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Assessment of Different Types Furrow Openers Using a Full Automatic Planter

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Abstract: The objective of this research was to evaluate the effects of different types of furrow opener and operation speed on soil properties, draft force and percentage of emerged tuber seedling. The experiment was conducted on a clay-silt textured soil using hoe, shoe and shovel type furrow openers with 2.02, 3.28 and 4.50 km h^{-1} operation speeds, respectively. After planting, soil penetration resistance, ridge height, mean emergence dates and percentage of emerged tuber seedling were determined. Soil penetration resistance increased with increasing operational speeds for each furrow opener type. The draft force requirement of furrow openers increased with operation speeds. Percentage of emerged tuber seedling was between 66.37 and 82.67%, based on furrow opener type and operational speeds. The lowest soil penetration resistance, draft force and high percentage of emerged tuber seedling occured found with shovel type furrow opener.

Key words: Furrow opener, soil penetration resistance, draft force, percentage of tuber seedling

INTRODUCTION

Furrow opener is an important component of a potato planter. Common types of furrow openers of potato planters are hoe and shoe furrow openers. Disc furrow openers are sparse. The furrow characteristics influence the germination and emergence of crop under different soil conditions. Therefore, designing a furrow opener needs many factors that affect the performance of furrow opener. Plant emergence and crop yield can be affected indirectly by the performance characteristic of furrow openers and the quality of operation. Some of these characteristics are the compaction in the furrow, planting depth, draft power and operational speed. Increases in the depth of furrow opener increase the draft force and affect the recovering of soil in the furrows.

Performance evaluation of various types of furrow openers have been studied by several researchers. The results showed that the characteristics of furrow openers have affected soil parameters, the draft force, seed distribution, plant emergence and plant growth (Ozmerzi, 1986; Gebresenbet and Jönsson, 1992; Darmora and Pandey, 1995; Choudhary and Baker, 1982; Chaudhury, 2001).

Sharma and Srivastava (1984) evaluated the performance of automatic potato planter with runner type furrow opener in sandy loam. Draft forces of potato planter increased with increasing operational speeds. Gebresenbet and Jönsson (1992) reported performance of seed drill coulter in terms of the operational speed, soil depths and rake angles. The empirical equations developed to describe the effects of speed, soil depth, rake angle and coulter width on horizontal and vertical forces with the data collected under both fields and laboratory conditions. Tajuddin and Balasubramanian (1995) evaluated performance of the various types of furrow openers such as hoe, shoe, wedge, single disc and double disc. They explained that performance of single disc-type furrow opener was better, having the highest performance index and lowest unit draft among the furrow openers compared. Morrison (2002) evaluated the impact on plant stand establishment, early-season plant height and yield of corn that are caused by the degree of compatibility among combinations of selected tillage systems, planter press wheels and planter furrow openers such as double disc, sweep and triple disc. Giron *et al.*(2005) evaluated the effect of soil compaction and water content on resulting forces acting on three seed drill furrow openers. The greater were the bulk density and water content of soil the greater was the draft force measured in three furrow openers (chisel-type, a non-winged combine type and a modified Suffolk type). Doan *et al.* (2005) evaluated the effect of residue type on the performance of no-till seeder openers. The double disc opener had the tendency to seed canola deeper than the hoe opener. The disc opener had a better uniformity of seeding depth and promoted speed of crop emergence compared to hoe opener (Doan *et al.* 2005).

The performance of furrow openers of potato planters are concerned the quality of planting and the furrow

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characteristics. Compaction of soil at planting depth, subsoil distribution patterns of tuber seed and soil coverage were considered as measures of the quality of planting and were correlated with the emergence rate. The draft force and the operational speed affect the performance of furrow opener and furrow characteristics. These parameters have a great concern a proper environment of tuber seedling and plant growth. The objective of this study was to evaluate the relationship between different types of furrow opener (shoe, hoe and shovel) and soil parameters, draft force and percentage of emergence in respect to operational speeds. This study aimed to determine the most proper combinations of potato planter furrow opener and operational speeds to be recommended to manufacturers and growers.

