

Quantitative losses of multi crop thresher for millet as affected by different operating speeds and feeding rates

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Abstract: An experiment carried out in private farm at Al Fula during the harvesting season of 2021/2022. The objective of the study was to investigate the effect of different speeds (650 rpm, 550 rpm and 300 rpm) and feeding quantities (13 kg, 11 kg and 6.5 kg) on the different losses of multi crop thresher for millet. Evaluated performance parameters were cleaning efficiency, threshing efficiency, cracked grains losses, unthreshed grains losses and blown grains losses. The results indicated that speed of 650 rpm and feeding quantity of 11 kg led to a significant increase in cleaning efficiency and cracked grains losses. While, the speed of 300 rpm and quantity of 6.5 kg showed a significant increase in the unthreshed grains with 0.08% and 0.06%, respectively and blown grains with 0.023% and 0.020% with the previous same respect. However, threshing efficiency was not significantly affected by different levels of speed and feeding rate. It can be concluded from the obtained results, optimum combination of different speeds and feeding quantities for attaining better thresher performance in terms of increasing efficiency and minimizing grain losses is the speed of 550 rpm and feeding quantity of 11 kg.

Keyword: millet, thresher, cleaning efficiency, cracked grains, unthreshed grains

Citation: Suliman, A. H., A. B. Saeed, B. M. A. M., Eisa. 2024. Quantitative losses of multi crop thresher for millet as affected by different operating speeds and feeding rates. *Agricultural Engineering International: CIGR Journal*, 26(4): 45-52.

1 Introduction

Pearl millet (*Pennisetum glaucum*) is a staple food grain in Western Sudan. It grown mostly in rain-fed sector in light soils and it ranks second in terms of both area and volume of crop production after sorghum. Millets are high energy, nutritious foods recommended for the health and well-being of infants, lactating mothers, elderly and convalescents. Millet grains are gluten-free, non-acid forming, consisting of a range of micronutrients. Since they take time to get

digested, it does not lead to sugar blood spike, making it a relatively low glucose food. These features make millet a good choice for people with celiac disease and diabetes (Dayakar, et al., 2022).

In Sudan, Production of millet is still at subsistence level by small holders. Also harvesting operation is done manually (cutting, threshing and winnowing) after completely dryness of the crop. Recently, many farmers are started using a thresher machine due to lower efficiency of traditional threshing methods as well as labor cost and shortage. In thresher all operations (threshing, separating, and cleaning) are performed by the thresher except cutting. As stated by Srivastava, et al. (2006) threshing is breaking grain free from other plant material by applying mechanical force that creates a combination

Received date: 2024-02-06 **Accepted date:** 2024-05-23

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of impact, shear, and compression. The operation of separation refers to separating threshed grains from bulk plant material such as straw. The cleaning operation uses air to separate fine crop material such as chaff from grain. An important feature of a machine unit is its performance (Izdebski et al., 2012). There are different parameters which effect on the performance of thresher such as crop parameter (type of crop, moisture content, and straw grain ratio), machine parameter (such as type of drum, peripheral speed of drum and number of rasp-bars and their shape) and operating parameter (such as feeding rate).

The work performed by a thresher should be done in a timely manner with minimum grain losses. Cylinder speed and feed rate are one of the most important variables affecting threshing losses. Saiedirad and Javadi (2011) studied the effect of thresher variables including cylinder speed and feed rate on the percentage of separated seeds and damaged seed. They found increasing cylinder speed from 12.8 to 16.5 m s⁻¹, increased the percentage of separated seeds and damaged seed. Desta and Mishra (1990) when studied the performance of corn threshing machine at three weights and three speeds of the thresher drum, they found by increasing the speed of the thresher drum, both cleaning and threshing efficiency of the thresher increased.

Weerasooriya et al. (2011) reported that average percentage of grain losses were significantly affected by thresher drum speed and crop feeding rate. Ahmad et al. (2013) found that increasing in feed rate decrease the grain damage, the threshing efficiency and cleaning efficiency. As the growing population linked with short in food production, efficiency and accuracy of work are highly needed to maximize machinery performance. Testing and evaluating agricultural machinery play a crucial role in improving performance, productivity, and reducing costs of agricultural operations (Al-Ani, et al., 2016).

