

Seeding Trials with Three Till-Planting Units

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Abstract

Three prototypes of a single till-planting unit system suitable for Egyptian agriculture were evaluated in clay soil by determining seedling emergence with three crops. Till-planting units were tested in the field at three speeds and three depths. Crop emergence data were collected on the 7, 14, and 20th days following seeding. Results indicated that the highest values of seedling emergence were obtained with unit two, which was equipped with a Barton angle disc opener, at 3 or 5 km/h speed, and 125 mm depth of operation for pea or corn crops.

Introduction

One of the primary objectives of any tillage system is to create an optimum seedbed for maximum germination and rapid seedling emergence. Egyptian summer crops include corn (0.8 million hectares), cotton (0.4 million hectares), and rice nearly 0.4 million hectares. Soil preparation for corn and cotton is tedious and costly as the available tillage equipment works the whole area. In addition, the problems associated with no till-planting systems through dry and hard soils have stimulated the need for new design of equipment and systems to prepare a suitable seedbed for successful seedling emergence. Therefore, till-planting systems might be the right solution to overcome these limitations that hinder the potential yield of crops. Till-planting system, where a strip is tilled ahead of planting, is not a new development. It is a practice that has found acceptance in the production of row crops, such as corn (Wittmus et al., 1971; Wald et al., 1971; Oschwald, 1973; and Borin and Sartori, 1995), sugar beets (Glenn and Dotzenko, 1978), green peas (Wilkins et al., 1992), and cereal crops (Bolton and Booster, 1981; and Peterson et al., 1983). Thus, the objective of this study was to evaluate a planting system suitable for Egyptian agriculture that combines tillage and planting in a single operation on clay soil by determining seedling emergence with three crops.

Literature Review

Germination of seeds requires four basic environmental conditions to produce a crop with high yields. These conditions include moisture, oxygen, heat, and light. The rate of emergence for most crops decreased with increase in soil moisture tension, but total emergence was not affected in the range between field capacity and permanent wilting percentage (Ayers, 1952). Hunter and Erickson (1952) found that the minimum value of metric pressure was -12.7 bar necessary for emergence of corn. However, over 85% of the peas seeds emerged and established plants when the soil water tension ranged from 1.5 to 0.5 bar (Wilkins et al., 1992). Increasing seed surface contact with liquid phase water decreases germination time and increases germination percentage (Rogers and Dubetz, 1980).

Factors such as soil type, condition of seedbed, planting depth and speed, the type of crop planted, planting method, and the type of furrow openers and packing devices influenced seedling emergence and maximization of yield. Choudhary and Baker (1982) suggested that the furrow opener and covering device should include the ability to minimize moisture diffusion across the soil-seed interface. In a sandy loam soil, Schuler and Bauder (1981) found that the plant emergence was delayed using a no-tillage system for corn and soybeans. However, in the same conditions the plants emerged most rapidly in the till-planting system. Kushwaha and Foster (1993) stated that there were no significant differences in the plant emergence obtained from different types of furrow openers except for the trailing Vee-tool furrow opener which showed a lower plant emergence. Morrison, (1989) stated that, crop establishment percentages of wheat, grain sorghum, and cotton were greatly affected by planting depth, starter fertilizer rate, planting date, and various combinations of rear presswheels. He added that no presswheels produced the lowest establishment for three crops. Results of many studies indicated that grain yield of several crops seeded with till-planting systems was higher than that with other tillage systems (Shear and Moschler, 1969; Griffith et al., 1973; Peterson, 1983; Toderi and Bonari, 1986; and Wilkins et al., 1992).

