EFFECT OF MOISTURE CONTENT ON PERFORMANCE OF A LOCALLY FABRICATED COWPEA THRESHER

A.U. Fulani, J.Y. Kuje and Mohammed, B. I
Department of Agricultural Engineering, College of Agriculture, Lafia, Nigeria.
E-mail: mbabaibraheem@yahoo.com

ABSTRACT: *The result of the physical properties of the common variety (kananado) grown in the area had 36mm, 7.88mm* 30^0 *and 9.01% respectively. The performance of the thresher was evaluated at the drum speed of 700,900 and 1200rpm each at the moisture content of 4.3, 6.4 and 9.01% and was replicated thrice. The result revealed that the average feed rate, percentage unthreshed, threshing efficiency, cleaning efficiency and grain output were 154.18kg/hr, 2.64%, 97.68, 1.56%, 97.58% and 107.67kg/hr respectively. The result of the study as indicated by the result of Analysis of Variance (ANOVA) showed that the drum speed has no effect except at seeds damaged and feed rate where it has high significant at* $p\leq0.01$ *and significant effect on grain output at* $p\leq0.05$. *The effect of moisture content showed high significance on performance efficiency at* $p\leq0.01$ *except on cleaning efficiency. The interaction between the drum speed and moisture content has no effect on performance efficiency. The machine can easily be dismantled for maintenance transportation. The thresher can also be used as a winnower if the concave and the threshing drum are removed, average seeds length, thickness, angle of repose and optimum moisture content of 10.*

Keywords: Thresher, Fabrication, Performance Evaluation, and Moisture Content.
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INTRODUCTION

Cowpea (*Vigna unguculata Walp.*) is a stable widely consumed proteinous leguminous crop. Being leguminous, it enriches the soil through the nitrogen-fixating bacteria in its root nodules (Komolafe and Joy, 1981). In West Africa where the crop is said to have originated, the planting period varies from April to May in the Southern parts and July to August in the Northern regions. This depends on the variety of beans. Spraying with pesticides "Karate" enhances yield (Olatunji, 1979). Based on colour and days of maturity the early maturity varieties include IT82E-18 brown, IT82E-60 white and IT84E-124 brown (55-70days) while the medium maturity varieties are VITA-3 red, TVX3236 cream, IT81D-994 white (70-85days) and IT81D-1228 14 white, IT82D-38D-5 white (45-55 days) (Adeyemo, 2004). The crop is grown in India, Southern Eastern Asia, Australia, the Caribean, Southern United States and throughout the lowland tropics of Africa (FAO, 1981). Nigeria alone produces 61% of the world's recorded yield of about 760,000 tonnes annually (Leaky and Wills, 1977). The use of the crop is common among Nigerian Communities. It may be soaked and the coat removed, ground into paste, mixed with little oil and boiled to serve as *moi-moi* or fried as cake (*akara*). In some communities the fresh seeds and young pods are eaten as vegetable and young shoots and leaves as spinach. Despite the wide nutritional value, the crop is not cultivated in large scale because of the labour involved in harvesting and threshing. In high yielding conditions the whole plant may be uprooted, gathered and left to dry. In some areas the pods are allowed to dry and handpicked where the yield is low.

Threshing is traditionally done on hard dry ground or on rock. To reduce the incidence of stone, a tarpaulin or similar materials are spread before threshing. Threshing is done using sticks or pestle and wooden mortar. Both methods of threshing inflict a lot of breakages to the seeds. The seeds are then separated by winnowing. Both the chaff and the haulm (vegetable parts) are fed to livestock as hay or fodder (Olatunji, 1979).

Modern technology on threshing relied upon had not caused any significant increase in the production of the crop probably because the equipment and machines were not designed for the local species and varieties and could not justify any meaningful output due to sophistication. Some of the local varieties have been found to be unsuitable for threshing (Choudhury and Kaul, 1978; Adewumi *et al*., 2007b). The threshing machines are imported from countries in Europe with different climatic conditions. These imported machines are more prone to maintenance problems since they are designed and manufactured under different operating conditions. To crown it all, they are only found in Research Institutes and Universities and are not within the reach of the rural farmers due to high cost. This therefore, hampers the smooth processing of the crop and also discourages farmers from cultivating the crop on a large scale. Also the very few ones available for use by farmers have exhibited poor performance in terms of winnowing (Adesuyi, 1983). For this reason, it is necessary for farmers to be provided with means by which their agricultural products can be processed with minimum drudgery.

