Flow accuracy of existing 10 mm flute diameter feed roller for high speed sowing of soybean

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ABSTRACT: The flow accuracy of exiting fluted feed roller for high speed drilling of soybean was studied. In this study a 10 groove fluted roller of 49 mm diameter, 10 mm flute diameter and 40 mm exposure length was tested for soybean seeds (JS-9560). The flow accuracy was measured at four fluted roll speed i.e. 20, 30, 40 & 50 rpm and three positions of width of slot between the roller and the bottom plate of the feed unit (WS) at full exposure length of the rollers. In conclusion, fluted roll speed had a significant effect on the flow evenness. The metering mechanism can be used as a high speed metering mechanism. The best result for seed flow accuracy was obtained for the flute speed of 50 rpm (9.9-11.9 km/h for 150 kg/ha seed rate) and 3rd WS position.

Key words: Cv**,** fluted roller, flow accuracy, soybean seed

Soybean-wheat is the third largest cropping system in India as per the area coverage. This cropping system is prevalent in Madhya Pradesh, Rajasthan, Maharashtra and adjoining Gujarat. The total area covered under this cropping system varied between 10.69-12.40 million ha during year 2013-14 to 2015-16. The area under cultivation is mostly under rainfed. In Madhya Pradesh it is grown in black soil (vertisols). After first two to three showers, the seed bed is prepared because the dry black soil becomes very hard due to high clay content. After seed bed preparation, the sowing is performed. In excess moisture black cotton soil behaves like plastic having low strength and becomes sticky. It leads to power source not able to generate requisite traction in field and sowing cannot be performed. The window for sowing is very small for soybean. Delayed monsoon onset or consecutive rainfall leads to delayed sowing and low yield. The timeliness of operation is required for optimum benefit from soybean farming.

Soybean seed can be sown by seed drills and pneumatic precision sowing machines. However, the prices of seed drills are lower as compared to pneumatic precision sowing machines. Additionally, these machines require less technical skill for use. One of the most important reasons for preference of the seed drills with fluted roller is to be able to sow in narrow spacing for seeds such as soybean, wheat, barley and maize. But, the pneumatic precision drills cannot do this due to the constructive properties (Ess *et al*., 2005). The number of seed-cum-fertilizer drill used in India increased from 1.01 million in 2003-04 to 2.85 million in 2013-14 (Tyagi *et al*., 2010). In Indian farming, the maximum speed of sowing is 3-5 km/h depending upon seed bed conditions and type of seeds. The timeliness of sowing operation can be done either by increasing width of machine or by increasing speed of sowing/planting. The increase in width of machine requires more headlands for turning, so increase in speed of sowing/planting is promising option for higher coverage area of sowing.

The higher speed of seeding machine requires higher amount of seeds to be delivered per unit time compared to lesser speed of the machine. The higher amount of seed delivery per unit time can be achieved by increasing speed of fluted roller, exposure length, flute diameter, fluted roller diameter and number of flutes. Different researchers have investigated seed flow accuracy of fluted roller metering mechanism for high speed sowing using different seeds. Yildirim and Kuş (2013) evaluated nine fluted rollers with the groove diameter of 18, 20, and 22 mm and groove helical angles of 0, 10, and 20° and determined seed flow accuracy for soybean seed. The fluted rollers used in the study were operated at the feed shaft speeds of 8, 13, and 18 rpm (therefore, at the ground speeds of 3.6, 5.4, and 7.2 km/h). They concluded that the flow accuracy gets worse as the flute diameter was increased and better as the helical angle of the flute and the speed of feed shaft was increased. In this regard, the optimum dimensions for the best seed flow accuracy were obtained from the flute diameter of 18 mm, the helical angle of 20°, and at the feed shaft speed of 18 rpm. Konak *et al.* (1992) studied the effect of the forward speed (1.8, 3.6 and 5.4 km/h) on the uniformity of row space distribution for dry bean and chickpea using fluted roller, studded roller, and big seed roller and found that all of the metering devices used for the study are suitable for seeding dry bean at the forward speed of 3.6 km/h only and suitable for chickpea at all the forward speeds. Parish *et al.* (1999)

developed a prototype precision seed drill, relatively inexpensive, which is be able to sow in narrow row according to the demands of soybean producers. The laboratory and field experiments were performed to compare this prototype with seed drill with metering devices of fluted roller. According to the results of the experiments, the prototype developed was not better than seed drill with metering devices of fluted roller.

