

Full Length Research Paper

Effects of diameter and helical angle of flute on the flow evenness of fluted roller used in seed drills using lentil seed

Ibrahim Ethem Guler

Department of Agricultural Machinery, Faculty of Agriculture, Ataturk University, 25240 Erzurum, Turkey.
E-mail: iguler@atauni.edu.tr. Tel: 0900442-2312691. Fax: 0900442-2360958.

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In this study, the optimum dimensions of flute diameter and helical angle of fluted roller used in seed drills were determined for lentil seeds at 100 kg ha⁻¹ of seed rate. The values of coefficient variation were used to determine the optimum dimensions of fluted rollers. The best rates of flow evenness and the minimum coefficient of variance values were obtained at the flute diameter of 8 and 10 mm, helical angle of 10 and 20 degrees (°).

Key words: Flow evenness, flute diameter, fluted roller, lentil, seed rate, seed drill.

INTRODUCTION

Lentil is very important for human nutrition because it has a high protein ratio, minerals and vitamins (Bhatty, 1998). It has good digestibility, flavor and high protein content. Lentil has the ability to overcome malnutrition problems of the poor due to its richness in protein (23 to 24%) (Rajput and Sarwar, 1988).

The lentil seeds, with diameters ranging from 2 to 9 mm, are typically lens shaped. The large-seeded types generally have a diameter range of 6 to 9 mm, medium size of 5 to 6 mm, and small size of 3 to 5 mm. Amin et al. (2004) reported that the dimensions of lentil are important to design properly the fluted metering devices in seed drills, the cleaning, sizing and grading machines. Carman (1996) determined several physical properties of lentil seeds as a function of moisture content. The average diameter, thickness, unit mass and volume of seed were 6.64 mm, 2.65 mm, 0.07 g and 49.08 mm³, respectively at 6.5% of moisture content (d.b).

Seed drills with fluted roller are mostly used to drill for wheat, barley and rye. However, these seed drills are also used to drill lentil and some big seeds in Turkey. Seed properties have an important effect on the performance of fluted roller in seed drills.

One important factor in increasing the yield of agricultural products is proper drilling. Successful drilling requires a good emergence together with a longitudinal, transverse and depth uniformity of seed. An even seed

distribution is first based on the performance of the feed mechanisms in seed drills. The considerable differences among the physical properties of various seeds may affect the performance of the feed unit (Bernacki et al., 1972).

Some factors affecting the flow evenness of the fluted roller determined in previous studies were flute diameter, helical angle of flute, active roll lengths, rate of revolution of shaft, flute shape, width of slot and wrapping angle (Turgut et al., 1995, 1996; Ryu and Kim, 1998; Ozsert et al., 1997; Yildirim et al., 2004; Yildirim and Turgut, 2007; Kara et al., 2010).

The objective of this study was to determine the optimum dimensions of fluted roller used in seed drills for lentil seeds. The parameters investigated to determine the optimum dimensions were flute diameter and helical angle of fluted roller at 100 kg ha⁻¹ of practical seed rate.

MATERIALS AND METHODS

The fluted rollers used in the study have different flute diameters (8, 10 and 12 mm) and different helical angle (0, 10 and 20°). This study was conducted with nine fluted rollers made of delrin. The technical properties of the fluted rollers evaluated in the study are shown in Figure 1. The experiments were performed with lentil seeds. The thousand seed mass, bulk density, repose angle and moisture content of lentil seeds used in the experiments were 34.78 g, 818.25 kg m⁻³, 31.25° and 8.60% (w.b), respectively. The