To encourage the cultivation of the crop on a large scale, technologies on threshing were developed under Nigeria's local situation using locally available materials. Nigeria agricultural engineers have designed, fabricated and evaluated the performance of manual threshers with low feed rate Umogbai and Shehu (2009). Also power threshers were developed by Kaul and Egbo (1985), with high maintenance cost (Fashina, 1990), and their performances showed low efficiency and appreciably high seed damage due to the spikes, since plain iron was used instead of the rasp iron material. Despite the research and designs carried out by various individual and institutions, poor and rural farmers in largely growing cowpea producing areas of middle belt region of Nigeria face challenges in accessing the threshers. This is because of the prohibitive costs of the machine or because the machines are not locally available. Acceptable cowpea threshers have not been produced for low and medium scale farmers in this largely cowpea growing areas to embrace.

The Main Objective of the Study

The main objective of this study is to construct and evaluate the performance of an engine powered cowpea thresher for use by medium scale farmers.

The specific objectives are; to carry out the performance of the cowpea thresher by determining the feed rate, unthreshed, threshing efficiency, cleaning efficiency, grain damaged and throughput capacity at three different drum speeds and moisture contents.

Scope of the Study

This study was centered on the construction and testing of the thresher. The performance evaluation includes feed rate, percentage unthreshed, threshing efficiency, cleaning efficiency, grain damaged and grain output. Cost implication of the machine was also assessed to draw suggestions and to enable targeted farmers take decisions.

Justification

The middle belt region of Nigeria which includes Nasarawa, Benue, Niger, Kogi and Plateau States is known for production of cowpea. This region is yet to be known for commercial production of the crop. This is as a result of the drudgery involved in threshing using sticks and pounding on wooden mortar which break the seeds and further reduces the market value. Also the rate of threshing is low and the quantity threshed is small. Some threshers have been locally designed and fabricated Dauda (2001), Ahaneku *et al.,* (2003), Adewumi *et al.,* (2006), Fashina (1990), Irtwange (2009), Umogbai and Shehu (2009). Their performances have not been satisfactory especially in the area of seed damage and winnowing. Also their capacity in kg/hr is low especially when the thresher is manually powered. Also the efficiencies such as seed damage and poor winnowing in the locally developed threshing would be corrected. To overcome these setbacks, and as an alternative to the traditional threshing methods, there is the need to develop a thresher that would be an asset to peasant farmers and suitable to thresh most varieties of cowpea grown in the region. This would encourage commercial cultivation of the crop.

MATERIALS AND METHOD

Data Collection, Methodology and Theory

To construct and evaluate the performance of the thresher, certain parameters were developed based on the engineering properties of grains (cowpea). These include grain size, angle of friction and weight of grains.

Measurement of Grain Size

A sieve that is too wide (also acting as the concave) would result in unclean grain, while small openings would lead to choking and excessive damage to grains. Small cylinder concave clearance apart from leading to grain damage also brings about excessive power losses as frictional force comes into play. To obtain optimum performance, the clearance and concave openings are therefore important, thus; the sizes and shapes of cowpea grain are required. The length of a grain was 10.36mm and its corresponding thickness;6.56mm were measured using vernier calipers while their weights 0.25g measured using a weighing balance.

Determination of Moisture Content

The moisture content (MC) % on dry basis is the weight of moisture contained in the sample as percentage of its dry matter was determined. Greater energy is required to thresh agricultural produce with higher moisture content compared to the ones with lower moisture content. For accuracy it was oven dried for 14 hours. The moisture content was determined using the formula;

$$MC = \frac{Weight\ of\ wet\ sample - Weight\ of\ dry\ sample}{Weight\ of\ dry\ sample} \times 100$$

(Brian, 1988)

At the time of threshing the moisture content of the cowpea was 9.01% (db). Ahaneku *et a*l., (2003) reported optimum moisture content of threshing beans to be 9.1% (db).

Performance Evaluation of Thresher

The performance of the thresher was evaluated using the formula below;

i. Feed rate = Quantity of pods fed into the thresher (kg)/hr.

ii. Percentage of the unthreshed grain

$$= \frac{Weight\ of\ the\ unthreshed\ pods (kg)}{Weight\ of\ total\ grain\ feed\ into\ the\ machine\ (kg)} \times 100$$

iii. Threshing efficiency

$$= 100 - Percentage\ of\ the\ unthreshed\ ponds$$

iv. Cleaning efficiency =

$$\frac{Clean\ grain\ received\ at\ the\ grain\ outlet\ (kg)}{Total\ grain\ and\ chaff\ received\ at\ the\ grain\ outlet\ (kg)} \times 100$$

v. Grain damaged

$$= \frac{Cracked\ or\ broken\ grains\ from\ the\ gra\ outlet\ (kg)}{Total\ grain\ received\ at\ the\ outlet\ (kg)} \times 100$$

vi. Grain Output = Quantity of grain threshed (kg)/hr

Description of the Thresher

An isometric view of the cowpea thresher is shown in figure 1, while plate 1 depicts the cowpea thresher. Its main features are the feeding, threshing, cleaning, grain outlet and chaff outlet units. All other parts are accessories to the basic units. The thresher works on the principle of rotary impact.