MATERIALS AND METHODS

The experiment was conducted under semiarid conditions of North Central Anatoila, Tokat, Turkey. Potato was planted using potato planter on 15 March 2002. The soil was a silty clay. The experimental design was a completely randomized blocks suit for split-plot with three replication including the main factor of furrow opener type and sub-factor of operational speed. The size of the experimental plot was 6×20 m and all the treatments were applied randomly to the each block. Standard tractor and the potato planter weights were 2.324 and 0.670 Mg, respectively. Tubers of variety Marfona were sown on the 70 cm spaced to a depth of 0.06 m at the rate of 3.6×10^4 tubers ha^{-1} with varying operational speeds of 2.02, 3.28 and 4.50 km h^{-1}.

Furrow openers were used in the experiments are shown in Fig.1. The potato planter was a full automatic and two row machine including tuber hopper, double cup belt planting mechanism, furrow opener and double disc to cover the tuber and to form the furrow. In this study, hoe shoe and shovel type furrow openers were used for performance evaluation. Shoe and hoe furrow openers were designed by Kanafojski (1972) and shovel type furrow opener was a modification as a combination of shoe and hoe furrow opener. Hoe furrow opener type has a tendency to move out of the soil depth and shoe type furrow opener has tendency of sinking the soil depth. The shovel type furrow opener has a function between shoe and hoe type furrow opener. The submersion angle of furrow openers were 140, 35 and 60° and rake angles were 150, 30 and 70° for shoe, hoe and shovel furrow openers, respectively. Each furrow opener had the same working width of 220 mm.

Results of statistical analysis suggested that the soil in the experimental plots was uniform in texture. The undisturbed soil samples taken from furrow depth were used for determinations of the soil moisture content

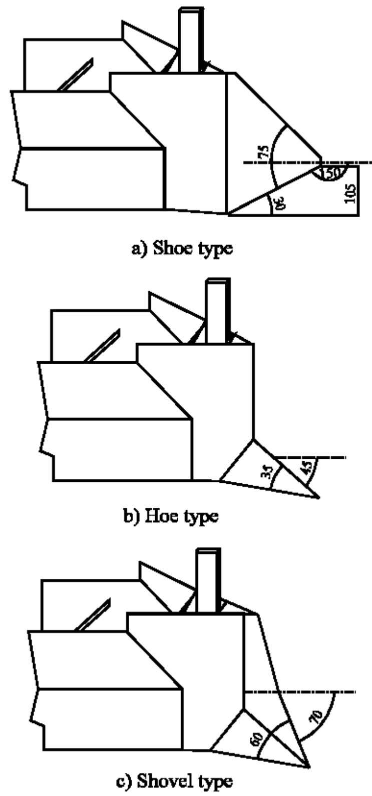

Fig. 1: Furrow openers were used in the experiment

and soil bulk density. Soil penetration resistance was evaluated with an Eijelkamp cone penetrometer (Eijelkamp, 1990). The cores were then dried at 105°C to determined dry bulk density and moisture content at sampling.

Draft force was measured with draft measurement set by loadcell. A loadcell was attached between the front bottom of the tractor and potato planter rocking system (Peker, 1990). Potato planter was pulled through the soil at a desired depth and different operational speeds. Loadcell signals were changed to digital values with an ADC converter and data was recorded in computer. The ridge height were determined by measuring the top ridge to bottom of tuber by six replications.

To determine Mean Emergence Dates (MED) and Percentage of Emerged seedling (PE), emerged seeds were counted several times during the emergence period in the rows with 6 m length for each treatment and were calculated using formula (1) and (2) (Bilbro and Wanjura, 1982). MED measurements were done for a month after planting.

$$MED = (N_1D_1 + N_2D_2 + \ldots\ldots + N_nD_n)/(N_1 + N_2 + \ldots\ldots + N_n) \quad (1)$$

$$PE = (TES/NSP) \times 100 \quad (2)$$

Where, N is number of seed emergence since previous count, D the number of days post planting, TES is the total emerged seedling at per meter and NSP is the number of seed planted per meter.

