Performance evaluation of modified cowpea (*Vigna Unguiculata*) decorticating machine

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Abstract

In this study, performance evaluation of a modified cowpea decorticator was carried out using IT 573-1 variety of cowpea. A factorial experiment in a completely randomized design was used. The machine was evaluated at three levels of independent variables moisture content, MC (8, 10 and 12%, wet basis), decorticating cylinder speed, SP (450, 550 and 650 rpm), and feed rate, FR (650 550 and 450 kg/h). Three replications were made. The dependent variables (performance indicators) used were decorticating efficiency (%), cleaning efficiency (%), mechanical kernel damage (%), kernel scatter loss (%) and output capacity (kg/h). Analysis of the results for the performance evaluation was done using GENSTAT package 17.1 version. Further, LSD tests (Fisher) were used for rankings of significant means. The range of mean values of decorticating efficiency, cleaning efficiency, mechanical damage, output capacity and scattered kernels was from 94.34 ± 0.028 to 99.31±0.026 %, 88.33 ± 0.019 to 97.30 ± 0.018 %, 3.97 ± 0.010 ± to 9.88± 0.009 %, 330.68±0.201 to 475.89±0.180 kg/h and 4.05±0.02 to 12.25±0.019 % respectively. Comparison of the mean values of decorticating efficiency for the modified cowpea decorticator and that for the existing one revealed that, they were statistically similar. The mean cleaning efficiency of 97.29±0.026 for the modified decorticator when compared with 93.22 ± 0.024 % for the existing, represents an increase of 4.37 %. The mean mechanical kernel damage for the modified machine was 7.47±0.02 % and when compared with the existing (15.30±0.03 %), gave a a reduction of 38.37 % .. , Similarly, the mean value of output capacity for modified decorticator was 497.04±0.201 kg/h while that of the existing was 182.01 ± 0.210 kg/h. This represents an increase of 173.08 % in output capacity. The modified decorticator was able to achieve relatively high output capacity with less damage and scatter of cowpea kernels.

Keywords: decorticator, moisture content, speed, feed rate, cleaning efficiency damage kernels

Évaluation de la performance d'une machine décortiqueuse modifiée de niébé (*Vigna Unguiculata*)

Résumé

Dans cette étude, une évaluation de la performance d'une machine décortiqueuse de niébé modifiée a été réalisée en utilisant la variété IT 573-1 de niébé. Une expérience factorielle dans un plan complètement aléatoire a été utilisée. La machine a été évaluée à trois niveaux de variables indépendantes : la teneur en humidité, MC (8, 10 et 12 %, base humide), la vitesse du cylindre décortiqueur, SP (450, 550 et 650 tr/min), et le taux d'alimentation, FR (650, 550 et 450 *kg/h). Trois répliques ont été réalisées. Les variables dépendantes (indicateurs de performance) utilisées étaient l'efficacité de décorticage (%), l'efficacité de nettoyage (%), les dommages mécaniques aux grains (%), la perte de grains dispersés (%) et la capacité de sortie (kg/h). L'analyse des résultats pour l'évaluation de la performance a été effectuée en utilisant le logiciel GENSTAT version 17.1. De plus, des tests LSD (Fisher) ont été utilisés pour le classement des moyennes significatives. La plage des valeurs moyennes de l'efficacité de décorticage, de l'efficacité de nettoyage, des dommages mécaniques, de la capacité de sortie et des grains dispersés variait de 94,34 ± 0,028 à 99,31 ± 0,026 %, 88,33 ± 0,019 à 97,30 ± 0,018 %, 3,97 ± 0,010 à 9,88 ± 0,009 %, 330,68 ± 0,201 à 475,89 ± 0,180 kg/h et 4,05 ± 0,02 à 12,25 ± 0,019 %, respectivement. La comparaison des valeurs moyennes de l'efficacité de décorticage entre la machine décortiqueuse modifiée et celle existante a révélé qu'elles étaient statistiquement similaires. L'efficacité moyenne de nettoyage de 97,29 ± 0,026 pour la machine modifiée, comparée à 93,22 ± 0,024 % pour l'existante, représente une augmentation de 4,37 %. Le dommage moyen aux grains mécaniques pour la machine modifiée était de 7,47 ± 0,02 %, et comparé à l'existante (15,30 ± 0,03 %), a donné une réduction de 38,37 %. De même, la capacité de sortie moyenne pour la décortiqueuse modifiée était de 497,04 ± 0,201 kg/h, tandis que celle de l'existante était de 182,01 ± 0,210 kg/h. Cela représente une augmentation de 173,08 % de la capacité de sortie. La décortiqueuse modifiée a réussi à atteindre une capacité de sortie relativement élevée avec moins de dommages et de dispersion des grains de niébé.*

