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A Evaluation of Soybean Thresher for Chickpea Crop

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ABSTRACT

This research project was conducted to optimize decisive operational and parameters of crops that affecting the threshing capacity of seeds of chickpea crop. Drum speed and feed rate were taken as independent parameters and threshing efficiency, mechanical grain damage and cleaning efficiency were observed as dependent parameters. Speed of drum was found to be the most vital factor influencing threshing efficiency, cleaning efficiency and visible seeds damage. As speed of drum increases from500 to 700 rpm, threshing efficiency increased from 83.95 to 93.54%, cleaning efficiency increased from 69.21 to 79.93% and grain damage increased from 2.35 to 2.94%, while increasing feed rate threshing efficiency, cleaning efficiency and grain damage decreased. Hence, the recommended treatment combination was 700rpm and 15kg/min at mean moisture content of 11.5%, as amongst the selected treatment the threshing capacity and threshing efficiency were maximum. At this combination the percentage of threshing capacity, threshing efficiency, cleaning efficiency and grain damage were 443.2kg/hr, 95.05%, 74.65% and 3.71% respectively.

***Keywords:** Thresher, Performance, Threshing efficiency, Cleaning efficiency and grain breakage.*

1. Introduction

The production of pulse crop has remained almost immobile and the crop area has decreased considerably in our country. Less production and increasing of demand have led to increase the price of pulse crop. Chickpea and haricot bean is very crucial pulse crop in Ethiopia. Chickpea (*Cicer arietinum L.)* is the most essential food legumes for consumption in the world.

Chickpea is produced in a range of crop systems and diverse environmental regions (FAO, 1999). The successful production and good marketability of these crops depend on both quantity and quality of the crop. To increase seed production with good quality feasibility of threshing machine must be for chickpea seed threshing and selecting the optimum operating conditions.

Since chickpea seed being dicotyledonous it is sensitive to mechanical damage. Conventionally, chickpea is threshing were carried out by trampling animals on a prepared threshing ground which is labour intensive, tedious and time consuming. The available mechanical threshing machines in the markets are mostly for crops like wheat and paddy. Threshing machines for seeds having pod pulse crops, like haricot bean, soybean, chickpea, field pea, and cowpea, still had not been available in the market.

Therefore, scholars had tried to use the available wire loop cylinder type paddy threshing machine with (Devnani, 1976), rasp bar or peg tooth cylinder type wheat threshing machines(Kulkarni and Singh, 1986) and peg tooth cylinder axial flow threshing machinery as multi-crop threshing machine for threshing haricot bean, chickpea, and other pulse crops (Majumdar, 1985).

However, substantial amount of mechanical damage was recorded. Nonetheless, due to changing of the operational parameters of threshing, visible mechanical seed damage was recorded. Hence, having those evidences, this research project was carried out with objective to optimize and determine essential operational circumstances affecting the quality of chickpea seed crops and threshing efficiency.

2. Materials and Method

Plot Thresher

Locally made plot threshing machine (Fig. 1) was brought for the experiments. It consists of types of wire loop drum, cleaning unit, separating and concave. The drum consisted of total 32 wire loop, and positioned 52 mm away from each other in staggering manner along six rows. The power source used was Diesel engine of 10 hp. The sets of V-belts and pulleys arrangements were used to transmit power from engine to the threshing drum and cleaning system.

Fig.1. Photograph of thresher at study area

Crop

Chickpea (*Cicer arietinum L.)* was taken for the study. Field test were conducted for chickpea crop threshing in a private farm during planting season of 2015. All experiments were conducted using plot threshing machine.