The success of a threshing job depends directly upon the manner in which the bundles are pitched into the feeder and the manner of feeding. So, performance knowledge of the thresher with regard to

crop, machine and operating parameters is essential for minimizing both losses and cost. It also improves overall quality and food safety and helps to increase the profits of the growers. In Sudan, this type of machine is widely used for sorghum, so there is lack of information in connection with practical performance data of the thresher used for the millet. Therefore, the objective of this study is to evaluate the effect of different operating cylinder speeds and feeding rates on the different losses of multi crop thresher for millet.

2 Materials and methods

An experiment was carried out during the harvesting season 2021/2022 in the private farm which located in the Eastern part of Alfula city (latitude 10°50' -12°30' N and longitudes 27°40' - 29°E). Within the farm three millet heaps were selected to evaluate the performance of the thresher. The grown millet was a local cultivar.

A tractor of 56 kw (75 hp) (Massy Fergusson) was used to operate the thresher. A thresher (five stars made in Turkey) was selected to perform the evaluation. It consists of; firstly thresher cylinder and semi-circular concave, the cylinder has 44 bars. A locally manufactured concave was used to be suitable for pearl millet. Secondly oscillating sieve for more separation of grain from the straw. Thirdly blower for cleaning, it lifts out the chaff, straw and other light materials. The thresher operational view, construction drawing and technical specifications are shown in figure 1, figure 2 and table 1, respectively.

Prior to the evaluation both tractor and the thresher were checked. Three PTO shaft speeds of 650 rpm, 500 rpm and 300 rpm were selected. The speed was adjusted by tractor engine throttle. A portable scale (25 kg) was used for millet bundles weighing. Three feeding quantities used in the experiment were 13 kg, 11 kg and 6.5 kg. The thresher feeding was done manually through skilled labors using basins. A sensitive electronic balance was used to weigh grain samples. A tarpaulin also placed behind the thresher to collect straw coming out

of the thresher. The direction of the prevailing wind was considered when running the thresher. Actual operating time for each of the test was recorded using a stopwatch.

A complete randomize factorial design was used in the experiment with three replicates. The operating speeds assigned as factor A while the different feeding rates allocated as factor B.

Evaluated performance variables were determined as follows:

Threshing efficiency:

A sample of threshed material was collected, cleaned and weighed. Then unthreshed grains were threshed again manually and weighed. A percentage of threshing efficiency calculated using following equation as suggested by Olaoye et al. (2010).

$$T.E. = 100 - \frac{Q_u}{Q_T} \times 100 \quad (1)$$

Where,

$T.E.$ = threshing efficiency in percentage;

Q_U = quantity of unthreshed grain in the sample (g);

Q_T = total grain in the sample (g).

Cleaning efficiency:

A sample of clean grain was weighed, and then it cleaned again manually. After cleaning, both grain and chaff were weighed and the cleaning efficiency of the thresher was determined using the following formula as stated (Ghonimy and Rostom, 2022):

$$C.E. = \frac{W-w}{W} \times 100 \quad (2)$$

Where,

$C.E.$ = cleaning efficiency in percentage;

w = weight of chaff in the sample (g);

W = total grain sample taken (g).

Cracked grains:

Samples of clean grain were taken randomly from the clean grain and weighed. Cracked grains sorted out manually from each of these samples and weighed. Percentage of cracked grain was calculated using following formula suggested by Alsharifi (2018):

$$G_c = \frac{wc}{W} \times 100 \quad (3)$$

Where,

G_c = percentage cracked grains losses;

wc = weight of cracked grain (g);

W = weight of sample (g).

Unthreshed grains:

Samples of the unthreshed and partially threshed ear heads were sorted out from the straw. Then unthreshed heads were re-threshed manually and the grains recovered were weighed. Then the percentage of the unthreshed loss was calculated using the following formula (Kumar et al., 2016):

$$G_u = \frac{w}{W} \times 100 \quad (4)$$

Where,

G_u = percentage of unthreshed grains;

w = weight of grain separated from un-threshed ear heads (kg);

W = total grain input (kg).