Materials & Methods

Till-planting units

Three prototypes of a single till-planting unit system were designed and fabricated to use a regular drawbar hitch clevis with A-frame shaped. The main frame consisted of four tool bars. Each tool bar was 0.064 m² in cross section by 2 m long was fabricated of hollow steel. The four tool bars were assembled in tandem with the two lateral tool bars (2 m long and 0.064 m² in cross section). A screw jack was mounted to level the frame by rotating a screw adjustment. Two hydraulic cylinders were mounted on each side of main frame to raise and lower the frame. Four transport wheels (9.5 -L15) were located outside of the main frame to transport and support the frame. An angle-iron frame was fabricated and attached upward from the rear tool bar and extended forward over the frame to place the seed and fertilizer hoppers. A single till-planting unit was assembled using standard parts. Unit one (Fig. 1) was composed of the following parts: i) a pair of smooth rolling coulters, 460 mm diameter, were designed to penetrate the hard soil surface and limit the row cultivation to a strip of 150 mm. ii) a twisted double point 100 mm wide shovel was mounted on a heavy-duty tillage shank to till a strip of soil. A granular fertilizer tube was mounted to add the fertilizer at the bottom of the shovel point. iii) a packer wheel with flat blades was located 150 mm behind the mid-point of the shovel point to provide a soil cover between seed and fertilizer and break-up of large clods to improve the seedbed. iv) a double disk furrow opener with closing system was used to place and cover the seed and also pack the furrow. Unit two (Fig. 2) was similar to unit one except for the following differences: i) in place of twisted shovel, a 100 mm wide sweep was used. ii) a packer wheel with round blades was used instead of a packer wheel with flat blades. iii) a Barton angle disk opener with closing system was used instead of a double disc opener. Unit three (Fig. 3) was similar to unit two except for the following differences: i) a single rolling coulters was used instead of double rolling coulters. ii) in place of a sweep share, a 100 mm wide wing share was used. iii) a packer wheel without blades was used instead of a packer wheel with round blades. iv) a hoe opener with closing system was used instead of a Barton angle disk opener.

Experimental procedure

A field experiment was carried out to plant corn, peas, and beans with three till-planting units at three speeds and three depths. The speeds were 3, 5, and 8 km/h. The depths were 75, 100, and 125 mm. The field soil was a clay soil, having 45% clay, 30.7% silt, and 24.3% sand. The land is located at the University Farm, Arable Acreage Animal Science Central, Saskatoon, SK. The experimental area had previously produced a canola crop with a limited amount of crop residue. A split-split-plot experimental design with three replicates was used. An area of about 1.1-hectare was divided into 243 plots. Therefore the area of each plot becomes 45 m² with 30 m length and 1.5 m width. All till-planting units were calibrated to seed 22, 25, and 34 kg/ha. These resulted in 11.97, 16.7, and 17.6 cm seed spacing for peas, corn and bean respectively. The seeding dates were 5, 6, and 7 May 1998 for corn, peas, and bean respectively. On the day of seeding, three core samples, 50 mm in diameter to 200 mm depth were collected before tests from each plot for water content analysis and bulk density measurements. The germination percentage was conducted under laboratory conditions for three crops before planting. The average values were 99%, 95%, and 88% for corn, peas, and beans respectively. Three samples of crop emergence data for three till-planting units were collected from each plot on the 7, 14, and 20th days following

seeding. Percent emerged was calculated as the observed seedling/m² divided by the product of actual seeding rate times the fraction of viable seeds.

Results & Discussion

Initial soil moisture content and bulk density

Figures 4 and 5 show the average values of soil moisture and soil bulk density versus soil depth before planting with three till-planting units. The value shown for each depth is an average of 27 individual measurements. There was a steady increase in the soil moisture and soil bulk density with increasing depth for the initial soil condition. Soil moisture increased from 15.3% to 28.6% between 0-50 and 100-150 mm depths for all units. However, the increase in the soil bulk density was 1.19 to 1.45 Mg/m³ when the depth increased from 0-50 to 100-150 respectively.

Accumulated heat units

Accumulated heat units were determined using the following equation:

$$AHU = \sum_{i=1}^n \left[\frac{T_{\max_i} + T_{\min_i}}{2} \right] - (\text{base temperature}) \quad (\text{Wilkins et al., 1992})$$

Where:

AHU = accumulated heat units, (degree - days),

T_{max_i} = maximum air temperature for the ith day, (° C),

T_{min_i} = minimum air temperature for the ith day, (° C), and

The base temperature = 4.4° C.