In India different sizes of fluted rollers were used for sowing of different seeds. One of the commercially available fluted roller with 10 grooves, 49 mm fluted roller diameter, 10 mm flute diameter and 40 mm exposure length is used for sowing of soybean and like seeds at 3-5 km/h forward speed. The suitability of this fluted roller for high speed sowing needs to be investigated so that farmers can sow their seeds at higher speeds. In this context the study was undertaken to investigate the flow accuracy of soybean for existing fluted feed roller in a stationary seed drill.

MATERIALS AND METHODS

The flow accuracy of soybean JS-9560, which is a common variety of soybean grown in Madhya Pradesh was investigated using an existing small fluted feed roller in a stationary laboratory seed drill setup. Some physical properties of soybean are shown in Table 1. Soybean is sown in row distances of 225-450 mm and the rates of 80-100 kg/ha based on the weather and date of sowing. The row distance of soybean was selected 450 mm according to the values used in practice. Table 2 shows the amount of soybean seeds to be sown (g/s) for seed rate of 80-120 kg/ha, speed of operation 2.5- 10 km/h and row to row spacing 450 mm. Late sowing of soybean due to monsoon and based on soybean seed quality farmer also adopts higher seed rate up to 150 kg/ha, hence this seed rate also was included in this study.

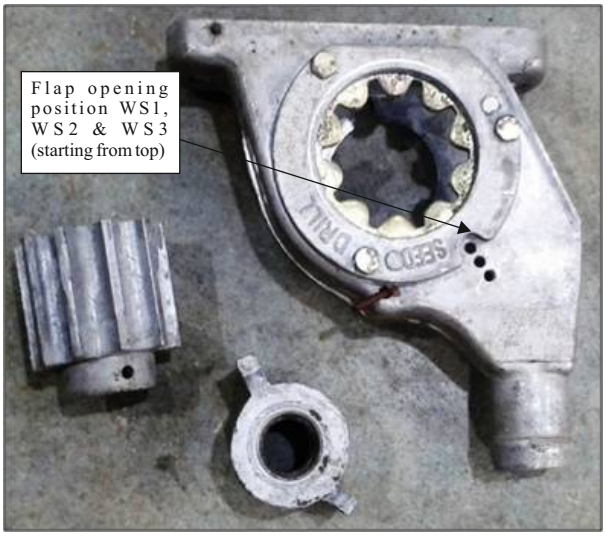

Fig. 1: Fluted roller

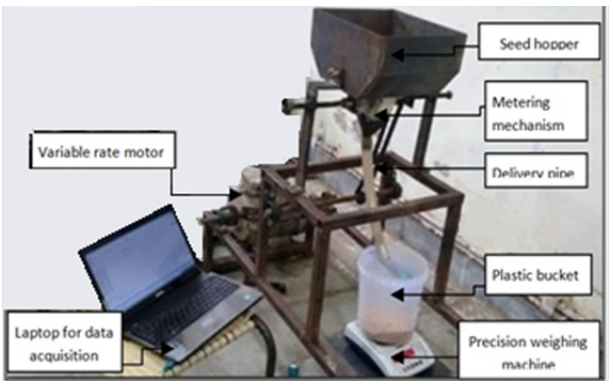

Fig. 2: Laboratry setup for testing of fluted roller

Table 1: Physical properties of soybean (Variety – JS-9560) used in tests

1000 kernel weight (g)	104.22
Moisture content, db (%)	9.43
Repose angle (°)	27.12
Bulk density(kg m^{-3})	772
length (mm)	6.4 ± 0.6
Width (mm)	6.3± 0.5
Thickness(mm)	4.2 ± 0.5
Sphericity	0.83 ± 0.1

Table 2: Weight of seed required to be delivered at different speed and different seed rate per unit time for 450 mm row spacing, g/s