Blown grains:

Straw coming out of the thresher was collected, and then the threshed grain in straw separated manually and weighed. The percentage blown grain was determined using following equation (Kumar et al., 2016):

$$G_b = \frac{w}{W} \times 100 \quad (5)$$

Where,

G_b = percentage of blown grains;

w = weighted of threshed grain obtained at outlet (kg);

W = total grain input (kg).

Data collected were analyzed using Statistix 8 software computer program for analysis of variance and least significant difference (LSD) used to compare treatment means at the 5% significance levels.

3 Results and discussion

3.1 Effect of drum speed and feeding rate on cleaning efficiency

The result of analysis revealed the cleaning efficiency is significantly increased with speed increased (Figure 3). The highest value of cleaning efficiency was obtained at the speed 650 rpm (99.9%) followed by the speed 550 rpm (99.2%), while the

lowest value of 93% was obtained at the speed of 300 rpm. An increase in cleaning efficiency with speed increase could be attributed to the increasing efficiency of blowing fan when operating at higher speed in which is strong enough to lift out the chaff

and other light materials. This result agrees with Chaturvedi et al. (2019) and Gbabo et al. (2013). They found when the speed of threshing drum increases the cleaning efficiency increases.



Figure 1 Operational view of the thresher

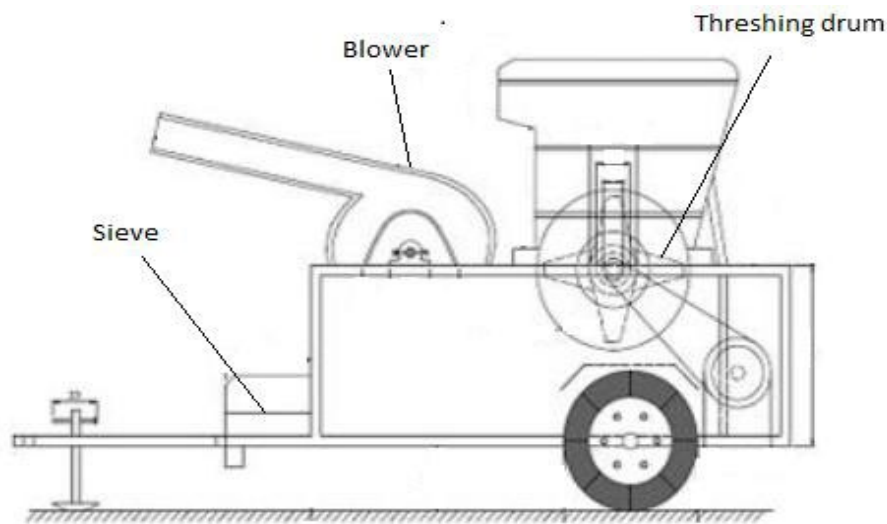


Figure 2 Construction drawing of the thresher

Table 1 Technical specification of the thresher

| Type of machine | Beater width (mm) | Number of beater knife | Diameter of beater sieve (mm) | Weight (kg) | Tyre size | Power requirement (hp) |
|-----------------|-------------------|------------------------|-------------------------------|-------------|-----------|------------------------|
| Shafted | 1200 | 44 | 12-14-22 | 1430 | 600×16 | 48 |

The quantities of feeding 11 kg and 6.5 kg when compared to 13 kg resulted in a significant increase on the cleaning efficiency (Figure 3). Lower cleaning efficiency at the quantity of 13 kg may be due to that any increase in feeding quantity could create extra

load on machine which in turn slows down the speed of fan and as a result the amount chaff and other foreign materials increased. The result is in consistent with Al-Shamiry and Yahya (2020); they observed the increase in feeding rate led to decrease in the

cleaning efficiency.

