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Analysis of the Effects of Flute Diameter, Fluted Roll Length and Speed on Sesame Seed Flow Using Minitab

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Abstract: In this study, flow rate and flow evenness of sesame seeds from fluted feed rolls in seed drills were investigated using Minitab. The variables are the flute diameter, the active roll length and the rate of revolution. The data obtained from the experiments were analyzed statistically and the graphics of flow rate and flow evenness were presented. In conclusion, in order to get an even flow of sesame seeds from fluted feed rolls, the flute diameter should be 6-8 mm and the rolls should also be run in the active roll lengths of 15-25 mm at the rate of revolution 20-40 min^{-1}.

Key words: Minitab, variance analysis, fluted feed roll, flow evenness

INTRODUCTION

The growth of a new crop begins with the planting of seed or transplanting of seedlings. After planting, seeds must survive on energy stored within the seed until germination occurs and a seedling emerges through the soil surface[1].

The primary objective of any planting operation is to establish an optimum plant population and plant spacing, the ultimate goal being to obtain the maximum net return per hectare. Population and spacing requirements are influenced by such factors as the kind of crop, the type of soil, the fertility level of the soil, the amount of moisture available and the effect of plant and row spacing upon the cost and convenience of operations such as thinning, weed control, cultivation and harvesting[2].

It should be apparent that planter performance cannot control all the factors involved in emergence. But the planter can have an important influence on many of these factors and good planter performance is essential for obtaining an adequate stand with crops whose emergence is critical. Packing of the soil by the planter can affect the availability of moisture, the availability of oxygen and mechanical impedance[2].

One of important factors in increasing the yield of agricultural products is proper drilling. Successful drilling requires a good emergence along 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[3].

The factors affecting the performance of the fluted feed roll were reported as roll diameter and flute number, active roll length, helical angle, rate of revolution, slot width, wrapping angle of the roll and direction of revolution of the roll[3].

The fluted feed rolls used in seed drills in Turkey are designed for large seeds such as wheat and barley. Can be the same roll used for fine seeds such as sesame, changing the flute diameter of the roll? In order to answer this question, this study was carried out. For this reason, fluted rolls with different flute diameter and hence different flute number were manufactured. The rolls were run at five rates of revolution and six active rolls lengths to compare in terms of their effects on the flow evenness and flow rates.

MATERIALS AND METHODS

Mathematical method: We used Minitab for our analysis. Minitab is a statistical program with a spreadsheet-like data worksheet. It is capable of manipulating and transforming this data and can produce graphical and numerical summaries. Minitab also allows us to perform a wide variety of statistical computations. Accessing Minitab's commands can be done through menus and dialog boxes. We use following linear mathematical model[4].

$$y_{ijkl} = \mu + a_i + b_j + c_k + (ab)_{ij} + (ac)_{ik} + (bc)_{jk} + e_{ijkl}$$

Where, y_{ijkl} are observation values, μ is mean of populations, a_i, (i = 1,..., 3) are flute diameters, b_j, (j = 1,..., 6) are active roll lengths, c_k, (k = 1,...., 5) are rates of revolution and e_{ijkl} show distribution of normal error terms(NID~0,σ^2e).We have also use variance analysis package of Minitab.

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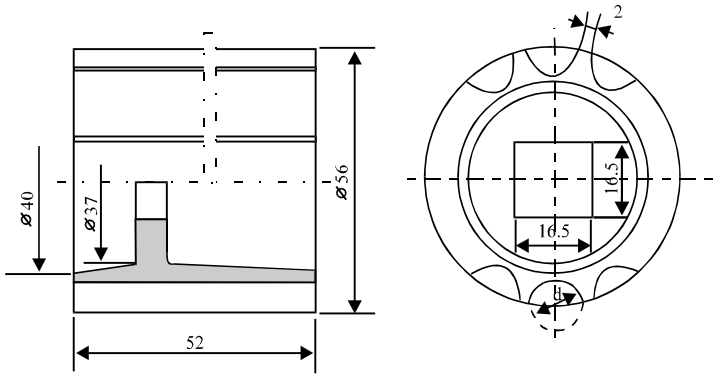