Forward speed	Seed rate (kg/ha)			
km/h	80	100	120	150
2.5	2.5	3.1	3.8	4.7
5	5	6.3	7.5	9.5
7.5	7.5	9.4	11.3	14.1
10	10	12.5	15	18.8

The fluted feed roller used in the study is shown in Fig.1. The fluted roller was made of 49 mm fluted roller diameter, 10 number flutes, 10 mm flute diameter (U shape) and 40 mm active exposure length. This fluted roller was used in the feed unit at the bottom of the hopper of seed drill. The setup used in lab study is shown in Fig. 2. The different WS positions were adjusted manually among 1, 2 and 3 positions, and the speeds of the feed shaft were adjusted by a variable speed motor. During the tests a precision balance was used and the soybean seed was collected in a plastic container by using a PVC pipe at outlet of fluted roller metering device to determine the seed flow rate of soybean.

The seed flowed from fluted roller metering device for each replication was weighed at an interval of 0.2 s cumulatively by the precision balance having an accuracy of 0.001 g and the data were transmitted simultaneously to a laptop with a

continuous stream by RS 232C interface circuit of the balance. To evaluate the flow accuracy of the fluted feed rollers, the values of variation of coefficient (CV %) were calculated for each replication. Turgut *et al*. (1995) and Özsert *et al.* (1997) reported that the CV values of 0-5, 5-10 and 10-20 were "very good", "good", and "acceptable", respectively. For CV calculation 200 data points for each replication were evaluated for the feed roller speed of 20, 30, 40 and 50 rpm, three WS i.e. 1st, 2nd and 3rd position at full exposure length, respectively. The ANOVA of flow accuracy data was done using SAS 9.3 software.

RESULTS AND DISCUSSION

Flow evenness (CV) and flow rate (g/s) were determined for fluted roll at four fluted roll speeds and three WS positions at full exposure length. The performance curves for these values are given in Fig. 3. The designer might choose the operational properties and desirable flow evenness within an acceptable flow range by using performance curve. It is possible to get the same flow rates and hence application rates with different combinations of active roll length and flute roll speed for any desirable CV values of flute diameter. In general, the CV decreases (flow evenness improved) with increase in the roll speed and decreases with increase in the WS positions for soybean seeds. Previous studies also reveal that flow evenness improved with increased fluted roll speed (Yildirim and Kuş, 2014 & 2016).

The CV varied between 9.6% - 17.9% and flow rates varied between 8.1 - 22.1 g/s for soybean seeds. As seen from the performance curves, the same flow rate can be obtained with different operation conditions and different fluted roller constructive properties. Therefore, the acceptable flow range which can be used for high speed seeding should be taken into consideration. The result of variance analysis shows (Table 3) that the effect of speed of fluted roller on flow accuracy were found highly significant (α=0.01). Whereas, the effect of WS positions on flow accuracy was not found significant. The analysis of result also shows that combine effect of interaction of speed of fluted roller and WS positions on flow accuracy was also not significant.

Considering, the good flow range, the CV for fluted roll speeds of 50 rpm and for 3rd position WS for soybean seeds were within range of 5-10%. The CV was also in acceptable range for other test conditions i.e. 10-20% (Table 4). At lower fluted roll speeds, flow will be irregular due to increased pulsation and hence higher CV was observed.

The relationship between seed rate and CV at different WS positions is shown in Fig. 4. The values of seed rate were calculated for different level of acceptability of CV. The corresponding forward speed of tractor/prime mover was calculated using Table 2. The range of seed rate and