Feeding Unit: This unit is triangular in shape; 54cm in width and 70cm in length. It is made of mild steel sheet of gauge 18. This is the medium through which the cowpea pods are introduced to the machine for threshing, the pods flow by gravity into the threshing chamber. The feeding unit is welded directly above the surface of the upper cylinder cover on a triangular hole drilled on it.

Threshing Unit: This unit is cylindrical in shape and comprises of the threshing drum with spikes of 3.5cm in length welded on its surface which thresh by impact. The upper concave (upper cylinder cover) and the concave serves as lower cover for the threshing drum. The concave is perforated with holes of 11mm in diameter and 6mm apart for the threshed materials to pass through to be cleaned by the blower. The threshing drum is welded onto the shaft which is inserted into bearing at both ends.

The clearance between the concave and the threshing drum is 2cm. The bearings are bolted to the frame through the holes drilled on the frame at the sides. Power is delivered to the shaft by the prime mover via belt and pulley. The ends of the drums are covered to prevent the seeds from scattering and the operator from injury.

Cleaning Unit: This unit is cylindrical in shape and made of mild steel sheet of gauge 20 which houses a centrifugal type of fan with three straight blades of 15cm in width and 55cm in length which are welded onto a shaft of 30mm in diameter. The rotation of the blades generates a blast of air which blows away the chaffs.

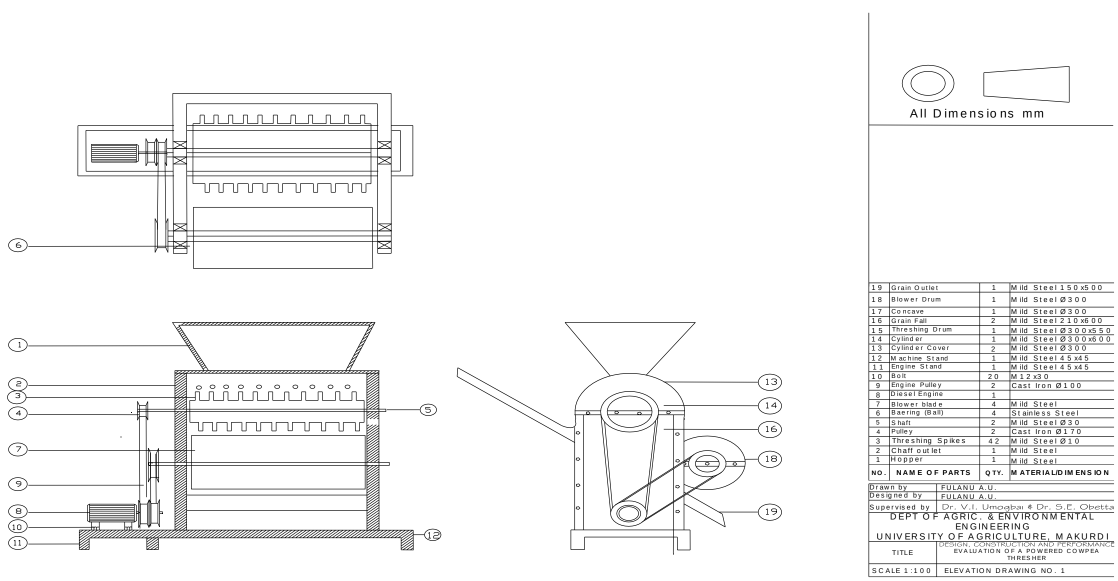
Grain Outlet: This is also made from mild steel of gauge 18(1.5mm thick). It is a continuous part of the chaff outlet inclined at an angle to facilitate easy flow of grain out of the thresher. The dimensions are 30cm in length and folded to a web of 10cm to direct the flow of grains.

Chaff Outlet Unit: This unit is the passage for the chaff after threshing of the cowpea has been accomplished. It is 36cm in length and covered to direct the flow of chaff. It is situated on the side of threshing unit such that the blower can blow the chaff through it.

Operation of the Thresher

The operation of the thresher is based on the use of beaters (spike tooth) which thresh the crop by impact and the use of radial type of fan paddles which generate a blast of air to clean the threshed cowpea. The thresher is operated by one person who after assembling the thresher, starts and sets the engine to the required speed. Then, feeds the cowpea pods into the machine which flow by gravity into the threshing chamber; the chaff is blown away while clean grains are collected at the grain chute.

