



Evaluation of The Use of Different Foot Types in Pneumatic Precision Single Grain Stubble Seeder

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HIGHLIGHTS

- Measuring the fuel consumption of different types of embedding feet
- Determining the degree of sprout emergence of different types of burying feet in the field
- Determination of soil surface roughness to different types of burying feet
- Conducting laboratory trials of the pneumatic precision seeder

Abstract

In this study, the effects of a pneumatic precision stubble planter with different planter feets on fuel consumption, post-sowing surface profile unevenness and field germination emergence values in second-crop corn production were investigated. Field trials were carried out on the adhesive tape system at Selçuk University Faculty of Agriculture Sarıcalar Research and Production Farm, and laboratory experiments were carried out on the adhesive tape system at Selçuk University Faculty of Agriculture, Department of Agricultural Machinery and Technologies Engineering. Field trials were carried out at a working speed of 5.4 km h⁻¹, and adhesive tape experiments were carried out at a tape speed corresponding to a working speed of 5.4 km h⁻¹. According to laboratory and field conditions; Acceptable seed spacing values of 0.5-1.5Z were found to be over 80%, and 0.5<Z and 1.5Z were found to be below 10%. After the stubble sowing process, soil surface roughness values were determined as 14.28% on the axe-type burying foot and 16.35% on the double-disc burying foot. Fuel consumption was determined as 10.90 l ha⁻¹ for the pneumatic precision stubble seeder with ax cultivator foots, and 9.81 l ha⁻¹ for the pneumatic precision stubble seeder with disc cultivator. The FGE (field germination emergence rate) rate of the pneumatic seeder with an ax-type planter foot was determined as 87.30%, and the FGE rate of the pneumatic precision seeder with a double disc-type planter foot was determined as 85.50%. Ax-type planter foot gave better results than disc foot in terms of surface profile unevenness, field germination emergence rate and sowing depth in both applications.

Keywords: Stubble sowing; corn; fuel consumption; field germination emergence; surface profile roughness

Citation: Çıtıl E, Marakoğlu T, Çarman K (2024). Evaluation of the use of different foot types in pneumatic precision single grain stubble seeder. *Selcuk Journal of Agriculture and Food Sciences*, 38(2), 205-215. <https://doi.org/10.15316/SJAfS.2024.019>

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Received date: 23/10/2023

Accepted date: 04/06/2024

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1. Introduction

The introduction should briefly place the study in a broad context and highlight why it is important. It is increasing fuel prices in parallel with the decrease in oil resources in the world has necessitated the search for cost-reducing alternatives in agriculture, as in many areas. In addition, rapidly developing agriculture in parallel with the increasing population has aimed to increase productivity without considering sustainability, and as a result, intensive use of pesticides, fertilizers and excessive soil cultivation has come to the fore. The soil loses its fertility as a result of intensive use of pesticides, fertilizers and excessive tillage. In addition to the negative effects of increasing fuel prices on production costs, protective tillage and direct sowing techniques have been developed in order to improve the soil structure that has deteriorated as a result of the intensive use of agricultural lands day by day. Conservation tillage and direct sowing methods, which save time and fuel, prevent erosion and allow efficient use of agricultural areas for a long time (Çakır et al. 2007).

It is a soil cultivation system in which at least 30% of the soil surface remains covered with plant residues after seed sowing, in order to ensure the continuity of soil fertility by reducing soil and water erosion in protective soil tillage methods. In the majority of studies on conservation tillage, it has been stated that conservation tillage and stubble cultivation increase energy efficiency by 25% to 100% and reduce energy need by 15% to 50% (Karayel and Özmerzi 2007).

Conservation tillage is an agricultural practice in which sufficient vegetation and plant residues are left on the soil surface in order to protect water and soil, minimizing energy use and costs. In stubble sowing, profitable production is achieved by minimizing soil erosion that may occur due to various reasons. Protection of soil moisture, energy consumed, labor force used and even agricultural machinery used are additional gains that should be emphasized as much as the protection of the soil (Köller 2003).

No-till agriculture; It is the direct sowing of seeds into undisturbed stubble soil with any soil tillage machine. In the direct cropping system, the soil is left undisturbed from sowing to harvest and from harvest to sowing. The burying feet of the direct sowing machine open a narrow incision in the soil and sowing is done. Therefore, direct sowing machines do not disturb the soil outside of the sowing process. The planters used to open a furrow at the depth where the seed will be deposited must be able to cut through plant residues and sink deep enough into undisturbed soil to provide sufficient depth. The solution to the weed problem is provided by herbicides applied directly before or after sowing. The application method and time of herbicide are selected according to the density of the weed and climatic conditions (Çıkman et al. 2017).