Data of air temperature was taken from National Hydrology Research Center, Environment Canada, for Saskatoon Area, May 1998. Negative values of heat units for any given day were set equal to zero. Accumulated heat units were calculated for the 7, 14, and 20th days following seeding. The relation between accumulated heat units and seedling emergence for three crops is shown in Figure 6. Seedling emergence increased with an increase in the accumulated heat units for all crops. For corn, seedling emergence increased by 51% and 35% when accumulated heat units increased from 48.7 to 81 and to 154.7 degree-days respectively. However, when accumulated heat units increased from 50.4 to 87.4, and to 167 degree-days, seedling emergence for peas increased by 48% and 21% respectively. No emergence observations occurred for the bean crop on the 7 days following seeding for all units. This may have occurred due to lack of soil moisture, as there was no precipitation for the first 9 days after seeding. Thus, the soil moisture in the seed did not reach the minimum required to start the germination process. However, seedling emergence for beans increased by 58% as the accumulated heat units increased from 96.6 to 182.4 degree-days.

Effect of the depth of operation

Figure 7 shows average values of seedling emergence versus depth of operation for three till-planting units at low speed. Seedling emergence increased with an increase in the

depth of operation with all units. The increase in the depth from 75 to 125 mm caused an increase of seedling emergence of bean crop by 22%, 14%, and 22% for unit one, unit two, and unit three respectively. However, for pea and corn crops, the increase in the depth of operation did not cause an increase in the seedling emergence by more than 14% for all units. This may be attributed to the following reasons:

- Shallow planting depth may have caused the seedling to dry out and die before its root system became established in moist soil (due to lack of soil moisture).
- The increase in the initial soil moisture and soil bulk density at seeding with the increase in the depth of operation for all units as shown in Figures 4 and 5.

Unit two, which was equipped with a Barton angle disc opener, resulted in the highest values of seedling emergence for all crops. These values were 68.72%, 89.42%, and 82.69% for bean, peas and corn respectively. However, the moderate and minimum values of seedling emergence were obtained with unit one (double disc opener) and unit three (hoe opener) respectively. The reasons for these results could be summarized as follows:

- The average soil cover over the seed was 42 mm, 33 mm, and 20 mm for unit two, unit one, and unit three respectively. This was due to the sweep share, which proceeded unit two, causing less soil spread sideways compared with shovel share (unit one) and wing (unit three) shares. Consequently, the area of soil disturbance for unit two was smaller than that for unit one and unit three (data not shown).
- Although unit three produced the smallest soil mean weight diameter (data not shown) than that for unit two and unit one. The closing system with a Barton angle disc opener (unit two) provided the desired seed-soil contact compared with the closing systems of double disc opener (unit one) and hoe opener (unit three). This may have been due to a V-shaped semi-pneumatic press wheel, which followed the angle disk opener, pressing the soil at the opposite angle to the disk to completely close the furrow and pack the soil.

In a comparison among three crops, the highest values of seedling emergence were obtained using pea crop for all units. However, the moderate and minimum values of seedling emergence were obtained using corn and bean crops respectively. This result may have been due to sufficient initial soil moisture surrounding the seed for germination for pea and corn seeds, but not for bean seed due to the slightly larger size of bean seed than corn and pea seeds.

Similar trends were obtained in the seedling emergence for all crops at medium and high speeds compared with that at low speed except for the following differences:

- There was no appreciable change in the seedling emergence for all crops when the speed increased from 3 to 5 km/h with different till-planting units.
- Seedling emergence for different crops decreased by almost 10%, 9%, and 12% as the speed increased from 3 to 8 km/h for unit two, unit one, and unit three respectively. This may have occurred due to the increase in soil dispersion at the high speed of operation, which might cause increased soil drying.

Statistical analysis

Analysis of variance (Table 1) was performed using the MINITAB statistical package for the seedling emergence in relation to speed of operation, depth of operation, three crops,

and three replicates with three till-planting units. Results indicated that the highest values of seedling emergence were obtained with unit two at 3 or 5 km/h speed, and 125 mm depth of operation for pea or corn crops.