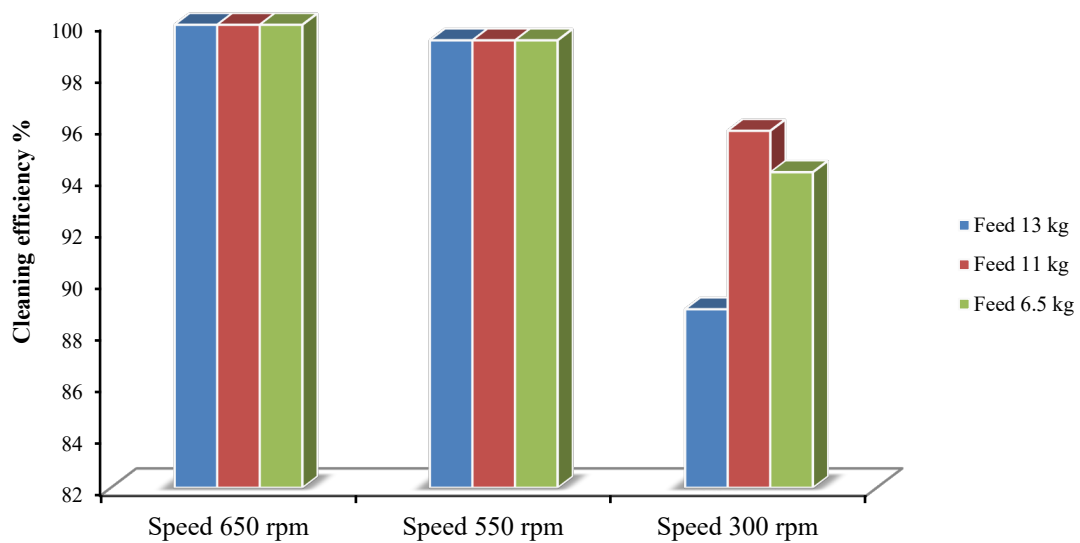


Figure 3 Effect of speed and feeding rate on the cleaning efficiency

3.2 Effect of drum speed and feeding rate on the threshing efficiency

There was no significant effect of the speed on the threshing efficiency (Figure 4). However, the speeds of 650 rpm and 550 rpm showed a slight increase in the threshing efficiency of 99.9 % when compared to the speed of 300 rpm (99.8%). Similar findings were observed by Al-Shamiry and Yahya (2020) and

Chaturvedi et al. (2019).They found threshing efficiency increased with speed increase. Similarly the feeding quantities did not show a significant effect on the threshing efficiency (Figure 4).The quantities of 11 kg and 13 kg had the highest threshing efficiency of 99.90% as compared to the quantity of 6.5 kg (99.86%).