Mots-clés : décortiqueuse, teneur en humidité, vitesse, taux d'alimentation, efficacité de nettoyage, grains endommagés

ملخص

في هذه الدراسة، تم إجراء تقييم أداء مزين اللوبيا المعدل باستخدام مجموعة متنوعة من اللوبيا IT 573-1. تم استخدام تجربة مضروب في تصميم عشوائي تمامًا. تم تقييم الآلة على ثلاثة مستويات من محتوى الرطوبة من المتغيرات المستقلة، MC (8 و 10 و 12٪، الأساس الرطب)، تزيين سرعة الأسطوانة، SP (450 و 550 و 650 دورة في الدقيقة)، ومعدل التغذية، FR (650 550 و 450 كجم/ساعة). تم إجراء ثلاث نسخ متماثلة. وكانت المتغيرات التابعة (مؤشرات الأداء) المستخدمة هي الكفاءة التزيينية (%)، وكفاءة التنظيف (%)، والتلف الميكانيكي للنواة (%)، وفقدان النواة المتناثرة (%)، وسعة الإخراج (كغم/ساعة). وأجري تحليل لنتائج تقييم الأداء باستخدام طرد GENSTAT 17.1. علاوة على ذلك، تم استخدام اختبارات LSD (Fisher) لتصنيف الوسائل المهمة. وكان نطاق القيم المتوسطة لكفاءة التزيين، وكفاءة التنظيف، والتلف الميكانيكي، وسعة الخرج، والحبوب المتناثرة يتراوح بين 94.34 0.028 إلى 99.31 0.026 في المائة، و 88.33 0.019 إلى 97.018 0.018 إلى 9.88 0.009 في المائة، و 330.68 020.0 في المائة. كشفت مقارنة القيم المتوسطة لكفاءة التزيين لمزين اللوبيا المعدل وأنه بالنسبة للقيمة الحالية، كانت متشابهة إحصائيًا. يمثل متوسط كفاءة التنظيف 97.29 ± 0.026 للمزين المعدل مقارنة بـ 93.22 ± 0.024٪ للوجود، زيادة بنسبة 4.37٪. كان متوسط تلف النواة الميكانيكية للآلة المعدلة 7.47 ± 0.02٪، وعند مقارنته مع الموجود (15.30 ± 0.03٪)، أعطى انخفاضًا بنسبة 38.37٪. وبالمثل، بلغت القيمة المتوسطة لقدرة الإنتاج بالنسبة لمزيلات القشرة المعدلة 497.04 ± 0.201 كيلوغرام/ساعة، بينما بلغت القيمة المتوسطة للقدرة الحالية 182.01 ± 0.210 كيلوغرام/ساعة. ويمثل هذا زيادة بنسبة 173.08٪ في قدرة الإنتاج. كان المزين المعدل قادرًا على تحقيق قدرة إخراج عالية نسبيًا مع تلف أقل وتناثر حبوب اللوبيا.