Conclusions

The results of this field study could be summarized as follows:

- Seedling emergence for all crops was highly dependent on soil moisture and soil temperature.
- There was no appreciable change in the seedling emergence for all crops when the speed increased from 3 to 5 km/h with different till-planting units. However, at high speed the seedling emergence decreased for all crops.
- Excellent seedling emergence was achieved with the 125 mm depth compared to other depths for all crops and till-planting units.
- The pea crop resulted in the highest values of seedling emergence compared with corn and beans with three till-planting units.
- With respect to the effect of three till-planting units on seedling emergence, unit two which was equipped with a Barton angle disc opener, resulted in the highest values of seedling emergence for all crops.
- The three till-planting units showed good potential in seedling emergence using a variety size of seeds without problems.

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References

- Ayers, A.D. 1952. Seed germination as affected by soil moisture and salinity. *Agron. J.* 4:82-88.
- Bolton, F.E. and Booster, D.E. 1981. Strip-till planting dryland cereal production. *Trans. Am. Soc. Agr. Engrs.* 24(1): 59-62.
- Borin, M. and Sartoni, L. 1995. Barley, soybean, and maize production using ridge tillage, no tillage, and conventional tillage in northeast Italy. *J. Agric. Eng. Res.* 62: 229-236.
- Choudhary, M.C. and Baker, C.J. 1982. Effect of drill coulter design and soil moisture status on emergence of wheat seedlings. *Soil & Tillage Res.* 2:131-142.
- Glenn, M.D. and Dotzenko, A.D. 1978. Minimum vs. conventional tillage in commercial sugarbeet production. *Agron. J.* 70(2): 314-344.
- Griffith, D.R., Mannering, J.V., Galloway, H.M., Parsons, S.D. and Richey, C.R. 1973. Effect of eight tillage-planting systems on soil temperature, percent stand, plant growth, and yield of corn on five Indian soils. *Agron. J.* 65(2): 321-326.
- Hunter, J.R. and Erickson, A.E. 1952. Relation of seed germination to soil moisture tension. *Agron. J.* 44:107-109.

- Kushwaha, R.L. and Foster, R.K. 1993. Field evaluation of grain drill furrow openers under conservation and conventional tillage systems. *Canadian Agricultural Engineering* 35(4): 253-260.
- Morrison, J.E., Jr. 1989. Factors affecting plant establishment with a no-tillage planter opener. *Applied Engineering in Agriculture* 5(3): 316-318.
- Oschwald, W.G. 1973. Chisel plow and strip tillage systems. In: *Conservation Tillage*. Soil Conservation Soc. Amer. pp. 194-202.
- Peterson, C.L., Dowding, E.A., Hawley, K.N., Harder, R.W. 1983. The chisel-planter minimum tillage system. *Trans. Am. Soc. Agr. Engrs.* 26(1): 378-383, 388.
- Rogers, R.B. and Dubetz, S. 1980. Effect of soil-seed contact on seed imbibition. *Canadian Agricultural Engineering* 22: 89-92.
- Schuler, R.T. and Bauder, J.W. 1981. Reduced tillage studies on irrigation sandy loam soil in corn and soybean production. *Am. Soc. Agr. Engrs. Paper No. 81-1013*, St. Joseph, MI 49085.
- Shear, G.M. and Moschler, W.W. 1969. Continuous corn by the no-tillage and conventional tillage methods: a six year comparison. *Agron. J.* 61(4): 524-526.
- Toderi, G., and Bonari, E. 1986. Soil tillage: crop management aspects. II. Tillage and crops. *Rivista di Agronomia*, 20(2-3): 106-133.
- Wald, A.J., Clarence, W.B., and Walter, G.L. 1971. Evaluation of rotary tillage systems for corn production. *Trans. Am. Soc. Agr. Engrs.* 14(1): 195-200.
- Wilkins, D.E., Bolton, F., and Saxton, K. 1992. Evaluating seeders conservation tillage production of peas. *Applied Engineering in Agriculture* 8(3): 165-170.
- Wittmuss, H. D., Lane, D. E., and Somerhalder, B. R. 1971. Strip till-planting of row crops through surface residue. *Trans. Am. Soc. Agr. Engrs.* 14(1): 60-63, 68.



Figure 1. Unit one.



Figure 2. Unit two.



Figure 3. Unit three.