In evaluating the performance of the tillage machine, the surface smoothness of the processed soil is an important feature in the preparation of the seedbed and in the control of water flow and soil erosion caused by rainfall (Römkens and Wang 1987).

Soil surface smoothness is a property affected by the processes performed on the soil. It is the soil surface structure formed by the random preparation of clods on the soil. Surface roughness occurs due to deterioration of the soil surface due to natural reasons or cultural processes (Guillobez and Arnaud 1998; Hauer et al. 2001).

Bayhan et al. (2001) in their study titled Reduced tillage and direct sowing applications in second crop silage corn agriculture, found that the lowest fuel consumption was in the direct sowing application among the applications and the highest efficiency was obtained from the application using a soil tillage combination, and similarly, Yalçın and Çakır (2006) in their study, they obtained fuel consumption values as 60 l ha⁻¹ in the traditional method and 7.5 l ha⁻¹ in the direct sowing method.

Especially in the single grain precision sowing method, where it is desired to plant as many seeds as the number of plants to be grown, the importance of seed distribution increases as each plant that does not germinate or does not continue its development well will directly affect the yield. In precision sowing, planter layouts have the primary effect of ensuring the uniformity of seed distribution on the row. However, it should not be forgotten that the problems that may occur in the proper placement of the seeds thrown from the planter into the soil have an important effect on the quality and success of the sowing process. Even if the precision

sowing machine has the most modern, highest quality sowing arrangement, sowing failures may occur due to the inability of the burying feet to perform their duties well (Önal 1995).

In this study, the effects of the pneumatic precision stubble seeder (P.P.S.S.) with different burying feet on fuel consumption, surface surface roughness, field sprout emergence and row distances in second-crop corn production were investigated.

2. Materials and Methods

Field trials were carried out in Selçuk University Faculty of Agriculture Sarıcalar Research and Production Farm, and laboratory trials were carried out with 3 replications on the adhesive tape system in the application workshop of Selçuk University Faculty of Agriculture, Department of Agricultural Machinery and Technologies Engineering. Some soil properties of the trial area are given in Table 1.

Table 1. Some soil properties of the in trial area

	% Sand	20.4
Tekstüre Analysis	% Silt	24.7
	% Clay	54.9
Tekstüre Class	Clay-Loam	
Applications		
Volume Weight (g.cm ⁻³)	(0-20 cm)	1.51
Moisture content (%)	(0-20 cm)	17.85
Penetration resistance (Mpa)	(0-20 cm)	1.41
Porosity (%)		43.01
pH		7.5

Before applying stubble sowing, the amount of stubble per unit area of the application field was determined. To determine the amount of stubble, the average amount of stubble was determined by counting the amount of stubble in a 1x1 m² frame created from different points of the field (Figure 1).



Figure 1. Determination of stubble amount

In the trials, two different vacuum-type pneumatic precision single grain stubble planters (P.P.S.S.) with 4-row axes and double-disc burying feet were used (Figure 2 and Figure 5).

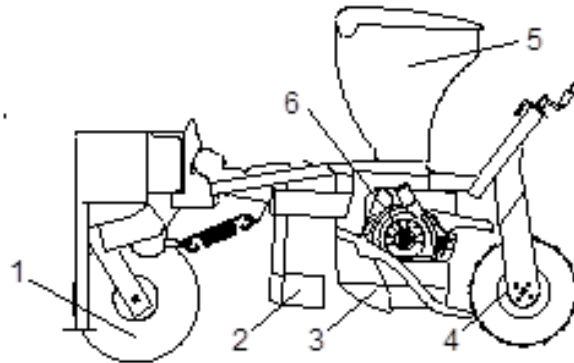


Figure 2. P.P.S.S. with axle burying foot

(1. Stubble cutting disc, 2. Stubble cleaner, 3. Axle burying foot, 4. Pressing wheel, 5. Seed storage, 6. Planter layout)