الكلمات الرئيسية: الديكور، محتوى الرطوبة، السرعة، معدل العلف، تنظيف نواة التلف بكفاءة

Introduction

Cowpea is a leguminous crop produced for human and animal consumption, it has numerous advantages such as high protein content, adaptability to different types of soil and inter cropping system, resistance to drought, and ability to improve soil fertility and prevent erosion. This makes it an important economic crop in many developing countries (IITA, 2023). Cowpea's high protein, its adaptability to different types of soil and inter cropping system, its resistance to drought and its ability to improve soil fertility, makes it an important economic crop in many developing countries. The sale of the stems and leaves as animal feed during the dry season also provides a vital income for farmers (IITA, 2023). More than 5.4 million tons of dried cowpeas are produced worldwide, with Africa producing nearly 5.2 million. Nigeria was the largest producer and consumer, accounting for 61% of production in Africa and 58% worldwide. African continent is the major exporter of cowpea in the world as significant amount was produced, while the importation was insignificant (IITA 2023). Cowpea is one of the most economically and nutritionally important indigenous African grain legumes produced throughout the tropical and subtropical areas of the world (GATE, 2008).

Decortication is a process of removing the husk covering the seed of a plant. Decorticating can be done either mechanically or manually. Olaoye (2011) asserted that better production techniques alone are not sufficient to solve the problem of field losses in production of cowpea. Attention must also be paid to the suitable method of harvesting, threshing or decorticating to minimize field losses. Some factors affecting the efficiency of decorticating operation include feeding method, cylinder speed, concave-to-cylinder clearance and moisture content (Dalha 2015).

With improved ways of cowpea decortication, all stake holders in the value chain would reap benefits in terms of reduced drudgery, increased efficiency (in both production and processing) and maximal profit. Kangiwa (2015) modified an existing manual cowpea decorticator into motorized decorticating machine. Hardened rubber attached to metal bars was used to avoid direct contact of metal to the cowpea kernels. However, the output and the cleaning efficiency need to be improved. Furthermore, the high scatter of cowpea kernels during feeding needs to be addressed. This gap motivated Matori (2021) for the modification of the existing cowpea decorticating machine. The objective of this research work was to evaluate the performance of the modified cowpea decorticator at different moisture contents, speeds and feed rate and to determine the best combination for machine performance.

Materials and Method

The various materials used for the performance evaluation include the developed cowpea decorticating machine, the cowpea pods IT 573-1-1 variety, weighing balance, polythene bags, tachometer and digital stopwatch. The modified cowpea decorticating machine developed was presented in plate I below.

The machine decorticates and cleans in one operation with the delivery of clean kernels at the outlet. It consists of 6.5 Hp diesel engine and the decorticating unit. The components of the decorticating unit were feeding hopper, decorticating chamber, blower, chaffs outlet, kernels delivery chute and frame. The un-decorticated cowpea is fed in through the hopper. The decorticating chamber consists of decorticating cylinder and concave. The blower is an axial flow fan powered by the prime mover with the aid of a pulley and belt. The frame acts as a support for all the machine components. As the cylinder rotates, the rasp bars beat and rub the un- decorticated pods against the concave to affects the breaking of the pods and release of the cowpea kernels with minimal damage. As the blower rotates, it generates a stream of air current which passes through the bottom of the concave sieve. The stream of air blows off the broken chaff through chaff outlet and the sole decorticated kernels pass across the air current to the kernels delivery chute.

Plate I modified cowpea decorticating machine.

The variation of moisture content for different readings during the performance evaluation was done through natural drying. To determine the moisture content of the kernels for experiment, the procedure set by FAO (1999) was followed that is 10g of cowpea sample was used at 130 ^{0}C in digital oven for 50 minutes. (Visvanathan *et al.,* 2010)

$$\%\text{Mc} = \frac{wtW}{wtD} \times 100 \quad (2.1)$$

Where,

% M_c = the percentage kernel moisture content, dry basis;

wtW= is the weight of water removed, kg and

wtD =weight of dry cowpea sample,kg

Performance of the machine was evaluated using the relation given by (Oluwatosin, 2009):

Decorticating efficiency, De, %

This is referred to as the ratio of quantity of decorticated kernels (seeds) in the sample to the ratio of total quantity of kernels in sample.

$$Te = 100 - (\frac{Qu}{Qt} X\, 100) \quad (2.2)$$

Where;

Qu = Quantity of un-decorticated pods in the sample (kg)

Qt = Total quantity of kernels collected at the output (kg)

Cleaning Efficiently Ce (%)

This is referred to as the ratio of mass of clean kernel collected to that of total mixture of kernel and chaff received at the outlet,

$Ce = \frac{wc}{wt}$ x 100 (2.3)

Where wt is the weight of total mixture of kernel and chaff collected at the main outlet (kg) and wc is weight of clean kernel collected at the main outlet of the decorticator (kg).