Plate 1: Pictorial View of the Cowpea Thresher



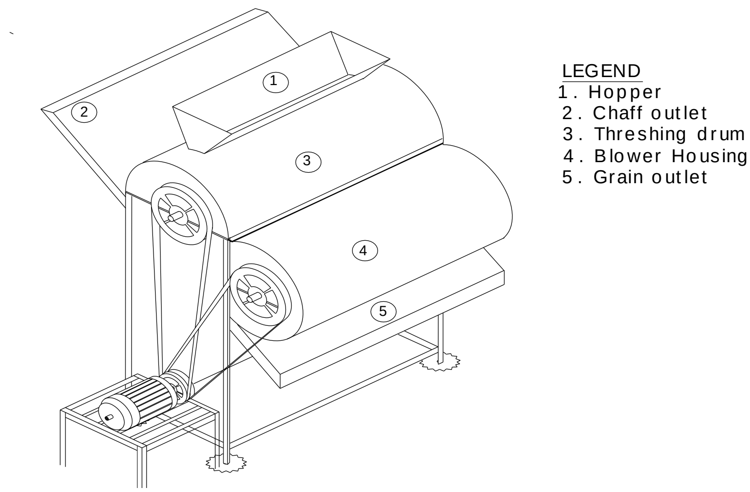


Figure 1: The Isometric View of the Thresher Showing Some Component Parts

RESULTS DISCUSSION

Performance test was carried out on the thresher. A quantity of 2160kg of cowpea pods was used for the test. 80kg each was threshed at three different drum speed of 700, 900 and 1200rpm and at the moisture contents of 4.3, 6.4 and 9.01% (db) and replicated three times as presented in Table 1, Table 2 is the average of the results. The result was also analyzed statistically as indicated in Table 3.

The Effect of Drum Speed on Feed Rate (kg/hr) at Different Moisture Contents

The highest average feed rate of 154.18kg/hr was attained at the drum speed of 1200rpm at the moisture contents of 9.01%. This was attributed to the high speed of the spikes which were able to split open the cowpea pods. The feed rate increases with increase in drum speed as well as moisture content. Ahaneku *et al;* (2003) and Vejasit and Salokhe (2004) reported feed rates of 545.66kg/hr and 214kg/hr for cowpea and soya beans respectively.

Figure 2 shows the effect of the drum speed on feed rate. As the drum speed increased feed rate also increased.

The result of the ANOVA on the effect of drum speed and moisture content as indicated in Table 3, significantly affected feed rate at 1% level, while the interaction between drum speed and moisture content did not affect feed rate.

Effect of Drum Speed on Unthreshed Cowpea at Different Moisture Contents

The highest average unthreshed percentage of 2.64% was observed at the drum speed of 700rpm at the moisture content 4.3% as showed Table 2 was as a result of low drum speed and moisture content. The kinetic energy of the spikes was not enough to impact the cowpea pods. Irtwange (2009) reported percentage unthreshed of 3.71% for cowpea.

Table 3 shows the effect of the drum speed and the interaction of drum speed and moisture content did not affect the unthreshed, it however, has significant difference on unthreshed when the moisture content was varied. Figure 3 shows the effect of drum speed on percentage unthreshed cowpea. The percentage unthreshed increased with increase in drum speed as well as moisture content.

Effect of Drum Speed on Threshing Efficiency at Different Moisture Contents

Table 2 shows that the highest average threshing efficiency of 98.28% was observed at the drum speeds of 1200 and moisture content of 9.01%. Test results showed that well dried pods can give an effective threshing as a result of high kinetic energy of the spikes which enables it to have contact with the pods thereby leading to greater splitting of the pods. Irtwange (2009) and Ahaneku *et al.*, (2003) reported threshing efficiency of 96.39% at the moisture contents of 11.06 to 12,02% and 99% at the moisture content of 9.1%(db) respectively for cowpea, while Vejasit and Salokhe (2004) reported 99% for soya beans. Figure 4 shows the effect of drum speed on threshing efficiency at different moisture contents studied. The results indicated that the threshing efficiency increased with an increase in drum speed for the different moisture contents. This is an agreement with the work of Ahaneku *et al.*, (2004) and Irtwange (2009) that threshing efficiency increased with increase in peripheral speed because of the kinetic energy of the spikes increased leading to greater splitting of the pods.

The result of ANOVA on the effect of drum speed on percentage threshing efficiency at different moisture contents as indicated in Table 3 revealed that the influence of drum speed was not significant (0.503^{ns}) on the threshing efficiency of the cowpea samples while the effect of moisture content was highly significant (0.001**) at P<0.05. Also, the influence of interaction among drum speeds and varying moisture contents was not significant (0.923^{ns}) on the threshing efficiency of the cowpea thresher.

Effect of Drum Speed on Cleaning Efficiency at Different Moisture Contents

In Table 2, the highest average cleaning efficiency of 97.72% at the moisture content of 9.01% at the drum speed of 1200rpm. The kinetic energy of the blades generated a blast of air which blown away the chaff. Ahaneku *et al.*, (2003); Dauda (2001) and Irtwange (2001) reported cleaning efficiency of 83.55%, 92.35% and 95.60% respectively for cowpea. Figure 3 shows the effect of drum speed on percentage cleaning efficiency at different moisture contents. It showed an increase with increase in drum speed as well as moisture content. At the moisture content of 4.3% and 6.4% (db), it falls and rises.