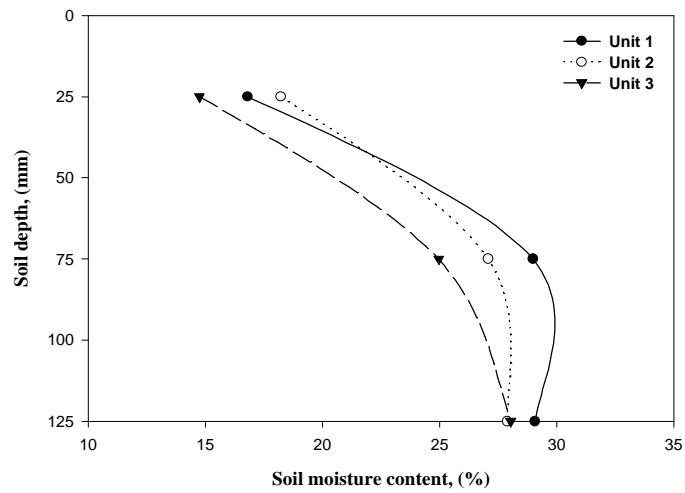


Figure 4. Soil moisture content with the soil depth for three till-planting units before planting.

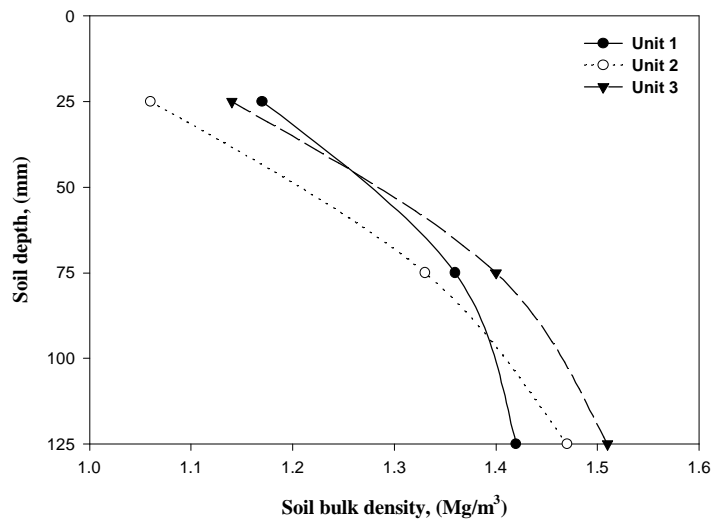


Figure 5. Soil bulk density with the soil depth for three till-planting units before planting.