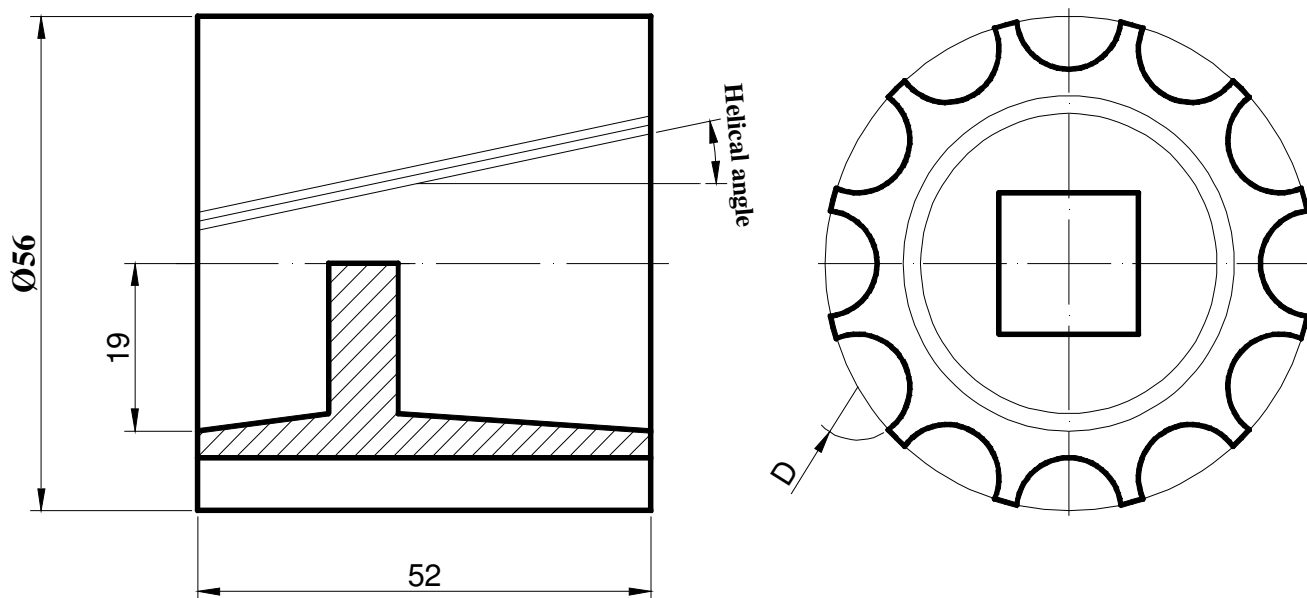


Figure 1. Technical properties of fluted roller used in this study.

average length, width, thickness and value of sphericity calculated based on these three values were 4.73 mm, 4.51 mm, 2.76 mm and 82.23%, respectively.

The experiment was performed on a stationary hopper of seed drill in the laboratory. The study was conducted for the ground speed of 1.5 m s^{-1} and inter-row distance of 0.20 m at seed rate of 100 kg ha^{-1} . All combinations of flute diameter and helical angle of flute were tested for active roll length of 15 mm. The revolution rate of feed shaft was controlled by a variable speed motor to obtain the seed rate of 100 kg ha^{-1} at each combination for active roll length of 15 mm.

The coefficient of variation (CV) was used to evaluate the flow evenness of the fluted rollers using lentil seeds. Each combination was performed with three replications, and lentil seeds discharged fluted roll were weighed cumulatively by a balance with a sensitivity of 0.01g. Weighing values recording with 0.1 s of interval by precision balance were transmitted simultaneously to a PC with a continuous stream by RS 232 C interface circuit of the balance. A total of 200 values for each replication were evaluated to calculate the CV values, and thus, the lentil seeds discharged along the row of 30 m were taken into consideration. Analysis of variance (ANOVA) was used to determine the effects of flute diameter and helical angle on the flow accuracy of lentil seed. The measurements of treatments were compared using Duncan's multiple range tests at the 0.01 significance level.

RESULTS AND DISCUSSION

The results of analysis of variance are the CV values obtained from each replication as shown in Table 1. As seen in Table 1, flute diameter and helical angle have a significant effect ($P < 0.01$) on CV values, and therefore the flow accuracy of lentil seed.

The results of Duncan's multiple range tests are shown in Table 2. According to Table 2, as the fluted diameter increased, the CV values increased too. Although, the minimum CV was obtained from 8 mm of flute diameter,

there was no significant different between 8 and 10 mm of flute diameter, statistically. The CV values obtained from the helical angle and flute diameter had a negative relationship. Although, the CV values increased as the flute diameter increased, the CV decreased as the helical angle of rollers increased. The lower the CV value, the lower the flow accuracy, which was obtained from helical angle of 0° . However, all the average CV values are within acceptable limits for flow evenness (6.82 to 10.057%). Even the CV values between 5 and 10% were considered "good" (Guler, 2005; Yildirim, 2008a, b). There was no difference between helical angle of 10 and 20° , but the CV value of 10° of helical angle was slightly lower, statistically.

The CV values obtained from each combination of flute diameter and helical angle are shown in Figure 2. According to Figure 2, generally, as the flute diameter increased, the CV values increased. The minimum CV values for each flute diameter were generally determined at the 20° of helical angle. However, as can be seen in Figure 2, the CV values for 8 and 10 mm of flute diameter, and 10 and 20° of helical angle were very close to each others.

The values of revolution of axis obtained from each combination of helical angle and flute diameter for 100 kg ha^{-1} of seed are shown in Figure 3. According to Figure 3, as both flute diameter and helical angle were increased, the values of revolution of axis decreased.

Conclusions

The flute diameter and helical angle of the roller on flow evenness of lentil seeds had an important effect. In

Table 1. The results of analysis of variance of lentil seed.

Variation resource	DF	SS	MS	F	P*
Flute diameter (FD)	2	60.447	30.224	42.28	0.000
Helical angle (HA)	2	23.049	11.525	16.12	0.000
FD x HA	4	66.438	16.609	23.24	0.000
Error	18	12.866	0.715		
Total	26	162.800			

*: P < 0.01, at significant level.