The result of the ANOVA in Table 3 shows the main effect of drum speed, moisture content and the interaction between drum speed and moisture content did not affect cleaning efficiency at $p \leq 0.05$. Threshing efficiency of the cowpea samples at P<0.05.

The Effect of Drum Speed on Grain Breakage at Different Moisture Contents

The highest average percentage grain breakage 1.56% was recorded at the drum speeds of 1200 rpm and at the moisture content of 9.01% (Table 2). Saeed *et al.*, (1995) and Vejasit and Salokhe (2004) reported that grain breakage increases with increase in drum speed and decreases with increase in feed rate. This could be attributed to the increase in drum speed and feed rate. Irtwange (2009) and Ahaneku *et al.*, (2003) reported grain breakage of 3.55% and 4.17% for cowpea respectively.

Figure 5 shows the effect of drum speed on grain damage at different drum speeds and moisture contents. The result indicated that the percentage of grain breakage increased with an increase in drum speed. The grain breakage increased from the moisture content of 4.3% to 9.01% and also from 700 rpm to 1200rpm. Irtwange (2009) and Ahanekul *et al.,* (2003) reported average seed breakage of 3.55% and 1.74% respectively at the moisture content of 11.06% and 9.10% (db).

The result of the ANOVA in Table 3 indicated that the effect of moisture content and the drum speed highly affected seed breakage at 1% level. The interaction between the moisture content and drum speed has no effect on grain breakage.

Effect of Drum Speed on Grain Output at Different Moisture Contents

The highest average grain output of 107.67 kg/hr was obtained at the drum speeds of 71200rpm respectively and at the moisture content of 9.01% (db). It was noticed that output capacity increase with an increase in drum speed as well as moisture content. Azouma *et al.,* (2009) and Vejasit and Salokhe (2004) reported out capacity of 350 to 400kg/hr and 143.80 to 204.7kg/hr respectively for soya beans, while Irtwange (2009) reported output of 74.33 to 102.09kg/hr for cowpea.

Table 3 is the result of the ANOVA which indicated the main effects of moisture content which significantly affected grain output at $p \leq 0.01$, while drum speed has effect on grain output at 5% level of significance. The interaction of drum speed and moisture content has no effect on grain output. Figure 6 shows the effect of drum speed on grain output at different moisture contents. The result indicated that grain output rapidly increased with increase in drum speed.

CONCLUSION AND RECOMMENDATIONS

Conclusion

A spike tooth thresher had been, constructed and its performance evaluated. The performance tests were conducted at the drum speeds of 700, 900, and 1200 rpm and moisture content of 4.3%, 6.4% and 9.01% (db). The effect of moisture content and drum speed affected feed rate, grain output while moisture content has effect on unthreshed and threshing efficiency. The highest average feed rate, percentage unthreshed pods, threshing efficiency, and grain output are 154.18kg/hr, 2.67%, 98.24%, 97.71%, 1.56%, 0.91%, 1.92%, 69.78% and 107.07kg/hr respectively for all drum speeds and moisture contents. The drum speed and moisture content of 900rpm and 9.01% respectively be used for threshing this variety (kananado) of cowpea.

Recommendation

The machine can also be used as a winnower if the concave and threshing drum are removed.

Suggestion for further work will dwell on increasing the width, length of spikes so as to increase the feed rate as well as incorporating a screen separator into the machine to grade the grains.