Figure 3. Burying foot with axle

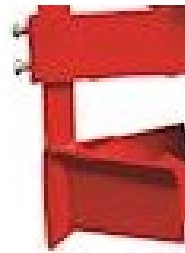


Figure 4. Stubble cleaner

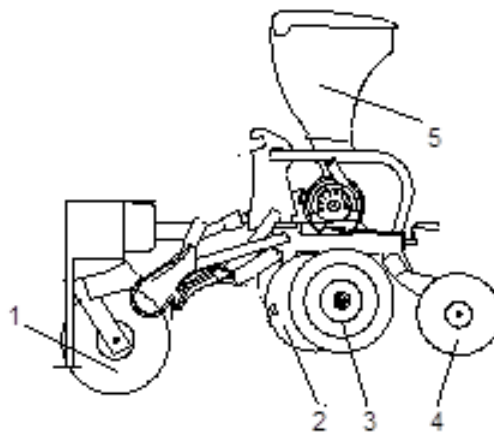


Figure 5. P.P.S.S. with Double disc burying foot

(1. Stubble cutting disk, 2. Double disc burying foot, 3. Depth adjustment wheel, 4. Pressing wheel, 5. Seed tank)

The diameter of the double-disc burying foot is 372 mm and the angle between them is 10°.



Figure 6. Double disc burying foot

Stubble-cutting discs are placed at the front of each unit of both machines to enable stubble cultivation in stubble fields. These discs are corrugated type and their diameter is 470 mm



Figure 7. Stubble cutter disc

DKC5783 FAO 500 was used as seed and the machines were adjusted so that the distance between the rows was 20 cm, the distance between the rows was 70 cm, the forward speed was 5 km h⁻¹ and the theoretical sowing depth was 5 cm. As fertilizer, 20x20 compound fertilizer was used with sowing.

The experiments were set up on a field with approximately 3.5 decare of wheat stubble, according to the randomized parcel trial design, with 3 replications (each parcel 3x100m). After sowing, the plots were irrigated with sprinkler irrigation at 4-day intervals during the germination period of the seeds.

A New Holland TD110D brand tractor was used in the trials. Trials were carried out on both foot types at a working speed of 5.4 km.h⁻¹. In order to clearly measure the instantaneous fuel consumption of the tractor during operation, one of the fuel meter connection hoses is connected to the fuel line from the fuel tank to the engine, and the other is connected to the return line from the engine to the fuel tank. The fuel meter measures the amount of fuel going to the engine fuel line and the return line to the fuel tank separately, and the net amount of fuel consumed by the tractor is determined as l h⁻¹ and calculated as l ha⁻¹.



Figure 8. Fuel consumption meter and display

A rod profile meter was used to determine surface unevenness after stubble sowing. The profile meter has rods placed at 2.5 cm intervals on a 1 m long profile material (Çarman 1997).

By measuring the surface profile with a profilometer placed perpendicular to the working direction, field surface unevenness was calculated with the help of the following equation (Kuipers 1957).

$$R=100 \log_{10} S$$

Here;

R: Soil surface roughness (%) after trials and

S: Standard deviation of measured values.

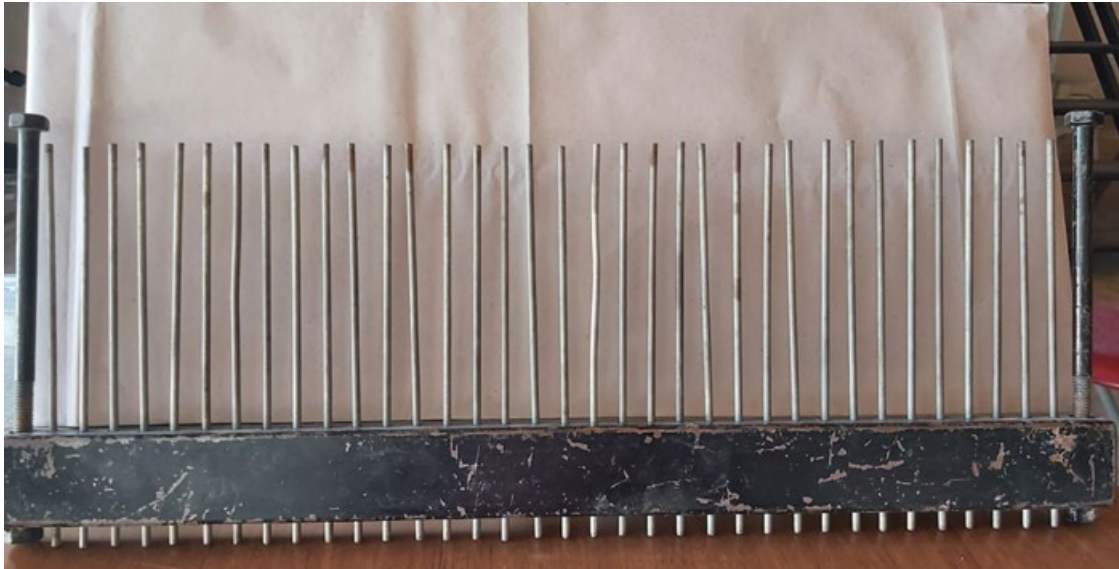


Figure 9. Profilometer

Soil moisture was measured with a TDR device calibrated by the gravimetric method.