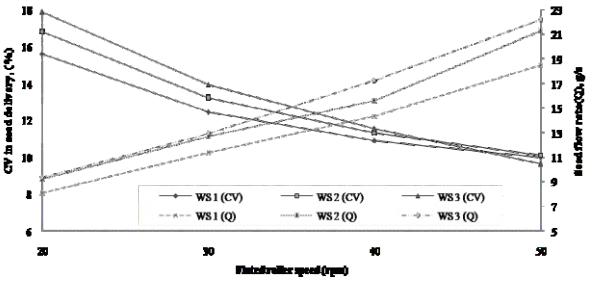

Fig. 3: CV and seed flow rate at different fluted roller speed and WS

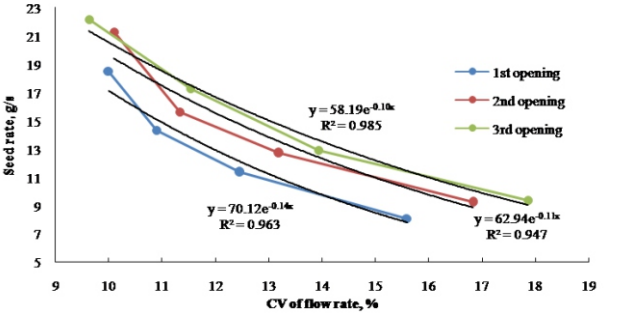

Fig. 4: Relationship between seed flow rate and CV at different WS

Table 3: The results of Duncan multiple test analysis of variance

Source	DF	Mean Square	F Value	Pr > F
WS	2	3.06	3.77	0.0377
Speed of fluted roller	3	79.87	98.27	<.0001
WS * Speed of fluted roller	6	0.97	1.19	0.3433
Error	24	0.81		
Parameter	**Speed of fluted roller**			
Mean value	20 rpm	16.7667[a]		
	30 rpm	13.2000[b]		
	40 rpm	11.2556[c]		
	50 rpm	9.9111[d]		

Table 4: Seed rate (g/s) and forward speed (km/h) at different level of acceptability of CV

CV range, % (acceptability)	Width of slot*, mm	Seed rate, g/s	Speed range of sowing for different sowing rate, km/h			
			80 kg/h	100 kg/h	120 kg/h	150 kg/h
5-10(Good)	1	17.1-34.7	17.1-35.1	14.4-28.4	13.2-24.5	9.1-18.7
	2	19.5-35.1				
	3	20.6-34.6				
10-20(Acceptable)	1	4.2-17.1	4.2-17.1	3.8-14.4	3.1-13.2	2.2-9.1
	2	6.1-19.5				
	3	7.3-20.6				
>20	1	<4.2	<4.2	<3.8	<3.1	<2.2
	2	<6.1				
	3	<7.3				

Table 5: Roller speed, seed rate, CV% in seed rate and forward speed of seed drill at different seed rate

Roller speed	Seed rate,gm/s	CV %	Forward speed for different seed rate (kg/ha), (km/h)			
			80	100	120	150
20	8.05-9.36	15.6-17.9	8.1-9.4	6.4-7.5	5.3-6.2	4.3-5.0
30	11.35-12.89	12.5-13.9	11.4-12.9	9.1-10.3	7.5-8.6	6.0-6.9
40	14.33-17.27	10.9-11.5	14.3-17.3	11.5-13.8	9.5-11.5	7.6-9.2
50	18.5-22.27	9.6-10	18.5-22.3	14.8-17.8	12.3-14.8	9.9-11.9

forward speed in different level of acceptability of CV is shown in Table 4. The seed rate was found to be 17.1-35.1 g/s and 4.2-17.1 g/s for good and acceptable range of CV, respectively.

The fluted roller speed and corresponding seed rate, CV% in seed rate delivered by single fluted roller with respect to time, seed rate and forward speed of seed drill at different seed rate is shown in Table 5.

CONCLUSION

The flow accuracy gets better as the speed of feed shaft increases and WS decreases. The studied fluted roller based seed drill will be capable of sowing of soybean seeds (JS-9560) at 4.2-35.1, 3.8-28.4, 3.1-24.5 and 2.2-18.7 km/h at full exposure length at seed rate of 80, 100, 120 and 150 kg/ha, respectively. In this study, the best values for the seed flow accuracy were obtained for the flute speed of 50 rpm, full exposure length and at 3rd WS position. The flow accuracy was in the acceptable range for the forward speed range of tractor 4.2-17.1, 3.8-14.4, 3.1-13.2 and 2.2-9.1 km/h at seed rate of 80, 100 120 and 150 kg/ha, respectively.

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