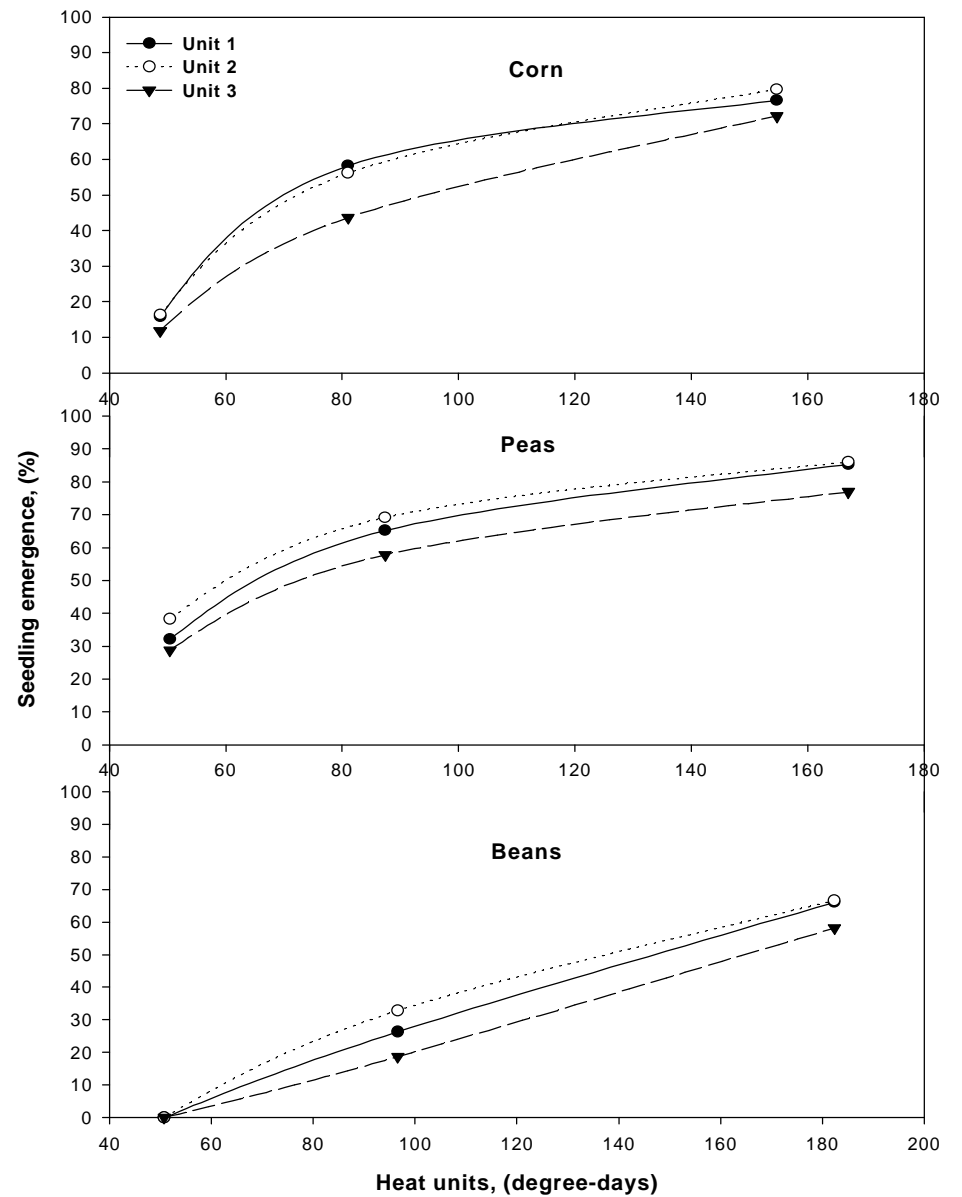


Figure 6. Accumulated heat units versus seedling emergence for three crops using three till-planting units.