Fig. 1: Some constructive properties of fluted rolls used in the tests

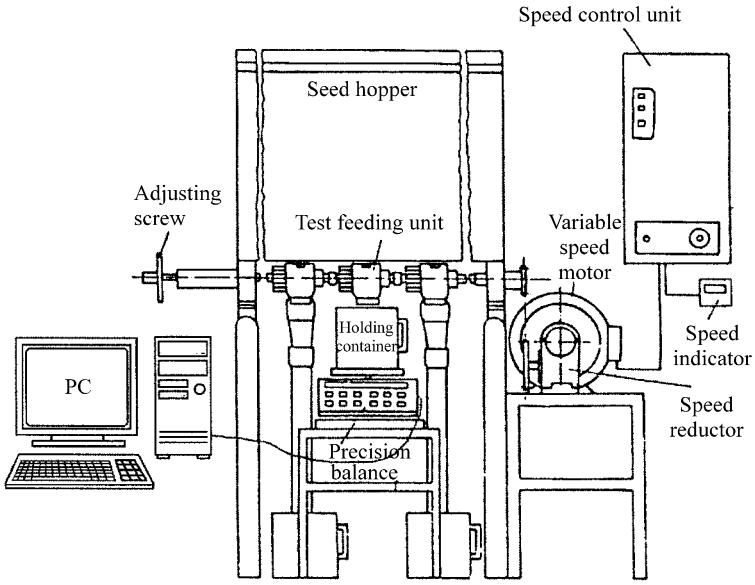

Fig. 2: Measurement setup

Materials: Three fluted rolls were manufactured out of delran and tested in the same feed unit together with aluminum rings in proper sizes. The diameter (D) of the rolls was 56 mm. The flute diameters (d) of the rolls were4, 6 and 8 mm, the number of flute were 29, 22 and 17 (Fig. 1).

As a variable, the diameter of flute was selected between 4, 6 and 8 mm, because of the constructive limitation of the constant diameter of the roll.

The width of the slot between the roll and the bottom plate of the feed unit was 4 mm, the angle between the end of the bottom plate and vertical axis was 47°. The sesame variety of Southeast native was used in the tests. The length of seeds is 3.49-3.83 mm, width 1.82-2.00 mm, thousand kernel weight 3.72 g, bulk density 628 kg m^{-3}.

Methods: The tests were conducted with the aid of a test stand including a variable speed motor, speed control unit and speed monitor (Fig. 2)[5]. Each roll was run for six active flute lengths and five rates of revolution with sesame seeds. The active flute length varied from 5 to 30 mm with increments of 5 mm and the rates of revolution varied from 10 to 50 min^{-1} with increments of 10 min^{-1}. Each test was replicated three times.

During the tests the precision balance was placed just under the feed unit and the material flowed from the feed roll was weighed continuously and cumulatively by a precision balance and the data were transmitted to PC in a continuous stream by the RC 232 C interface circuit of the balance. The balance can automatically weigh in accuracy of 0.01 g and its transfer rates are selectable from 300 to 4800 bauds[6,7]. The seeds of sesame were clean.

The time of scaling-recording was selected as 0.1 s in order to weigh the material as it flowed. For each test, at least 250 scale values were taken from the balance and the seed flow along a 35 m row was determined[8].

RESULTS AND DISCUSSION

Flow rates (g s^{-1}) and flow evenness (CV %) were determined for each roll. The analyses of variance for

Table 1: The variance of analysis of sesame for flow rates (g s^{-1}) and flow evenness (CV %)

	Flow rates				CV %		
Source	DF	MS	F	P	MS	F	P
Flute Diameter (FD)	2	0.21188	2595.63	0.000	394.79	426.19	0.000
Active Roll Length (ARL)	5	0.55150	6756.21	0.000	651.52	703.35	0.000
Rate of Revolution (RR)	4	0.79677	9760.92	0.000	876.95	946.70	0.000
FDXARL	10	0.00683	83.68	0.000	25.59	27.63	0.000
FDXRR	8	0.01311	160.60	0.000	4.59	4.96	0.000
ARLXRR	20	0.03202	392.23	0.000	61.37	66.26	0.000
Error	220	0.00008			0.93		