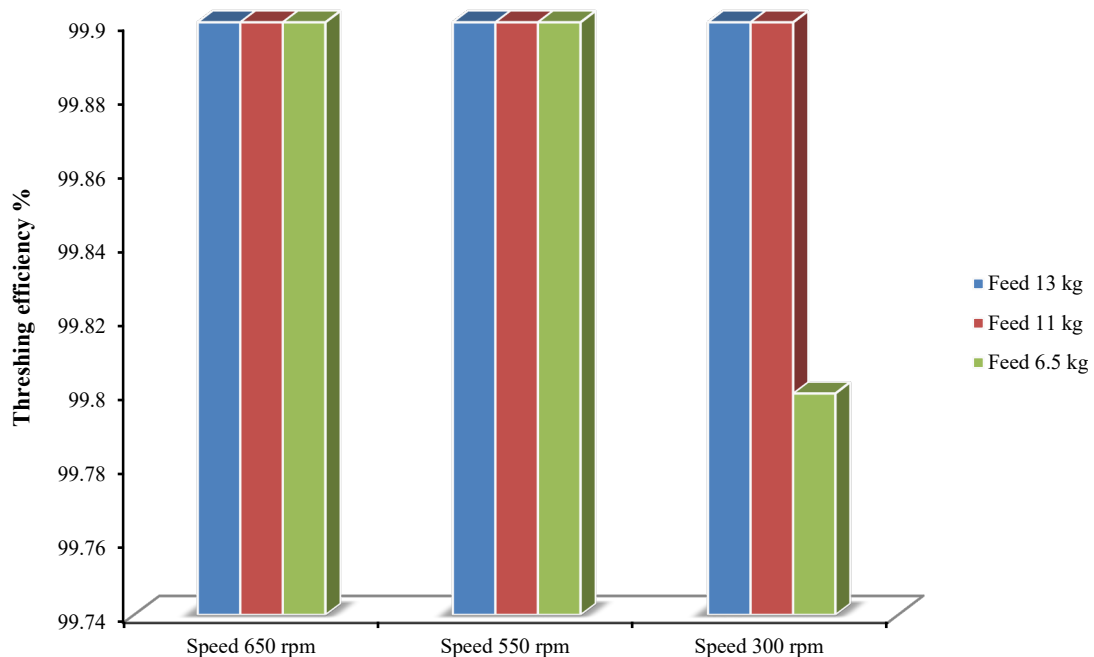


Figure 4 Effect of speed and feeding rate on the threshing efficiency

3.3 Effect of drum speed and feeding rate on the percentage of cracked grains

The percentage of cracked grains losses is

significantly affected by different levels of speed and feeding rate as shown in Figure 5. The maximum value of cracked grains losses recorded under the first

speed (650 rpm) of 6.29%, while the second speed (550 rpm) recorded the minimum value of 0.25%. The increase in percentage of cracked grains under the first speed may be due to increase the force exerted by the threshing drum that needed to detach millet grains from the ear heads by which in turn increases grains damage, because each crop has specific range of speeds that should be maintained. Thus selecting the right speed is important for achieving higher machine performance. The result is

in agreement with the result of Al-Shamiry and Yahya (2020).

With regard to the feeding rates the quantity of 11 kg recorded the highest value of cracked grains is 3.65% followed by the quantity of 6.5 kg is 3.36%, while the quantity of 13 kg recorded the lowest value is 2.14%. Similar results reported by Kumar et al. (2016), who observed the grains damage decreased with the feed increase and increased with the cylinder speed increase.