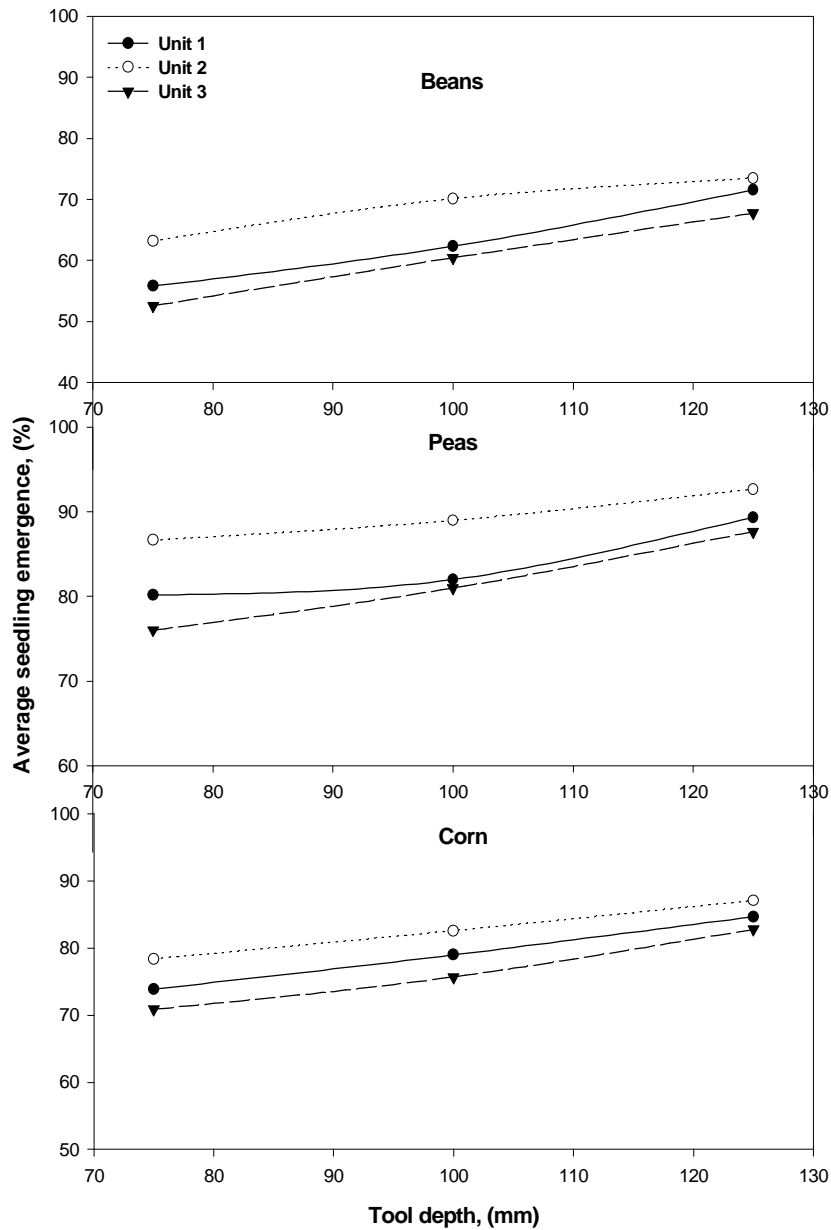


Figure 7. Average seedling emergence with the depth of operation for three crops using three till-planting units at low speed.

Table 1. Analysis of variance for average seedling emergence of three crops using three till-planting units.

ANOVA TABLE

Source	DF	SS	MS	F	P
S	2	1445.07	722.54	144.45	0.000**
C	2	16624.40	8312.20	1661.77	0.000**
U	2	2974.17	1487.08	297.30	0.000**
R	2	164.20	82.10	16.41	0.000**
D	2	4982.58	2491.29	498.06	0.000**
S*C	4	51.68	12.92	2.58	0.049*
S*U	4	32.57	8.14	1.63	0.183-
S*R	4	61.22	15.30	3.06	0.025*
S*D	4	21.15	5.29	1.06	0.388-
C*U	4	68.56	17.14	3.43	0.015*
C*R	4	45.23	11.31	2.26	0.076-
C*D	4	173.86	43.46	8.69	0.000**
U*R	4	163.51	40.88	8.17	0.000**
U*D	4	149.37	37.34	7.47	0.000**
R*D	4	116.88	29.22	5.84	0.001**
S*C*U	8	74.69	9.34	1.87	0.088-
S*C*R	8	49.84	6.23	1.25	0.294-
S*C*D	8	28.05	3.51	0.70	0.689-
S*U*R	8	70.91	8.86	1.77	0.106-
S*U*D	8	12.97	1.62	0.32	0.953-
S*R*D	8	67.60	8.45	1.69	0.125-
C*U*R	8	52.47	6.56	1.31	0.261-
C*U*D	8	64.03	8.00	1.60	0.150-
U*R*D	8	71.12	8.89	1.78	0.105-
C*R*D	8	90.62	11.33	2.26	0.038*
S*C*U*R	16	152.23	9.51	1.90	0.044*
S*C*U*D	16	12.27	0.77	0.15	1.000-
S*U*R*D	16	82.24	5.14	1.03	0.447-
C*U*R*D	16	187.11	11.69	2.34	0.012*
Error	48	240.10	5.00		
Total	242	28330.69			

- None significant
 * Significant at 5% level of confidence
 ** High significant at 1% level of confidence

MEAN VALUES

Speed	G	Units	G	Crops	G	Depth	G
3	76.2 ^a	1	72.9 ^b	beans	61.9 ^c	75	67.6 ^c
5	73.3 ^{ab}	2	77.6 ^a	peas	81.6 ^a	100	73.3 ^b
8	70.2 ^b	3	69.1 ^c	corn	76.1 ^b	125	78.7 ^a

LDS(0.05)=3.69
 Means within the same column followed by the same letter are not significant.