fertiliser tine resulted in a greater depth of soil cover on the seeds. For example when lossening to 75mm the depth of cover over the seed was 28 mm but with a 50 mm increase in depth the depth of cover increased by 31 mm to 59 mm. As the discharge height of the seeds was increased by 50 mm the depth of seed placement reduced by only 13 mm. 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 [8].

Table 3: Effect of opener on parameters of seed

Seed placement Parameters	Narrow	Wide	
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 4: Effect of seed boot discharging on seed placement parameters

Seed placement parameters	b=10	b=70	
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

3.3. 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-8 for the travel speeds of 8 km/h. Iqbal et al. [9] 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. Narrow point openers often create high soil disturbance which generates the following issues: slow or inhibited crop establishment in seed rows subjected to excessive soil throw from adjacent openers increasing the depth of soil cover over seeds; associated contamination from preemergence herbicides leading to increased risks of crop damage [10,11], increased weed seed germination [12]; faster furrow moisture loss due to soil being spread outside of the furrow [13]; and changes in weed seed distribution in the soil profile [14,15,16,17].

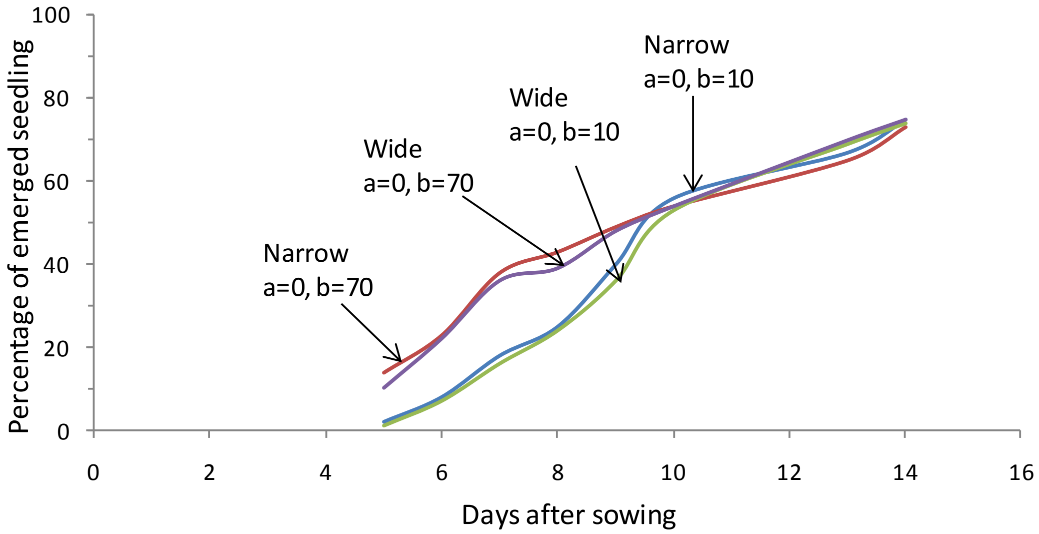


Figure 8: The effects of tests on emergence

4. Conclusion and Comments

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 furrow width, furrow depth, soil throw height, soil throw width, and seed spread and position, 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.

Acknowledgments

The corresponding author acknowledges the support of TÜBİTAK (The Scientific and Technological Research Council of Turkey) for providing financial support for this project.

References

[1]. Derpsch, R., Franzluebbers, A. J., Duiker, S. W., Reicosky, D. C., Koeller, K., Friedrich, T., et al., (2014). Why do we need to standardize no-tillage research? *Soil and Tillage Research*, 137, 16-22.

[2]. James, B. Barr, J.B., Desbiolles, J.M.A., Fielke, J.M., (2016). Minimising soil disturbance and reaction forces for high speed sowing using bentleg furrow openers. *Biosystems Engineering*, 151, 53-64.

[3]. Fielke, J., Bayhan, Y., (2011). Effect of set up parameters for a dual tine and presswheel seeding module on seed placement and germination. *Tarım Makinaları Bilimi Dergisi (Journal of Agricultural machinery Science)*, 7 (2), 191-197, İzmir-Turkey.

[4]. Fielke, J., Bayhan, Y., Saglam, C., (2009). Investigation of Furrow Profile, Seed Placement and Wheat Germination for a Combined Dual Tine and Presswheel Seeding Module. ISTRO 18th Triennial Conference, June 15-19, 2009 İzmir-Turkey.

[5]. Klute, A., Dinauer, R.C., Page, A.L., Miller, R.H., Keeney, D.R., (Eds.), (1986). Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods, Agronomy Monograph 9, American Society of Agronomy, Madison, pp. 1182.

[6]. Bilbro, J.D., Wanjura, D.F., (1982). Soil crusts and cotton emergence relationships. *Transaction of the ASAE*, 25 (6), 1484-1487.

[7]. Anonymous, (1988). MSTAT Microcomputer statistical programme. Michigan State University, East Lansing, MI, USA.

[8]. Desbiolles, J., (2003). Key aspects of the mechanics of tillage points. Proceedings of the 2003 GRDC and SAFF Farmer cropping Update, 26 August 2003, Naracoorte, SA. 4p.

[9]. Iqbal, M., Marley, S.J., Erbach, D.C., Kaspar, T.C., (1998). An evaluation of seed furrow smearing. *Transactions of the ASAE*, 41, 1243-1248.

[10]. Desbiolles, J., Saunders, C., (2006). Soil throw characteristics of no-till furrow openers: a pilot study. Paper presented at the Proceeding of the 17th triennial conference of the International Soil and Tillage Research Organization, Kiel, Germany, 28 Auge3 Sep.

[11]. Solhjou, A. A., Fielke, J. M., Desbiolles, J. M. A., (2012). Soil translocation by narrow openers with various rake angles. *Biosystems Engineering*, 112, 65-73.

[12]. Chauhan, B. S., Gill, G., Preston, C., (2006). Influence of tillage systems on vertical distribution, seeding recruitment and persistence of rigid ryegrass (Lolium rigidum) seed bank. *Weed Science*, 54, 669-676.

[13]. Chaudhuri, D., (2001). Performance evaluation of various types of furrow openers on seed drills e a review. *Journal of Agricultural Engineering Research*, 79, 125-137.

[14]. Chauhan, B. S., Gill, G., Preston, C., (2006). Influence of tillage systems on vertical distribution, seeding recruitment and persistence of rigid ryegrass (Lolium rigidum) seed bank. *Weed Science*, 54, 669-676.

[15]. Conn, J. S., (2006). Weed seed bank affected by tillage intensity for barley in Alaska. *Soil and Tillage Research*, 90, 156e161.

[16]. Mohler, C., Frisch, J. C., McCulloch, C. E., (2006). Vertical movement of weed seed surrogates by tillage implements and natural processes. *Soil and Tillage Research*, 86, 110-122.

[17]. Aliakbar, S., Desbiolles, J., M.A., Fielke, J.M., 2013. Soil translocation by narrow openers with various blade face geometries. *Biosystems Engineering*, 114, 259-266.