Machine performance

The chickpea thresher was evaluated in terms of threshing capacity (kg/hr), grain breakage percentage (%), threshing efficiency (%) and cleaning efficiency (%)in order to check its performance using the following equations,

$$\text{Threshing capacity (Kg/hr)} = \frac{W}{T} \qquad (1)$$

Where: W = Weight of threshed grains (kg), T = Time consumed in threshing (h).

$$\text{Percentage of grain brakege (\%)} = \frac{B_g}{T_g} \times 100 \qquad (2)$$

Where: B_g = Broken grain (Kg), T_g = Total weight of sample grain taken from main outlet (Kg)

$$Threshing\ efficiency, \% = \frac{T_g - U_g}{T_g} \times 100 \qquad (3)$$

$$Cleaning\ \ efficiency\ ,\% = \frac{W}{W_O} \times 100 \qquad (4)$$

Where: U_{g} = Weight of un threshed grains (Kg), W = Weight of grains from the main output opening after cleaning (Kg), W_o = Weight of grains and small chaff from the main output opening, (Kg).

3. Design of Experiment and Analysis of Data

The performance tests of the plot thresher was conducted for chickpea crop at different three levels of drum speeds and three different levels of feed rates using randomized complete block design (RCBD).

The design was laid as a 3x3 factorial experiments with three replications in each treatment and comparison between treatments means at least significance difference (LSD) at 5% level was conducted. The drum speeds of 500, 600 and 700 rpm and feed rates of 5, 10 and 15 kg/min were considered for experiment at moisture content of 11.5 % (db).

4. Results and Discussion

The thresher machine performance is discussed in this section. The thresher performances were evaluated at various drum speed and feed rate at constant moisture content of 11.5% for chickpea in terms of threshing capacity, threshing efficiency, cleaning efficiency and percentage of grain breakage.

Threshing Capacity

The drum speed effect and different levels of feed rate on grain throughput capacity are given in figure 2. As the result indicated, with the drum speed and level of feed rate, throughput capacity of the machine tends to increase. The higher the feed rate and at an increase in speed, throughput capacity increases. A high throughput capacity of 443.2kg/hr was obtained at the highest speed of 700rpm and highest feed rate of 15kg/min. The value of feed rate in figure 1 indicates that there is a close relationship with grain throughput capacity. The R^2 values for all levels of feed rate indicate that there is a close relationship between the speed and the grain throughput capacity.