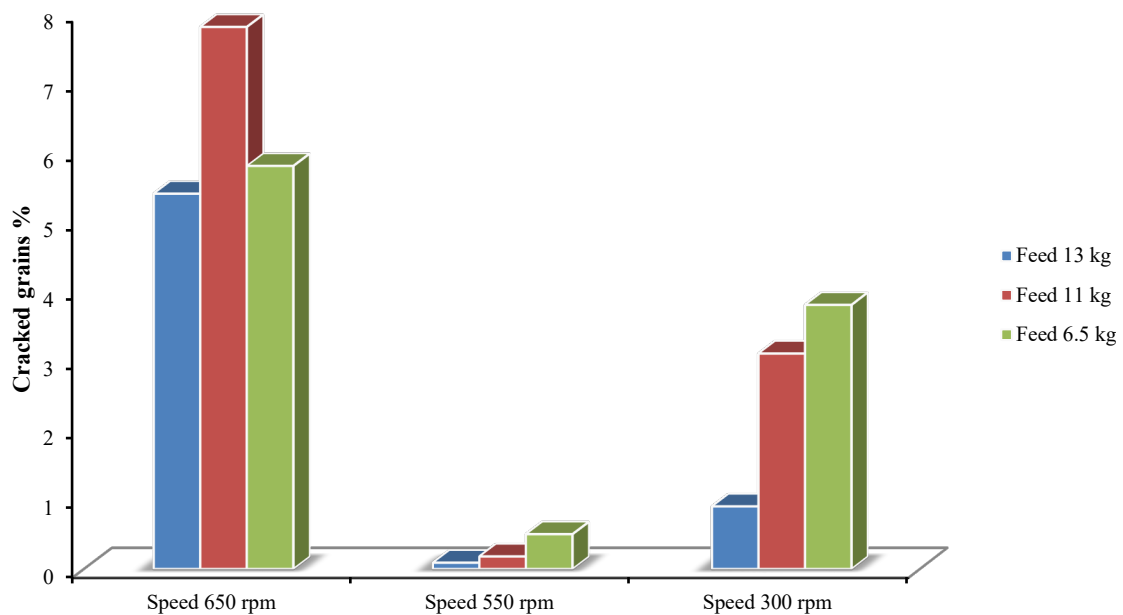


Figure 5 Effect of speed and feeding rate on the percentage of cracked grains

3.4 Effect of drum speed and feeding rate on the percentage of unthreshed grains losses

The effect of different speeds on the unthreshed grains is presented in Figure 6. The percentage of the unthreshed grains losses was significantly higher under the speed of 300 rpm (0.08%) as compared to speeds of 650 and 550 rpm were 0.02% and 0.01%, respectively. An increment of unthreshed grain losses at 300 rpm speed could be attributed to the speed reduction of threshing cylinder teeth in which reduces the force needed to thresh the grains out of the heads. Similar findings observed by Pandey and Stevens (2016), they found the percentage of grains loss increased with cylinder speed of thresher decrease.

Also the effect of feeding rates on the unthreshed grains was significant. The highest value of

unthreshed grains recorded under the quantity rate of 6.5 kg (0.06%), while the quantity rate of 11 kg recorded the least value of 0.01% (Figure 6). The increasing of unthreshed losses at the feeding rate of 6.5 kg might be due to the cylinder-concave gap is become large when adding few amount of feeding to the thresher and as a result large part of the crop is not completely threshed.

3.5 Effect of drum speed and feeding rate on the blown grains

Figure 7 shows the effect of different speeds and feed quantities on the percentage of blown grains. The operating speeds had a significant effect on blown grains losses. The third speed (300 rpm) recorded the highest value of blown grains losses was 0.023%, followed by first speed (650 rpm) was

0.020%, while the lowest value of blown grains of 0.01% obtained at the second speed of 550 rpm. As the percentage of blown off losses increases when sieve openings being blocked by means of straw and other materials as a result of thresher overloading; or increase of blowing fan speed more than recommended. Therefore, increasing in percentage of blown grains losses at the first speed in the present study is attributed mainly to higher speed of blowing fan. A similar finding observed by Adekanyem et al.

(2016).The result also is in accordance with Weerasooriya et al. (2011).Who found the percentage of blown grains losses is significantly affected by thresher drum speed.

There was no significant effect of different feeding rate on blown grains. The maximum value of blown grains losses recorded under the quantity 6.5 kg of 0.02% while the lowest value obtained at the quantity of 11 kg (0.01%).