Table 1: Result of Replicated Performance of Cowpea Thresher Characteristics

Drum Speed (rpm)	**700**			**900**			**1200**			
MC (%)	**4.3**	**6.4**	**9.01**	**4.3**	**6.4**	**9.01**	**4.3**	**6.4**	**9.01**	**9.01**
Feed rate (kg/hr)	**137.14** 140.6 137.93	**138.4** 139.13 142.01	**139.2** 145.45 140.58	**138.00** 143.28 137.14	**150.00** 146.49 145.45	**153.6** 149.07 148.15	**140.10** 150.00 141.18	**152.3** 151.9 152.38	**154.84** 153.85 153.85	**154.84** 153.85 153.85
Percentage unthreshed (%)	**2.53** 2.48 2.9	**2.35** 2.25 2.36	**1.71** 2.30 1.25	**2.48** 2.26 2.69	**1.93** 2.25 2.81	**1.59** 2.09 1.96	**2.25** 2.38 2.73	**1.86** 2.13 2.56	**1.56** 1.94 1.76	**1.56** 1.94 1.76
Threshing efficiency (%)	**97.47** 97.52 97.10	**97.65** 97.75 97.64	**98.29** 97.7 98.74	**97.5** 97.74 97.31	**98.07** 97.75 97.19	**98.41** 97.91 98.04	**97.75** 97.62 97.27	**98.4** 97.87 97.44	**98.55** 98.06 98.24	**98.55** 98.06 98.24
Cleaning efficiency (%)	**97.06** 95.86 95.58	**98.91** 96.4 96.77	**97.59** 96.27 97.993	**97.63** 97.69 96.07	**95.85** 96.92 95.58	**98.91** 96.65 97.18	**97.93** 96.02 96.43	**98.54** 96.61 95.93	**98.73** 96.94 97.49	**98.73** 96.94 97.49
Percentage breakage (%)	**1.00** 1.07 1.26	**1.34** 1.02 0.99	**1.61** 1.34 1.28	**1.02** 1.00 1.07	**1.46** 1.16 1.41	**1.44** 1.51 1.6	**1.17** 1.06 1.32	**1.5** 1.43 1.57	**1.54** 1.6 1.54	**1.54** 1.6 1.54
Grain output (kg/hr)	**94.8** 98.12 94.83	**105.19** 96.35 99.05	**108.19** 101.00 98.82	**95.43** 88.22 97.94	**103.88** 102.14 100.01	**108.39** 104.35 100.6	**95.33** 104.18 99.35	**105.06** 105.76 104.57	**107.81** 107.59 107.50	**107.81** 107.59 107.50

Table 2: Average Results of the Thresher Performance Characteristics

Drum Speed (rpm)		**700**		**900**			**1200**	
Moisture content (MC) %db	4.3	6.4	9.01	4.3 6.4	9.01	4.3	6.4	9.01
Feed rate (kg/hr)	138.56	139.85	141.74	139.5 147.31	150.27	143.8	152.19	154.18
Percentage unthreshed (%)	2.64	2.32	1.75	2.48 2.33	1.88	2.45	2.18	1.75
Threshing efficiency (%)	97.36	97.68	98.24	97.52 98.67	98.12	97.54	97.90	98.28
Percentage damaged (%)	1.11	1.12	1.41	1.03 1.34	1.53	1.18	1.50	1.56
Cleaning efficiency (%)	96.17	97.36	97.28	97.13 96.12	96.12	97.58	96.79	97.03
Grain output (kg/hr)	94.58	100.20	102.67	97.53 102.01	104.45	99.62	105.13	107.67

Table 10: ANOVA for the Cowpea Threshing Performance

Source of Variation	**df**	**Unthreshed**	**Threshing Efficiency**	**Cleaning Efficiency**	**Feed Rate**	**Grain Output**
Drum speed (A)	2	0.682^{ns}	0.503^{ns}	0.733^{ns}	0.001**	0.011*
Moisture content (B)	2	0.001**	0.001**	0.065^{ns}	0.001**	0.001**
AB	4	0.928^{ns}	0.923^{ns}	0.186^{ns}	0.101ns	0.996^{n}s
Error	16					
Totals	**26**					

Note: ** Highly Significant at P ≤ 0.01, * Significant at P ≤ 0.05, ns = not

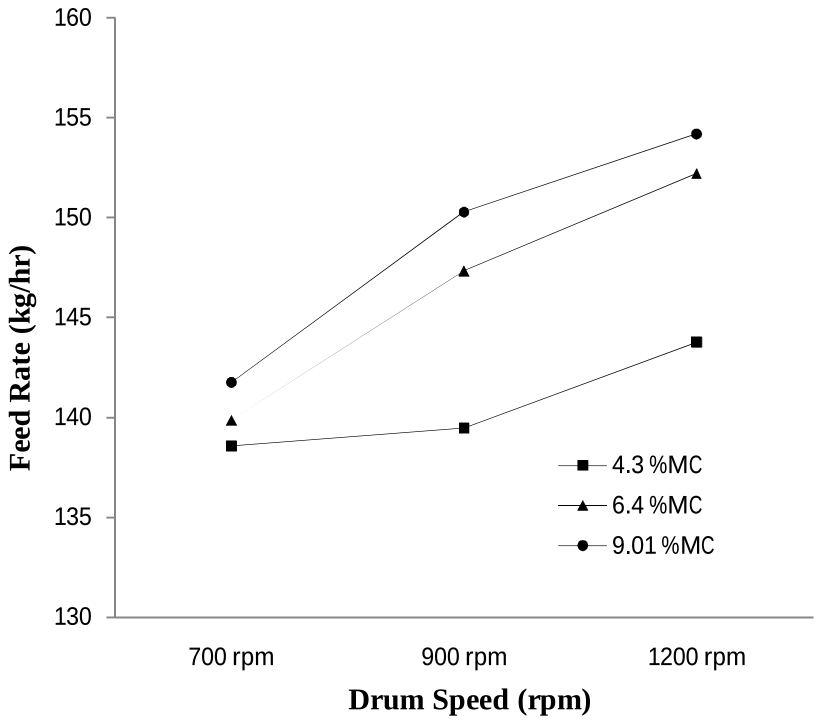
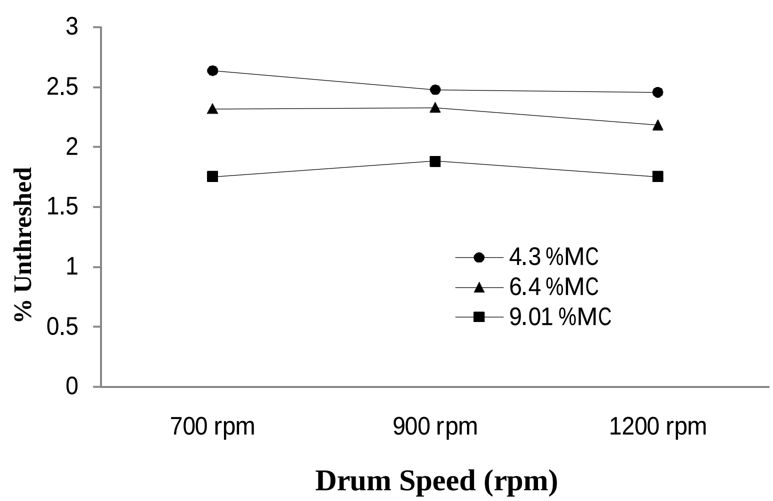