Results of the randomized complete block design with split plot were analyzed with analysis of variance and the means were compared by LSD test as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

This section focuses the relationship the three furrow opener and operational speeds compared in terms of soil parameters, draft force, ridge height and mean emergence dates and percentage of emerged tuber seedling.

Soil penetration resistance, draft force and ridge height: Soil moisture contents were approximately 17.2 and 16.9% and bulk density were 1.35 and 1.34 g cm^{-3}, respectively at the 0-20 cm soil depth before and after potato planting. Table 1 shows the average soil penetration resistance values for the three furrow openers at the three operational speeds and two working depths considered. At both depths and with the three openers, soil penetration resistance decreased with increasing operational speeds. The highest penetration resistance values were found at 2.02 km h^{-1} operation speed for each soil depth. The greatest mean soil penetration resistance values were found for hoe furrow opener followed by those for shovel and shoe furrow opener at the 0-10 cm and 10-20 cm soil depth, respectively.

Table 2 shows the average ridge height for three furrow openers at the three operational speeds. The highest ridge height value was found with hoe furrow opener, followed by those for shovel and shoe furrow openers. The ridge height values decreased by increasing operation speeds for each furrow opener type. Chaudhury (2001) reported that the increases in depth with the furrow openers affected the recovering of the soil in the furrow.

Figure 2 also presents the effect of the interaction between each furrow opener and operational speed on draft force curves in terms of time period. Figure 3 shows the average draft force for the three furrow openers at the three operational speeds considered. The highest draft force value occured with for hoe type furrow opener, followed by shoe and shovel furrow opener. The draft force values increased by increasing operation speeds in all furrow opener type. In this study, the relationship between operational speeds and draft force required of the different furrow opener could be described with by the regression equation:

$$\text{Hoe type} \ : F = 19.92 + 3.205\ S\ (R^2 = 0.979) \quad (3)$$

Table 1: Effect of furrow opener type and speeds on soil penetration resistance (MPa)

Furrow opener type	Soil depth (cm)	Speeds (km h^{-1}) 2.02	3.28	4.50	Mean	LSD values
Shoe		1.50	1.29	1.14	1.31ab†	0.32
Shovel	0-10	1.23	1.13	1.19	1.15b	
Hoe		1.79	1.47	1.29	152a	
Mean		1.51	1.30	1.17		
Shoe		1.77	1.70	1.37	1.61	
Shovel	10-20	1.65	1.49	1.28	1.47	
Hoe		1.85	1.80	1.65	1.77	
Mean		1.76	1.66	1.43		

† : The tillage and compaction means in the same group not followed by the same letter (within same column) are not significantly different according to Fishers Protected LSD test (p = 0.05)

Table 2: The effects of furrow opener type and speeds on ridge height (cm)

Furrow opener type	Speeds (km h^{-1}) 2.02	3.28	4.50	Mean	LSD values
Shoe	20.17	17.33	16.33	17.94b†	1.72
Shovel	21.33	20.50	18.00	19.94a	
Hoe	22.25	21.33	17.33	20.31a	
Mean	21.25a‡	19.72a	17.22b		2.41

† :The tillage and compaction means in the same group not followed by the same letter (within same column) are not significantly different according to Fishers Protected LSD test (p = 0.05). ‡ : The compaction means in the same group not followed by the same letter (within same line) are not significantly different according to Fishers Protected LSD test (p = 0.01)

$$\text{Shoe type} \ : F = 15.06 + 3.881\ S\ (R^2 = 0.999) \quad (4)$$

$$\text{Shovel type} : F = 14.77 + 3.374\ S\ (R^2 = 0.997) \quad (5)$$

where F is draft force and, S is operational speed

Other researches such as Sharma and Srivastava (1984), Gebresenbet and Jönsson (1992), Damora Pandey (1995), Al-Suhaibani and Al-Janobi (1997) and Giron *et al.* (2005) have studied the effect of some opener design factors (e.g., rake angle, working width and operational speeds) and alternative approaches to the former openers. They generally agreed to that the greater the rake angle and width of the furrow opener and operational speed, the greater is the draft force required. In our case, the lowest draft force values were found for shovel type, the opener with the rake angle (70°). However, hoe and shoe furrow openers had the lowest and highest rake angles with 30 and 150°, respectively and their respective draft forces were higher than that shovel furrow opener. Others explained that the draft force was affected by rake angle, working width, operational speed and working depth. In present results, the effect of operational speeds on the draft force was in accordance with those found by Sharma and Srivastava (1984) and Al-Suhaibani and Al-Janobi (1997).