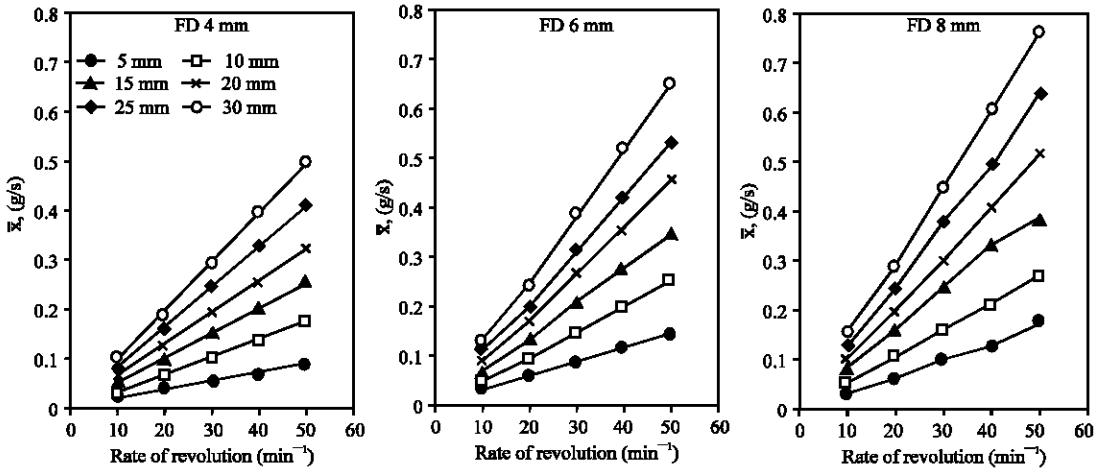

Fig. 3: Curves related the flow rates in the rates of revolution and different active roll lengths for sesame

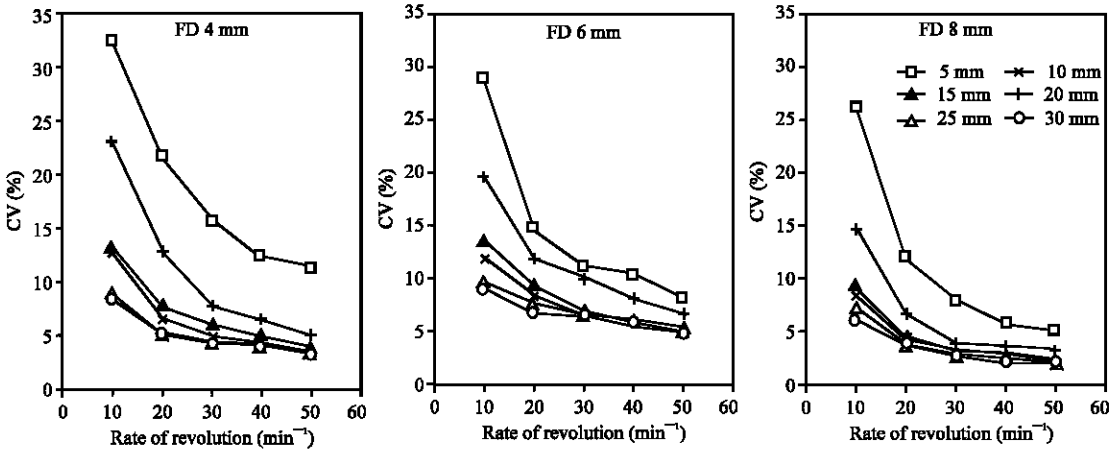

Fig. 4: Curves related the CV % values in the rates of revolution and different active roll lengths for sesame

these values are presented in Table 1. This table showed that, the flute diameter and active roll length and the interactions had a significant effect ($p<0.01$) on flow rates and flow evenness. Additionally, the performance curves obtained from these values are presented in Fig. 3 and 4.

In general, the flow rate increased as the flute diameters the rates of revolution and the active roll lengths increased. The flow rate values were between 0.022 and 0.76 g s^{-1} (Fig. 3).

The values of CV % varied from 1.87 to 32.38. The values of CV between 10 and 20% were considered "acceptable", the values between 5 and 10% "good" and the values less than 5% "very good". The values of CV decreased with increases in the flute diameter and rate of revolution (Fig. 4). In general, the CV values obtained from the tests were within the acceptable limits. But, only the values of CV obtained from the roll with flute diameter of 4 mm were above 20% for the rates of revolution

of 10 and 20 min^{-1} and the active roll length of 5 mm. The former studies had also emphasized that the flow evenness decreases with increases in the active roll lengths, flute diameter and rate of revolution[5,8,9].

In order to obtain an even flow for sesame seeds, fluted feed rolls with flute diameter of 6 and 8 mm should be run in active roll lengths of 15-25 mm at the rates of revolution of 20-40 min^{-1} (Fig. 3 and 4).

CONCLUSIONS

Finally, in order to get an even flow for the drilling of sesame seeds, flute diameter should be 6-8 mm and the rolls should be used and these rolls should also be run in active roll lengths of 15-25 mm and rates of revolution of 20-40 min^{-1}.

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