Figure 2: Effect of Drum Speed on Feed Rate (kg/hr) at Different moisture contents



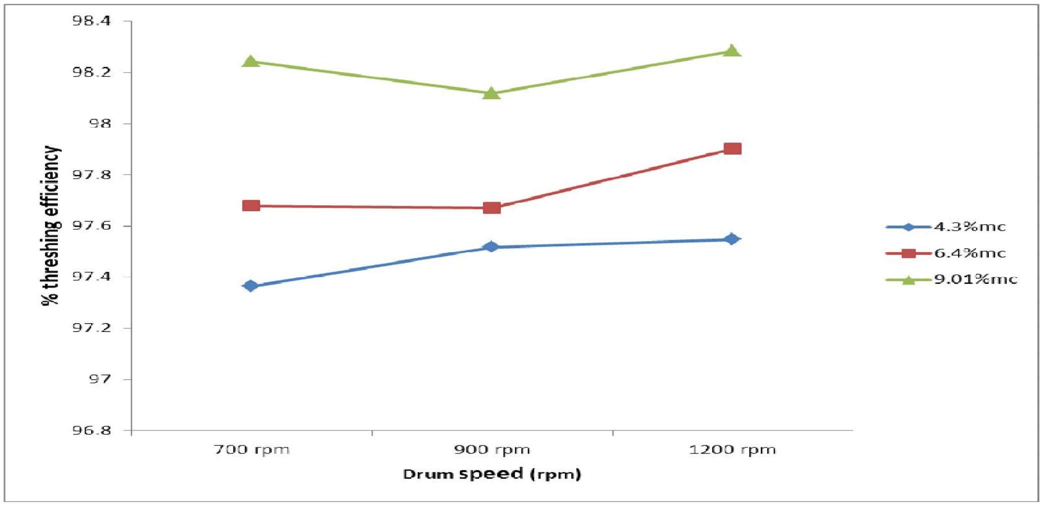


Figure 4: The Effect of Drum Speed on Threshing Efficiency at Different Moisture Contents