Mechanical kernel damage, Md (%)

It could be calculated by collecting the broken kernels in sample so that the grain damage would be determined in the decorticated sample.

$Md = \frac{Qb}{Qt}$ X 100 (2.4)

Where; Qb is the quantity of broken kernels collected at the outlet, per unit time (kg) and Qt is the total quantity of kernels collected at the outlet, per unit time (kg).

Kernel Scatter losses, SL, (%)

This is referred to as the loss due to kernel scattering around the decorticator during operations.

, $SL = \frac{Qe}{Qt}$ X 100 (2.5)

Where; Qe is thequantity of kernel scattered around the decorticating operation (kg) and Qt is the total quantity of kernels collected at the outlet (kg).

Output capacity, OC, (kg/h)

This referred to as the capacity of the decorticator to decorticate a quantity per unit time

$OC = \frac{Qs}{T}$ X 100 (2.6)

Where; Qs is thequantity of decorticated material that passed through the grain collector (kg) and T is thetime taken to complete de-cortication operation, (h).

Experimental Design for the Performance Evaluation.

The performance test of cowpea decorticator developed was conducted at three moisture levels (8 % 10 % and 12 % moisture content, db) at three drum speeds (500, 600 and 700 rpm) and three levels of feed rate (450, 550 and 650 kg/h) by using factorial experiment in a completely randomized design with three replications in each treatment. Cowpea variety IT573-1-1 was used for performance evaluation.

Analysis of results.

Analysis of results for the performance evaluation were analyzed using GENSTAT package 17.1 version. LSD test was used for further analysis for means that are significant

Results and Discussion

The analysis of variance (ANOVA) and fisher's protected ranked Least Significance Difference test (LSD) comparison of significant means were presented.

Table 1 shows the summary of F-values for analysis of variance (ANOVA) results for the effect of independent variables moisture content, speed and feed rate and their interactions on the performance indices: decorticating efficiency, cleaning efficiency, kernel damage, kernel scatter loss and output capacity. The results indicated that all the dependent variables were significantly affected at 1% probability level by all the independent variables and their interactions. This trend agrees with those reported by

Muhammad-Bashir *et al.* (2018).

For the interaction effect, first order interaction of moisture content and speed, moisture content and feed rate, speed and feed rate are highly significant. The second order interaction moisture content, speed and federate (MC.SP.FR) were also statistically significant.

Decorticating efficiency, De

The results for mean values of decorticating efficiency at different combinations of MC, SP and FR ranged from 94.34 ± 0.028 to 99.31±0.026 %. These figures are similar to the works of Ahmad (2015), Dalha (2015) and Ahmad (2019).

Table 1: Summary of Analysis of variance F- values result for decorticating efficiency (%), cleaning efficiency, mechanical damage, output capacity and scatter kernels.

S	F- value for performance indicators					
Parameters	D.f	De	Ce	Sc	DM	Oc
MC	2	4272.80**	2.531E+05**	1.568E+05**	8015.94**	4378.14**
SP	2	991.00**	14149.89**	79095.33**	792.19**	1920.82**
FR	2	491.60**	19207.02 **	32804.46**	215.76**	1.232E+05**
MC.SP	4	270.24**	2673.76 **	7264.68**	424.88**	250.39**
MC.FR	4	6.00**	4157.73 **	508.92**	42.88**	416.22**
SP.FR	4	7.83**	173.35 **	415.07**	737.48**	119.14**
MC.SP.FR	8	6.58**	103.78 **	1283.14**	272.71**	208.01**
Residual	54					
Total	80					