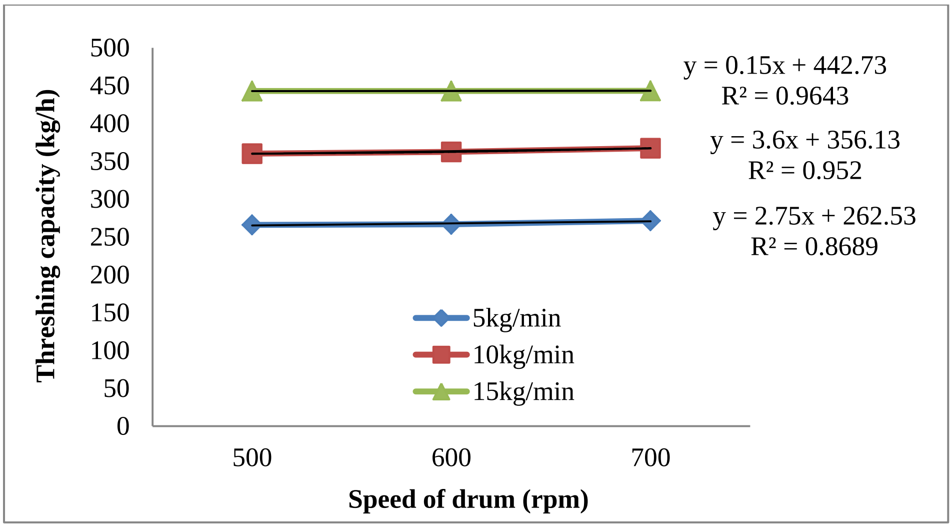

Fig.2. Speed of drum speed Effect on threshing capacity at various feed rate

Threshing Efficiency

The values of percent threshing efficiency at different drum speeds and feed rates have been plotted on Fig 3. As indicated on the figure, it is can be observed that increasing the speed of drum from 500 to 700 rpm increased the threshing efficiency from 85.90 to 93.54, 85.43 to 93 and 83.92 to 92.87 % at feeding rates 5, 10 and 15 kg/min, respectively and constant grain moisture content of 11.5% of crops. The speed of drum effect was significant at 5 percent significance level. However, the feed rate and speed of drum interaction has no significance. Less threshing efficiency (83.92 per cent) was recorded at feed rate of 15kg/min and speed of drum of 500 rpm, whereas the higher threshing efficiency was (93.54 per cent) observed at feed rate feed rate of 5kg/min and speed of drum 700 rpm. Threshing efficiency has direct and inversely relationship with drum speed and feed rate, respectively. This finding agrees with that of Zaalouk (2009) who reported the same trend for haricot bean thresher. According to *Baldev Dogra et al. (2014)*, peripheral speed of threshing drum has positive relationship with threshing efficiency and negatively correlated with the feed rate. The R^2 values of the three feed rate shows that at both feed rates, there is a close relationship between the drum speed and the threshing efficiency.

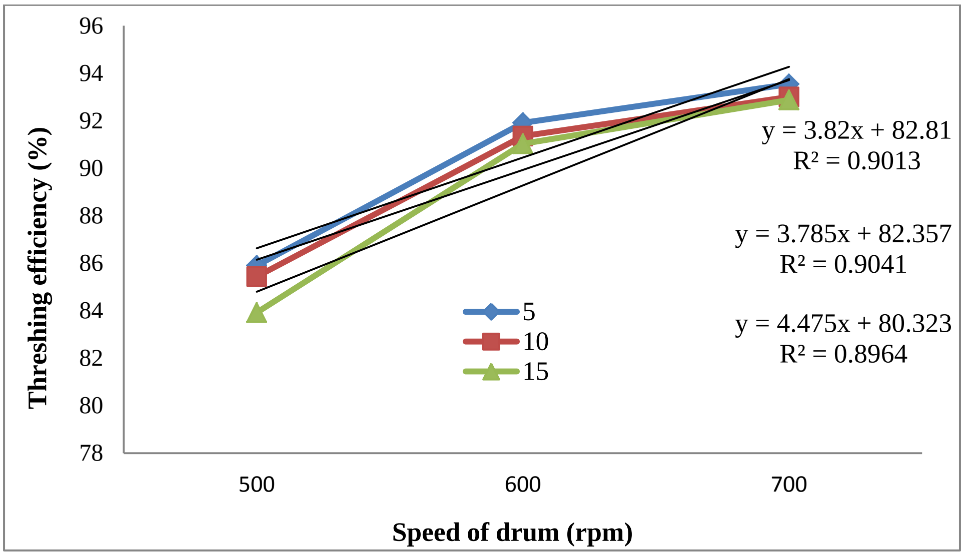

Fig.3. Speed of drum effects on threshing efficiency at various feed rate

Cleaning Efficiency

The three different levels of feed rates and speed of drum effect on cleaning efficiency were observed. The values of percent cleaning efficiency have been plotted on Figure.4.The data for cleaning efficiency were also analyzed statistically. Speeds of drum effect were found to be significant at 5 percent significance level. Nevertheless, feed rate effect and the combination of effect of feed rate and speed of drum were not significant. The result indicated that the cleaning efficiency ranged from 69.21 to 79.93 at 500rpm and 15kg/min and 700rpm and 5kg/min, respectively (Fig.4). Cleaning efficiency has direct relationship to the drum speed, i.e. as drum speed increases, the cleaning efficiency also increased, and it decreased as the feed rate increases. Since threshing drum and blower were driven by threshing drum, cleaning efficiency were increased with increase in drum speed. Therefore, increasing the threshing drum speed increases separation of the material other than grain. Further, cleaning efficiency decreased with the increase in feed rate, as at higher feed rates, frequent choking occurred. Baldev Dogra *et al(*2014) reported that, the same trends of cleaning efficiency has positive relationship with peripheral speed , mean that. as peripheral speed increases , it tends to increase cleaning efficiency , but as feed rate increases it decreases cleaning efficiency. The R^2 obtained for the three feed rate shows a close relationship between drum speed and the cleaning efficiency.