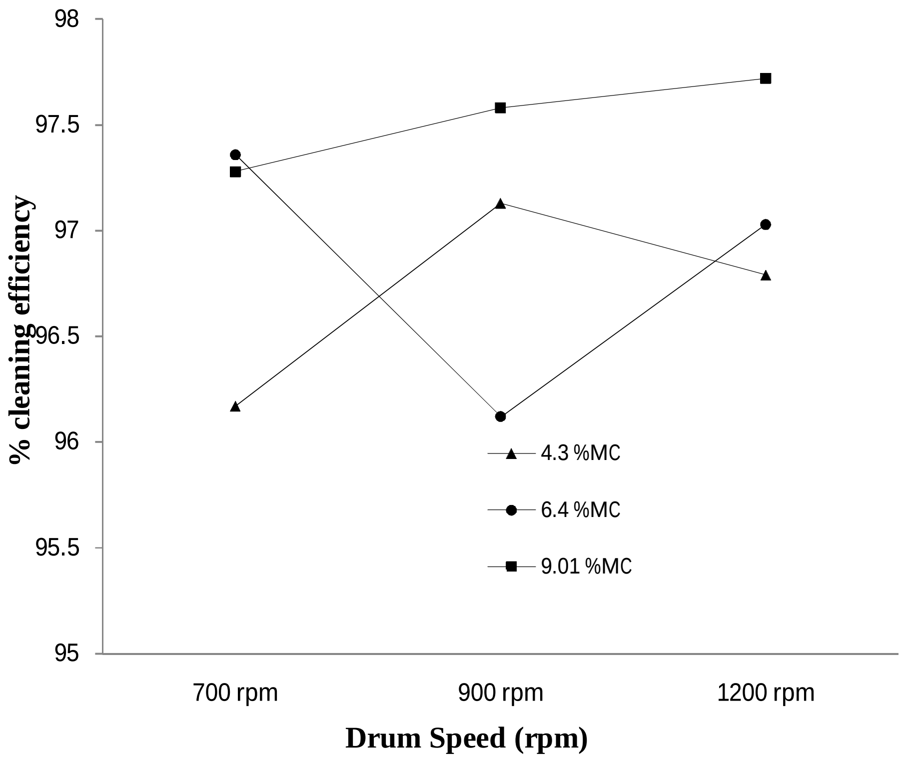


Figure 5: Effect of Drum Speed on Cleaning Efficiency at Different Moisture Contents

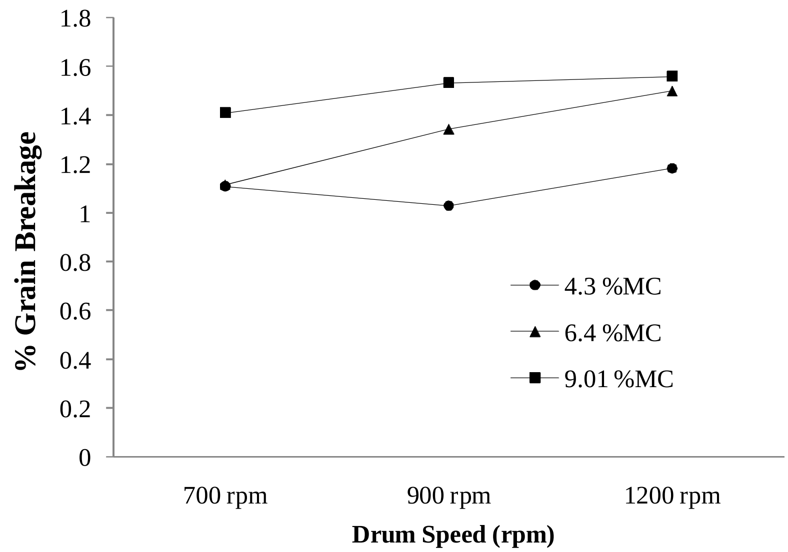


Figure 6: Effect of Drum Speed on Percentage Grain Breakage at Different Moisture Contents

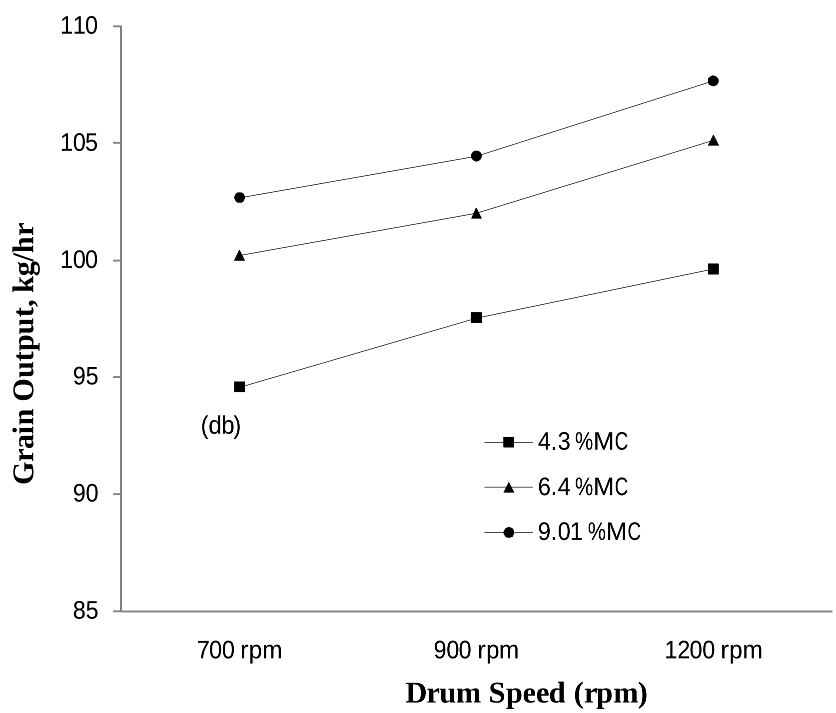


Figure 7: Effect of Drum Speed on Grain Output (kg/hr) at Different Moisture Contents

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