** = Highly significant (at 1% level)

Comparison of significant mean values for decorticating efficiency using fisher's protected ranked LSD test is presented in Table 2. The result showed that for the interaction effect, the highest mean value (99.31± 0.016%) for decorticating efficiency was obtained at the $MC_3SP_3FR_3$ combination, which is at par with $MC_3SP_3FR_2$ combination. The lowest mean (94.34± 0.014 %) decorticating efficiency was obtained at the $MC_1SP_1FR_1$ combination. The analysis indicates that decorticating efficiency increased with decrease in moisture content. This agrees with Muhammad-Bashir *et al.* (2018). The increase in decorticating efficiency with decrease in moisture content may be because at lower moisture content, the bonding between the pods and kernels were weak, thus increasing decorticating efficiency. It indicates that decorticating efficiency increases with increase in speed. This agrees with findings of Ahmad (2015). The reason for higher decorticating efficiency at high speed may be since at higher speed, the impact force on the cowpea pods is repeatedly higher which means high decorticating efficiency.The ranked LSD also revealed that decorticating efficiency decreases with increase in feed rate. This agrees with findings of Umogbai (2009). The reduction of decorticating efficiency with increase in feed rate may be because at higher feed rate, there is more cowpea pods to decorticate which may tend to have clogging effect and hence reduced the decorticating efficiency

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***Cleaning efficiency**, Ce*

The results for mean values of cleaning efficiency at different combinations of MC, SP and FR of the modified machine ranged from 88.33 ± 0.019 to 97.30 ± 0.018 %. These figures are like the works of Irtwange (2009). Comparison of significant means for cleaning efficiency using Fisher's protected ranked LSD test presented also in Table 2 below showed that for second order interactions effect, the highest mean cleaning efficiency is 97.30 % obtained at the $MC_3SP_3FR_3$ combination, the lowest cleaning efficiency is 88.33 % obtained at the $MC_1SP_1FR_1$ combination. It shows that cleaning efficiency increase with decrease in moisture content. This agrees with Dalha (2015). The increase in cleaning efficiency with decrease in moisture content may be since at lower moisture content material other than the grain is lighter and hence easily blown off by fan, thus increasing cleaning efficiency. It also indicated that the cleaning efficiency increases with corresponding increase in cylinder speed. This agrees with findings of Ahmad (2019).

The reason for higher cleaning efficiency at high speed may be because at high speed, the fan speed is higher and as fan speed increased there was more stream of air flowering across the fallen object there by blowing off the material other than kernels and hence increased cleaning efficiency. It could also be seen from the analysis that cleaning efficiency decreases with increase in feed rate. This trend agrees with research of Kangiwa (2015). The reduction of cleaning efficiency with increase in feed rate may be due to the fact that at higher feed rate, there were more materials other than kernels and this may reduce the cleaning efficiency.

Output capacity. Oc

The mean values range of output capacity at different MC, SP and FR of the modified machine were found to be 330.68±0.201 to 475.89±0.180 kg/h for $MC_3SP_3FR_3$ and $MC_1SP_1FR_1$ combination respectively. These values are similar to the ones reported by Muhaamd-bashir *et al.,* (2018).

Fisher's protracted ranked LSD test comparison of significant means for output capacity in Table 2 showed that for second order interactions effect at 1 % probability level, the highest mean output capacity is found to be 497.04 kg/ h at combination of $MC_1SP_3FR_1$ while the lowest mean value was 318.93 kg/h at combination of $MC_3SP_1FR_3$. The Results further showed that output capacity increases with increase in moisture content this agrees with Dalha (2015). The increase in output capacity with increase in moisture content may be since at high moisture content, the weight of cowpea pods was higher, and the corresponding output also has higher weight which resulted in high output capacity. Results also showed that output capacity increases with increase in speed. This trend agrees with the findings of Kangiwa (2015). The reason for high output capacity at higher speed may be since at high speeds, more cowpea pods are decorticated thus increased output capacity of the machine. It further revealed that output capacity increases with increase in feed rate. This agreed with findings of Muhammad-Bashir *et al.,* (2018). The increase of output capacity with increase in feed rate may be because at high feed rate, more quantity of cowpea pods has been used at the input thus increasing output.