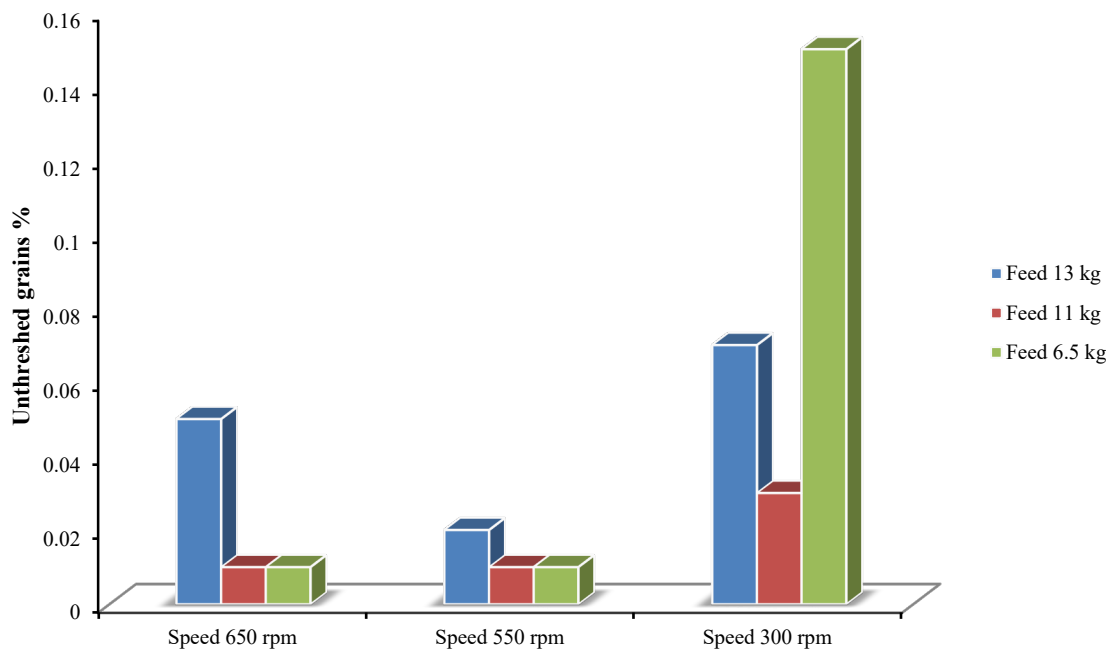


Figure 6 Effect of speed and feeding rate on the unthreshed grains

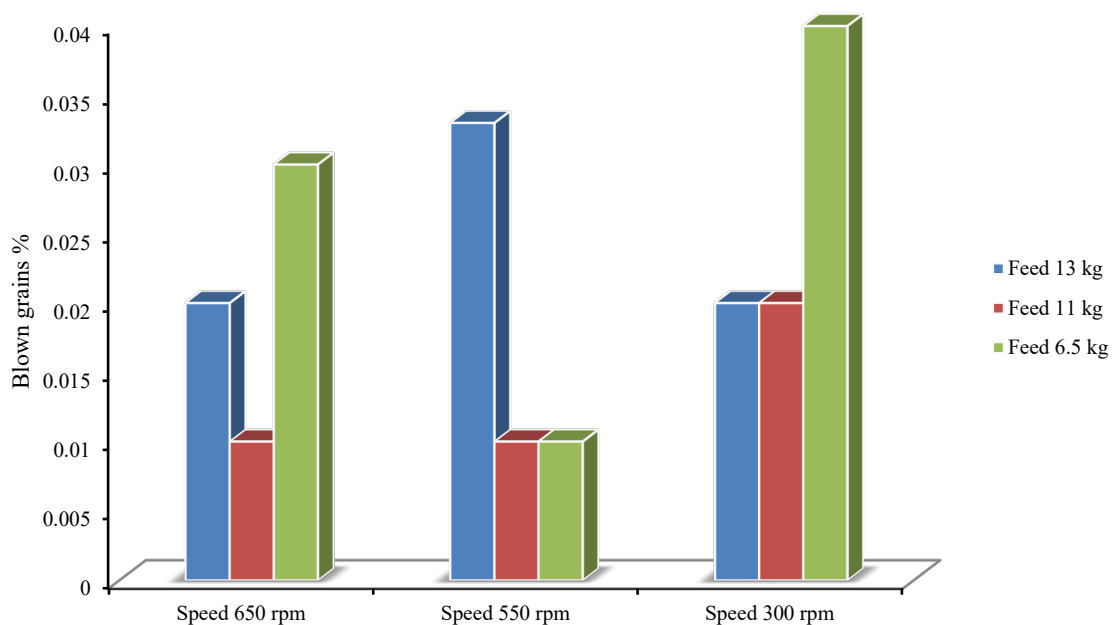


Figure 7 Effect of speed and feeding quantity on the blown grains

4 Conclusion

This study demonstrated that cleaning efficiency, percentage of cracked grains and percentage of blown grains significantly increased with speed increased. While the percentage of unthreshed grains significantly increase with speed decreased. The feeding rate of 11 kg showed a significant increase in the cleaning efficiency and percentage of cracked grains. As well as the feeding rate of 6.5 kg led to a significant increase in the percentage of unthreshed grains. Threshing efficiency was not affected with different drum speeds and feeding rates. To obtain optimum thresher performance the combination of speed 550 rpm and feeding quantity 11 kg could be recommended.

Acknowledgment

Authors wish to express their sincere thanks and appreciation to the Faculty of Natural Resources and Environmental Studies at Alsalam University for assisting in providing the thresher machine to achieve this study.

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