Figure 10. Humidity measuring device (TDR)

A penetrometer device with digital display was used to measure the density of the soil. Soil resistance was measured as MPa at every 1 cm up to a depth of 80 cm in vertical condition with a penetrometer. A cone tip with an apex angle of 30° and a cone base area of 1cm² was used in the measurements. Among the values obtained in the measurements, values taken from a depth of 0–20 cm were taken into account.



Figure 11. Penetrometer

In order to determine the field sprout emergence rate, the sprouts emerging on the soil surface were counted by observing during the germination period on 3 randomly selected strips of 10 m length from 2 different rows in each plot, and the TFS was calculated with the following relation using the obtained data (Işık et al., 1986).

$$FSE = \frac{\text{Total number of seeds germinated in one meter}}{\text{Total number of seeds planted in one meter}} \times 100 \quad (1)$$

FSE: Field sprout emergence degree (%)

Since the depth measurement was done under field conditions, the grass length measurement method was used. Plants that had completed the germination period were removed from the soil and the distance between the seed residue and the point where the germinated plant turned from green to white was measured. Measurements were made on 25 plants randomly selected among the rows in each replication, and the data obtained from these measurements were entered into the MS Excel program and the average planting depth and vertical seed distribution coefficient of variation (VK, %) values were calculated in this program (Özmerzi and Keskin 1983).

3. Results and Discussion

The pneumatic precision stubble planter used in the trial was tested to determine the uniformity of distribution in the row under both laboratory and field conditions. The results regarding the adhesive tape test regarding the planter arrangement and the evenness of distribution of the corn seeds obtained in the field according to the planter foot type are given in Table 2. Under laboratory and field conditions, acceptable seed spacing values of 0.5-1.5 Z were found to be over 80%, and 0.5<Z and 1.5>Z were found to be below 10%.

In the adhesive tape experiments carried out in the laboratory, the expression 0.5<Z, which expresses the twinning rate of the seeds on the row, was found to be 0% at a row distance of 20 cm, and the expression 1.5>Z, which expresses the spacing ratio between the seeds on the row, was found to be 2.5%. These values were

found to be below the 10% limit value. It was determined that the ratio of seeds expressing the ideal row distance 0.5-1.5. Z was 97.50%, and this expression was above the 80% limit value (Table 2).

When evaluating single-grain precision sowing systems, the relative proportions of (0.5-1.5) Z plant spacings within the total plant spacing are taken into account. In the distribution of plants on the row (0.5-1.5). Z ratio is considered as acceptable plant spacing on the row. In modern single-grain sowing machines, it is required that the ratio of plants in the Z range (0.5-1.5) be greater than 80%, and the ratio of plants in the <0.5. Z and >1.5.Z range should not be more than 10% (Önal 1987).

In order to determine the field sprout emergence values, the distances between the sprouts emerging on the soil surface on different strips from the plots during the germination period were measured and post-sowing twinning and gap ratios were determined. The twinning rate ($0.5 < Z$) of ax foot and disc foot P.P.S.S. was determined as 6.10% and 8%, respectively. It was observed that these values were below the 10% limit value. The clearance ratio ($0.5 < Z$) for ax foot and disc foot P.P.S.S. was determined as 6.60% and 6.50%, respectively. It was observed that these values were below the 10% limit value (Table 2).

Table 2. Regularity of distribution over the row of the machine

Application	Sowing distance (Z) (cm)	Working speed (km h ⁻¹)	0.5<Z (%)	0.5-1.5Z (%)	1.5>Z (%)
Laboratuvar			0.00	97.50	2.50
Field					
Ax-foot	20	5	6.10	87.30	6.60
Disc- foot			8.00	85.50	6.50

Parish and Bracy (2003) reported that increasing the seed drop height in vacuum pneumatic single-grain sowing machines negatively affects seed distribution.

Karayel and Özmerzi., (2005) stated that due to the structural features of the single-disc and double-disc burying feet used in their research, the seed falling height increases compared to the axe-type and hoe-type burying feet. mm, and 265 mm in the double-disc seeding foot type, they reported that this caused the double-disc burying foot to provide worse horizontal plane seed distribution than expected.