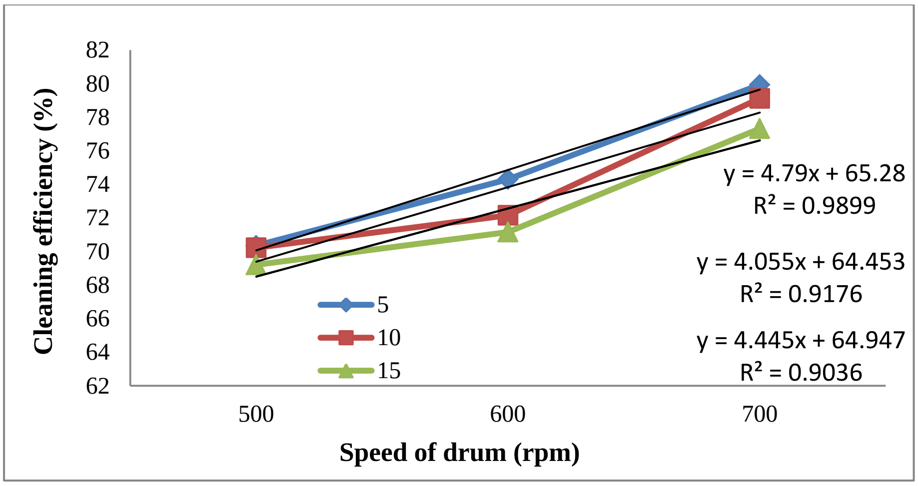

Fig.4. Drum speed effect and feeding rate on cleaning efficiency

Percentage of Grain Breakage

The three different levels of speed of drum and feed rates effect were studied on seed damage. The percentage breakage at three level of speed of drum and crop feed rate is indicated in Figure 5. The result shows that grain damage was proportional to the speed of drum and negatively related to feed rate. The speeds of drum effect on percentage of seed breakage were significant at 5 percent significant level. Nonetheless, feed rate and its combination effects on percentage of grain breakage were not significant. The percentage of grain breakage ranges from 2.35 to 2.94. The minimum seed damages of 2.35% was obtained at and higher feed rate (15 kg/min) and 500 rpm r speed of drum, whereas maximum damage of 2.94% was obtained at higher drum speed of 700rpm and lower feed rate (5 kg/min). Zaalouk (2009) reported that increasing the speed of drum from 11.72 to 15.38 m/s tends to increase the seed damage from 2.40 to 2.90, 1.95 to 2.51 and 1.89 to 2.17 % at different feed rates of 10, 15 and 20 kg/min respectively and at constant grain moisture content of 10.5%. Seed damage was observed to be higher at higher drum speed because of higher combination effect of rubbing force and impact force (Neeraj and Singh, 1988).

The percentage seed damage was higher at minimum feed rate because of greater threshing members impact. The particle velocity and rigidity are the factor affecting breakage in grain mechanical handling (Paulsen, 1978 and Paulsen *et al*, 1981). According to Anwar and Gopta (1990), the seed breakage percentage tends to increase as speed of drum increases at all feed rates and the average seed breakage was found to be decreased as the feed rate increases. Baldev Dogra *et al.(*2014) found that, the lower seed damage of 0.64 per cent was recorded at minimum peripheral speed (16.4m/s) and maximum feed rate (1000 kg/h), whereas seed damage were the higher at maximum peripheral speed (21.9m/s) and lower feed rate (700 kg/h). The R^2 values of feed rate 15 and 10kg/min i.e. 0.9119 and 0.9891 indicates that there is a very close relationship between the cylinder speed and the mechanical grain damage while the R^2 value of feed rate 5kg/min, which is equal to 1.00 shows a perfect or linear relationship between the drum speed and the mechanical grain damage.