Mechanical damage. Dm

The results for mean values of mechanical damage at different MC, SP and FR of the modified machine ranged from 3.97 ± 0.010 ± to 9.88± 0.009 %. These figures are similar to the works of Ahmad (2019). Fisher's LSD rankings in Table 3 shows that the highest mean mechanical damage was found to be 7.47 % at combination of $MC_3SP_3FR_3$ while the lowest mean value was 3.98 % at combination of $MC_1SP_3FR_1$. It revealed that kernel damage increases with decrease in moisture content. This agrees with findings of Adekunle *et al.* (20018). This is since at lower moisture content the internal binding of pods is weak thus easily susceptible to impacts

Table 2 Fisher's protected LSD test for Mean Values of decorticating efficiency, cleaning efficiency and output capacity at MC.SP.FR interactions (1 % level).

Decorticating efficiency %			**Cleaning efficiency %**			**Out capacity kg/ h**		
MC.SP.FR	Mean	Ranks	MC.SP.FR	Mean	Ranks	MC.SP.FR	Mean	Ranks
3 3 3	99.31	A	3 3 3	97.30	A	1 3 1	497.0	A
3 3 2	98.98	A	3 3 2	97.00	B	1 2 1	487.1	B
3 2 3	98.93	AB	3 2 3	97.00	B	2 3 1	481.0	C
3 3 1	98.56	BC	3 2 2	96.71	C	1 1 1	475.9	D
3 2 2	98.56	BC	3 3 1	96.70	C	2 2 1	472.6	D
3 2 1	98.37	C	3 1 3	96.69	C	3 3 1	467.8	E
3 1 3	97.27	D	3 1 2	96.42	D	2 1 1	462.5	F
2 3 3	97.06	DE	3 2 1	96.39	D	1 3 2	450.1	G
2 2 3	96.99	DE	3 1 1	96.06	E	3 1 1	448.8	G
2 1 3	96.80	EF	2 3 3	95.06	F	2 3 2	433.7	H
2 3 2	96.76	EF	2 2 3	94.67	G	1 2 2	433.2	H
2 2 2	96.52	FG	2 3 2	94.45	H	2 1 2	430.8	H
2 3 1	96.36	G	2 1 3	94.25	I	2 2 2	426.8	I
3 1 2	96.33	GH	2 3 1	94.13	J	3 3 2	423.7	IJ
2 2 1	96.25	GH	2 2 2	94.10	J	1 1 2	420.7	JK
1 3 3	96.23	GHI	2 1 2	93.76	K	3 2 1	420.7	JK
2 1 2	96.20	GHI	2 2 1	93.63	L	3 1 2	418.8	K
3 1 1	95.95	HIJ	1 3 3	93.48	M	3 2 2	411.6	L
1 2 3	95.85	IJ	2 1 1	93.16	N	1 3 3	350.7	M
2 1 1	95.79	J	1 3 2	92.74	O	2 3 3	346.7	N
1 3 2	95.77	JK	1 2 3	92.55	P	1 2 3	342.7	O
1 2 2	95.38	K	1 2 2	92.06	Q	1 1 3	336.3	P
1 1 3	95.38	K	1 1 3	91.63	R	2 2 3	334.8	P
1 3 1	95.37	K	1 3 1	91.26	S	3 3 3	330.7	Q
1 1 2	94.86	L	1 1 2	90.56	T	2 1 3	330.5	Q
1 2 1	94.46	M	1 2 1	89.98	U	3 2 3	325.9	R
1 1 1	94.34	M	1 1 1	88.33	V	3 1 3	318.9	S

Thus increases the damage. It also reveals that as the cylinder speed increases the kernels damage increases. This agrees with Ahmad (2019). The increase in kernel damage at higher speed may be due to high repeated impact forces on the kernel and thus causing higher damage. It further that at higher feed rate, the kernel damage decreases. This trend agrees with the findings of Kangiwa (2015). This is due to the fact at higher feed rate material volume is high which provide cushioning effect and thus damage. Similarly, at lower feed rate the cowpea kernel collides with concave instead of one another and hence increased damage.