When the applications were compared in terms of field sprout emergence rate, the highest field sprout output value was obtained as 87.30% from the P.P.S.S. with ax type burying feet and 85.50% from the P.P.S.S. with disc type burying feet. The FSE rate of the P.P.S.S. with ax-type burying feet is 2% higher than that of the P.P.S.S. with disc-type burying feet.

According to the results of field trials, the coefficient of variation of the depth distribution of corn and the average sowing depth at 20 cm in-row sowing distance; Values for different applications and foot types are given in Table 3. The ax type burying foot gave better results than the disc foot in terms of both coefficient of variation and sowing depth in both applications (Table 3).

Table 3. % CV and sowing depth of treatments

Applications	Burying foot type	Coefficient of variations (% CV)	Sowing depth (cm)
	Ax- foot	13.5	4.1
	Disc- foot	15.4	3.7

As a result of the depth measurement performed after the germination period, it was reported that the coefficient of variation value of the sowing depth distribution should be at most 25% (Anony-mous 1999).

According to Slattery (1997), in order to obtain a high-yield, sowing should be done at a depth as close to the optimum sowing depth as possible.

Heege (1993) stated the negativities that would occur as a result of insufficient sowing depth and stated that the increase in the coefficient of variation in sowing depth negatively affects the field sprout emergence rate.

The amount of stubble in the cultivation plots of the trial area was determined as 800 pieces.m². Sin-ce the amount of weeds was almost non-existent, no herbicide application was made before sowing.

The ratio of 0.5-1.5.Z, which indicates the appropriate sowing distance relative ratio, was determi-ned to be 87.30% in the Ax foot P.P.S.S. and 85.50% in the disc foot P.P.S.S. It has been observed that the ideal sowing distance ratio in the P.P.S.S. with both foot types is over 80%. Accordingly, it was determined that the distribution uniformity in the row in the P.P.S.S. with ax feet was better than in the P.P.S.S. with disc feet.

Table 5. Evaluation of field germination emergence degree (Anonymous 1999)

FSE (%)	Assessment
>80	Very good
>70-80	Good
>60-70	Middle
>50-60	Sufficient
=50	Insufficient

Karayel and Özmerzi., (2005) examined the effect of different seeding feet on seed distribution in precision sowing machines, and when they evaluated the coefficients of variation related to row distance, they generally found that the coefficients of variation of hoe, single and double-disc sowing feet were higher than the axe-type burying feet and improved soil penetration. They repor-ted that the increase in resistance decreased the coefficient of variation of the embedded piers.

It was observed that the FSE values in the P.P.S.S. of both foot types were good at > 80% within the evaluation criteria given in Table 5.

In the study, the fuel consumption of the tractor was measured as 10.90 l ha⁻¹ from the pneumatic precision seeder with ax-type burying foot and 9.81 l ha⁻¹ from the pneumatic precision seeder with disc-type burying foot. The fuel consumption of the P.P.S.S. with an ax-type burying foot consumed approximately 11% more fuel than the P.P.S.S. with a disc type foot. It can be said that this is due to the contact of the burying foot with the soil during operation. Aykas et al. (2007) and Korucu and Kirişçi (2003) reached similar results.

The soil surface roughness values of the soil for the applications varied between 14.28% and 16.35%. In the ax foot type, there was a 12.66% decrease in soil surface roughness compared to the disc foot type. This decrease had a positive effect on field sprout emergence, depth distribution coefficient of variation and sowing depth. In the cultivation of hoe crops, it is desired that the field surface be as smooth and smooth as possible after the stubble sowing process. This is especially important in terms of sowing depth and field output being of the desired quality. When examined from this perspective, we can state that the surface unevenness values obtained from the axe-type burying foot are appropriate.

Based on the results obtained from the experiments, the following evaluations can be made.

-The on-row distribution uniformity values obtained from the adhesive tape test conducted in the laboratory of the ax and disc-footed P.P.S.S. were within acceptable limits.

-When the results of field sprout emergence were evaluated, the best result was obtained from the machine with an ax-type burying foot.

-According to the results of field trials, the coefficient of variation of depth distribution and average sowing depth were obtained better with ax-type burying feet.

-Among the applications, the highest fuel consumption was obtained on the machine with an ax-type burying foot.

-In terms of soil surface roughness, the ax type burying foot gave better results than the double disc burying foot.

-The ax-type burying foot, which has a high field sprout output, can be recommended for direct sowing conditions.

Author Contributions: The authors have an equal contribution. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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