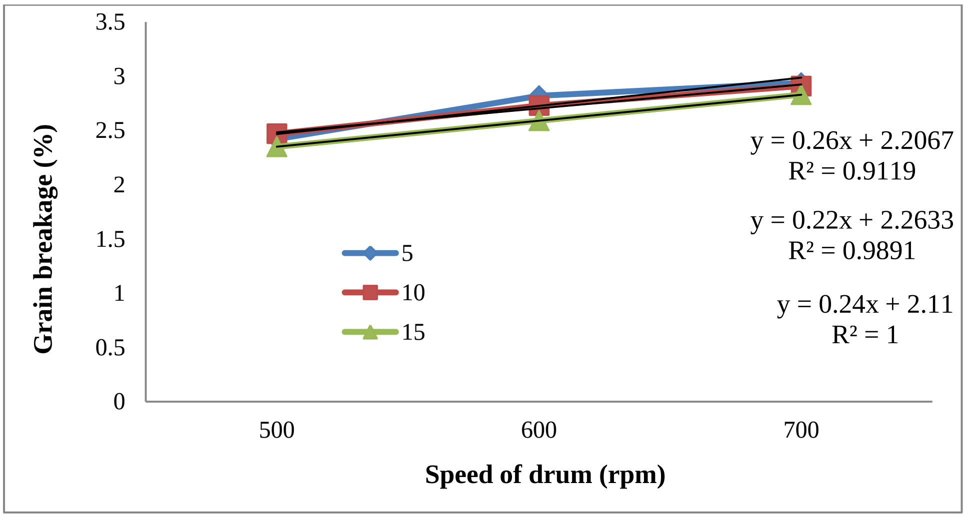

Fig.5. Effect of speed of drum and feeding rate on percentage of grain breakage

5. Summery and Conclusion

The feed rate and drum speed effect on dependent variables *viz.*, grain breakage, cleaning efficiency and threshing efficiency, were determined. The criteria adopted to have best combination of factors were that the cleaning efficiency and threshing efficiency should be the higher and percentage of seed damage should be at recommended level.

Drum speed and feed rate plays a vital part in quality of threshed chickpea seed. Speed of drum has a significant effect on threshing efficiency, cleaning efficiency and percentage of grain damage, while feed rate significantly affect threshing efficiency only. Test results indicate that cleaning efficiency, percentage of grain damage, and threshing efficiency were found to be the most critical factors that affected by speed of drum, and. With increasing speed of the drum from 500 to 700 rpm, threshing efficiency increased from 83.95 to 93.54%, cleaning efficiency increased from 69.21 to 79.93% and percentage of grain damage increased from 2.35 to 2.94%, while increasing feed rate, percentage of seed breakage, cleaning efficiency, and threshing efficiency, decreased.

ANOVA revealed that the effect of speed of drum on threshing efficiency, cleaning efficiency and percentage of seed breakage were significant at 5 percent significance level. Nonetheless, feed rate level and the interaction of speed of drum and feed rate level effect were not-significant. Kepner et al. (1992) reported that four factors are very important when threshing is considered; these factors includes the peripheral speed of the cylinder, the clearance between cylinder and concave, crop maturity and the feed rate. Hence, the recommended treatment combination was 700rpm and 15kg/min at mean moisture content of 11.5%, as amongst the selected treatment the threshing capacity and threshing efficiency was maximum. At this combination the percentage of grain breakage, cleaning efficiency, threshing efficiency and threshing capacity were 3.71%, 74.65%, 95.05%, and 443.2 kg/hr, respectively. Baldev Dogra (2014) reported, speed of drum of 18.2 m/s and 1000 kg/h feed rate lead to finest percentage of cleaning efficiency and threshing efficiency and minimum percentage of grain breakage.

6. Recommendations

From the performance test result and analysis of soybean thresher and so as to increase its performance, the following recommendations should be well-thought-out: (1) To increase the threshing capacity, concave clearance, hopper inlet opening mechanism should be improved, (2) The pegs of the drum should be rubber coated to decrease grain breakage.

Declarations

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This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The authors declare no competing financial, professional and personal interests.

Ethical Approval

Not Applicable.

Consent to participate

The consent to participate in this research was sought for and approved by the subjects to be used.

Consent for publication

Authors declare that they consented for the publication of this research work.

Availability of data and material

Authors are willing to share data and material according to the relevant needs.

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