Table 2. Duncan's multiple range test results.

Variation resources	Flow evenness (CV, %)
Flute diameter	8 mm 6.829b [√]
	10 mm 6.932b
	12 mm 10.057a
Helical angle	0° 9.2322a
	10° 7.1344b
	20° 7.4511b

[√]: Not significant among figure with the same letter.

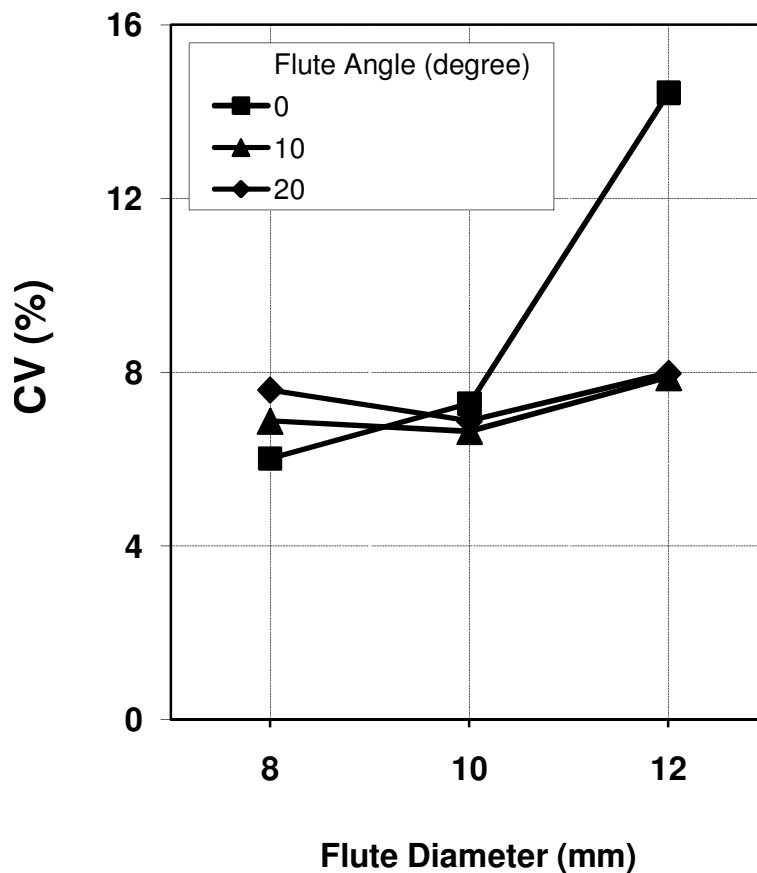


Figure 2. The CV values obtained from flute helical angle and flute diameter combination.

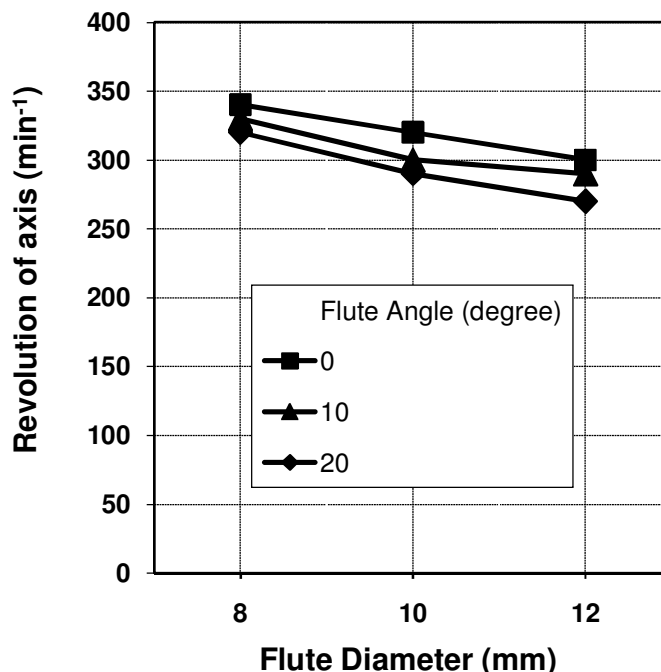


Figure 3. The values of revolution of axis of the seed rate.

addition, the effect of interaction of flute diameter and helical angle on flow evenness was also very important.

The lowest CV values were obtained from the 8 and 10 mm of flute diameter, and the highest values were found in 12 mm. The most proper flow evenness was determined in 10 and 20° of helical angle of fluted roller. To get better flow evenness, the flute diameters and helical angles should be 8 to 10 mm and 10 and 20°, respectively. Finally, the present study showed that the fluted rollers can be used to drill lentil seed in seed drills with the values of flute diameter and helical angle determined in the study.

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