Mean emergence dates and percentage of tuber seedling: Table 3 shows the mean emergence dates and percentage of emerged tuber seedling values for the three furrow

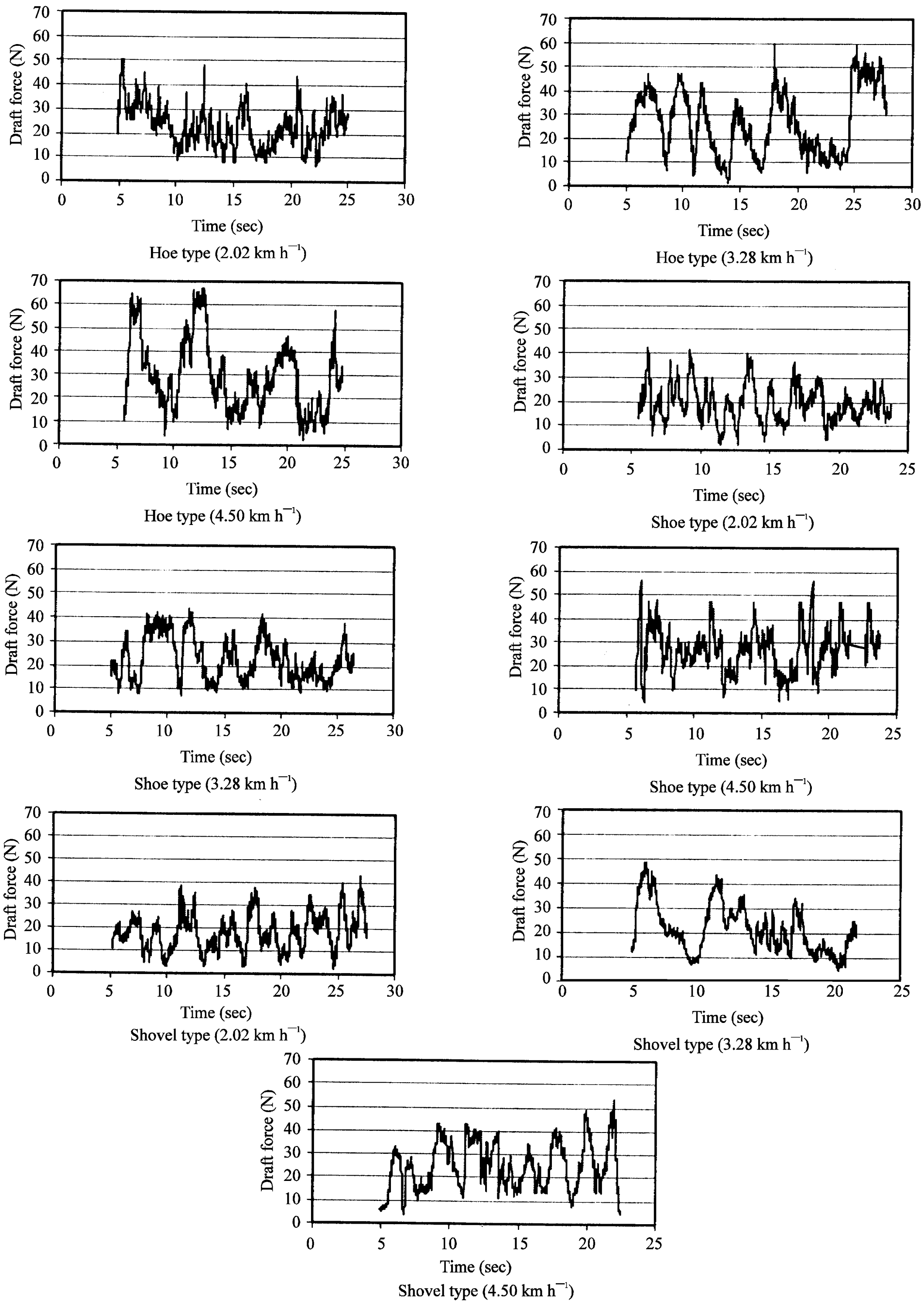

Fig. 2: Relationship between time and draft force for different type of furrow openers and speeds