Kernel Scatter loss. Sc

The results for mean values of kernel scatter loss at different MC, SP and FR of the modified machine ranges from4.05±0.02 to 12.25±0.019 % for $MC_3SP_3FR_3$ and $MC_1SP_1FR_1$ combination respectively. This agrees with works of Muhamad-bashir*et al.,* (2018) and Ahmad (2019).

Comparison of significant means for kernel scatter loss using Fisher's protected ranked LSD test presented in Table 3 shows that for second order interactions effect, the highest mean kernel scatter loss is 12.25 % obtained at the $MC_3SP_3FR_3$ combination, the lowest kernel scatter loss is 4.05 % obtained at the $MC_1SP_1FR_1$ combination. It indicated that kernel Scatter loss increase with decrease in moisture content. This agrees with Muhammad-Bashir *et al.,* (2018). The increase in scatter kernels with decrease in moisture content may be due to the fact that at reduced moisture content density of the material other than kernels is lower. Therefore, the pods and other foreign could not provide cushioning effect hence the kernel easily scatter and thus increasing kernel scatter loss value. It also indicated that the kernel scatter loss increases with corresponding increase in cylinder speed. This agrees with findings of Ahmad (2019). The reason for higher kernel scatter loss at high speed may be because at high speed, the fan speed is higher and as fan speed increased there was more stream of air flowering across the fallen object there by blowing off the material other than kernels and hence increased loss. From the results also show that with increase in feed rate the corresponding value of scatter kernels also increases. This agrees with finding of Kangiwa (2015). The increase in kernel scatter loss with increase in feed rate may be because at higher feed rate there is more material other than kernel on the sieve which would cause delay in separation, thus increased scatter loss.

Table 3: Fisher's protected ranked LSD comparisontest for Mean Values of mechanical damage and kernel Scatter loss at different MC, SP, FR interactions (1% level).

Mechanical damage %			Scatter kernels %		
MC.SP.FR	Mean	ranks	MC.SP.FR	Mean	Ranks
3 3 3	7.47	A	3 3 3	12.25	A
3 3 2	7.12	B	3 3 2	10.16	B
3 3 1	6.95	C	3 2 3	9.94	C
3 2 3	6.57	D	3 2 2	9.46	D
3 2 2	6.17	E	3 3 1	9.44	D
3 2 1	5.98	F	2 2 3	9.17	E
3 1 3	5.78	G	3 2 1	8.66	F
3 1 2	5.37	H	2 2 2	8.46	G
2 3 3	5.12	I	2 3 3	8.26	H
3 1 1	5.07	J	3 1 3	8.16	I
2 3 2	4.98	K	2 3 2	8.14	I
2 2 3	4.86	L	2 2 1	7.98	J
2 2 2	4.78	M	3 1 2	7.86	K
2 2 1	4.48	N	1 3 3	7.36	L
2 3 1	4.23	O	2 1 3	7.23	M
2 1 3	4.15	P	2 3 1	7.15	M

2 1 2	3.98	Q	1 3 2	6.84	N
1 2 3	3.84	R	3 1 1	6.51	O
1 2 2	3.71	S	1 3 1	6.35	P
1 2 1	3.65	T	1 2 3	6.16	Q
2 1 1	3.53	U	1 2 2	5.96	R
1 1 3	3.22	V	1 1 3	5.66	S
1 3 3	3.14	W	2 1 2	5.65	S
11 2	2.97	X	2 1 1	5.26	T
1 3 2	2.83	Y	1 2 1	4.83	U
1 1 1	2.45	Z	1 1 2	4.71	V
1 3 1	2.13	Z	1 1 1	4.05	W

Conclusion

The modified cowpea decorticating machine performance was evaluated using moisture content, speed and feed rate each at three levels. The performance parameters used were decorticating efficiency%, cleaning efficiency %, mechanical kernel damage, %, scatter loss, % and output capacity, kg/h. The result obtained from the performance evaluation test revealed that, the mean values of range for the indicators were comparable with existing research works. Comparison of the modified machine with the existing one showed remarkable improvements. The modified decorticator was able to achieve relatively high output capacity with less damage and scatter of cowpea kernels.

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