Table 3: Values of mean emergence of dates (day) and percentage of emerged seedling (%) for furrow opener types and speeds

Parameters	Furrow opener type	Speed (km h^{-1}) 2.02	3.28	4.5	Mean	LSD values
	Shoe	38.97	39.01	38.84	38.94	
MED (day)	Shovel	39.04	39.22	39.10	39.12	
	Hoe	39.27	39.69	38.81	39.26	
	Mean	39.09	39.31	38.91		
	Shoe	82.67	75.11	75.56	77.78a†	7.14
PE (%)	Shovel	78.48	72.20	74.67	75.12ab	
	Hoe	72.74	66.37	71.70	70.27b	
	Mean	77,96	71.23	73.98		

MED: Mean emergence of dates (day); PE: Percentage of Emerged tuber seedling (%), †: The tillage and compaction means in the same group not followed by the same letter (within same column) are not significantly different according to Fisher Protected LSD test (p = 0.05)

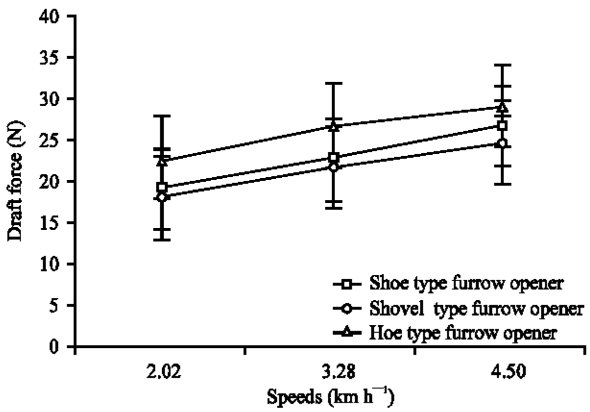

Fig. 3: Mean values of draft force as affected by speed for type of furrow opener

openers at operational speeds considered. The three furrow openers showed the similar behaviour at three operational speeds on mean emergence date at potato planting. The mean emerged date values were higher in hoe type furrow opener. The three furrow opener were significantly found to affect the percentage of emerged tuber seedling. Percentage emerged of tuber seedling in shoe type furrow opener was higher than those of hoe and shovel type furrow opener.

The effect of furrow opener on seed emergence has been studied by many others such as Choudhary and Baker (1982), Dubey and Srivastava (1985), Kushwana and Foster (1993) and Doan *et al.* (2005). One general conclusion from these studies is that the effect of different furrow opener on plant emergence differs greatly. In our case, the effect of interaction between furrow opener and operational speeds on mean emergence dates was not significant, but the effect of furrow opener on percentage of emerged tuber seedling ($p \leq 0.05$).

CONCLUSIONS

In this study we assessed the effect of the furrow opener and operational speed on soil penetration resistance, the draft force, ridge height and mean emergence dates and percentage of emerged tuber seedling. Soil penetration resistance values decreased with increasing operation speeds for all types of furrow openers. The draft force requirement of furrow openers increased with increasing operational speeds. The lowest value occured for shovel furrow opener. The percentage of emerged tuber seedling values was higher at shoe and shovel than hoe furrow opener. The lowest draft forces and high percentage of emerged tuber seedling were recorded for the opener with the 70° rake angle of the shovel furrow opener. This, enabled modified shovel opener to be more efficient than the other furrow opener in terms of furrow characteristics. The performance of hoe furrow opener was found the lowest than the other furrow opener. The management of soil by using suitable furrow opener achieves a favourable environment for the germination of tuber seedling and plant growth. Based on the results of this case study, planting performance of potato planter with shovel furrow opener at lower speeds may be preferred over others.

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