PERFORMANCE EVALUATION OF A MODIFIED SOYA BEAN (*Glycine max L)*

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ABSTRACT

Performance evaluation tests of a modified Soya bean thresher was carried out using TGX 1485 soybean variety. Cylinder drum speed, soya bean feed rate, and kernel moisture content were used as independent variables. The performance tests of the soya bean thresher were conducted at three levels of moisture content were (13.64, 11.3 and 9.12 % (w.b)), three levels of drum speeds (800, 850 and 900 rpm) and three levels of feed rates (200, 300 and 400 kg/h) by using a randomized complete block design (RCBD) in a 3x3x3 factorial experiment with three replications. The grain kernel moisture content was blocked to allow for natural variability of the soya bean grain cleaning efficiency (%), scatter loss (%), output capacity (kg/h), and grain damage (%) were used as performance indicators. SAS statistical package version 9.5 was used for the analyses of results. All the independent variables have significant effect on the performance indicators. The range of performance values for the modified thresher are 94.81-99.13%, 1.79-3.74%, 76.24-211.06 kg/h and 1.83-14.00% for cleaning efficiency, scatter loss, output capacity and grain damage respectively. For all combinations, the threshing efficiency was 100 %. Lowest mean grain damage of 1.83 % was obtained with the combination of 800 rpm, 400 kg/h and 13.64 % speed, feed rate and moisture content (wet basis) respectively. This is the requirement for seed processors which gives 156.17 kg/h, 94.81 % and 2.20 % for Output capacity, Cleaning efficiency and Scatter loss respectively. The best combination for food processors is a combination of 400 kg/h, 13.64 %, 900 rpm for feed rate, grain kernel moisture and speed respectively. This combination gave 211.06 kg/h, 97.39 %, 2.86 % and 2.80 % for Output capacity, Cleaning efficiency, Scatter loss and Mechanical grain damage respectively.

Key words: Performance evaluation, Cylinder drum speed, grain Kernel moisture content, Cleaning efficiency, Output capacity, Grain damage.

1.0. INTRODUCTION

Soya bean is considered as a very important grain grown commercially in more than 35 countries of the world (Hasan, 2016). In Africa, Soybean is the second most important legumes after cowpea where about 20 million tonnes per annum are produced. In the year 2013, the average area cultivated in Africa was about 26 million hectares (ha) with a production of about 25 million tonnes with an average yield of about 0.9 tonnes per ha (FAOSTAT, 2017).

Threshing is a major post-harvest operation which is carried out after crops have been gathered from the field. Threshing consists of separating the beans from the pods (portion of the plant fruit that encases the soya bean seeds). Different Mechanical threshers are being developed and their performance evaluated. According to Ojediran *et al.* (2010), the performance of any thresher is dependent upon the moisture content of the crop, the peripheral speed of the cylinder, the clearance between concave and cylinder as well as the feed rate of the thresher. Based on these factors, many previous works (Abarchi, 2011, Gbabo *et al*., 2013 and IAR, 2018) have been done to determine the moisture content, the best peripheral speed of cylinder, the ideal clearance of drum and cylinder and the most adequate feed rate of various threshers and crops to achieve the best result for the threshing of the different crops. The aim of this work was to carry out performance evaluation of a modified soya bean threshing machine.

2.0 MATERIALS AND METHOD

2.1 Description of the modified Soya bean thresher

The machine threshes soya bean crop by impact and rubbing action and it derives its power from a diesel engine prime mover (5.965 kW). The soya bean is fed into the threshing chamber through the hopper. The product immediately experiences impact force due to the rotating pegs of the threshing drum against the concave screen. The detached grains and materials other than grains form a stream which moves along the threshing length. The grains and chaffs are separated through the concave screen. Shredded stalk passes through the stalk outlet with the help of a flail. The separated seeds and chaffs pass through the air stream provided by the fan and the chaffs were blown. Clean seeds then pass through the seed outlet. Plate 1 shows the modified thresher.

2.2 Instrumentation: A digital tachometer was used to measure the exact speed of the threshing drum before each sample was fed into the machine. Also, a manual weighing balance model (G & G JJ3000Y) with a sensitivity of 0.1g was used to measure the quantity of samples used. An electric oven was used to determine the moisture contents of soybean grain kernels (on wet basis).

Plate I: Modified soya bean thresher

2.3 Experimental Procedures

The performance tests of the soya bean thresher were conducted at three levels of grain moisture content (13.64, 11.3 and 9.12 % (w.b)), three levels of cylinder drum speeds (800, 850 and 900 rpm) and three levels of feed rates (200, 300 and 400 kg/h) by using a y randomized complete block design (RCBD) in a 3x3x3 factorial experiment with three replications. The moisture content of the soyabean grain kernels was blocked to allow for natural variability during field experiments. TGX 1485 soybean variety was used.

2.4 Performance Parameters: The formulae used for evaluating the various performance parameters of the thresher were calculated according to Ndirika (1997) as follows:

(i) Cleaning efficiency, C_e (%)

This is defined as the ratio of grain collected to the total mixture of grain and chaff received at the main outlet per unit time.

$$C_e = \frac{W_c}{W_t} \qquad (1)$$

Where,

C_e = Cleaning efficiency, %

W_c = Weight of clean grain at the main outlet of the thresher (kg)

W_t = Weight of total mixture of grain and chaff received at the main outlet (kg)

(ii) Mechanical grain damage, M_d (%)

This was determined by separating all the broken grains in the threshed sample collected per unit time.

$$M_d = \frac{Q_b}{Q_T} x100 \qquad (2)$$

Where

M_d = Mechanical grain damage, %

Qb = Quantity of broken grains in the sample (kg)

Q_T = Total quantity of grains collected at the outlet per unit time (kg).

(iii) Scatter loss, SL (%)

This is the loss acquired due to grain that scattered around the thresher during operation.

$$S_L = \frac{Q_g}{Q_T} x100 \qquad (3)$$

Where

S_L = Scatter loss, (%)

Qg = Quantity of grain scattered around during the threshing operation (kg)

QT = Total quantity of grains collected per unit time (kg).

(iv) **Output capacity, Tc (kg/h)**

This is the capacity of the thresher to thresh a quantity per unit time

$$T_c = \frac{Q_s}{T} \qquad (4)$$

Where

T_c = Output capacity, Tc (kg/h)

Qs = Quantity of threshed material collected at outlet per unit time (kg).

T = Time taken to complete threshing operation (hour)

(v) **Threshing efficiency, Te (%)**

$$T_E = 100 - \left(\frac{A}{T_G}\right) x\,100 \qquad (5)$$

Where:

T_E = Threshing efficiency (%)

A = Weight of un-threshed grain in unit time (kg)

TG = Total grain input in unit time by weight (kg)

2.4 Data Analysis

The data collected from the performance evaluation were analysed using SAS statistical package, version 9.5. Significant factors were further analysed using Fischer protected least significant difference, lsd (GENSTAT version 8.9).

3.0 RESULTS AND DISCUSSION

3.1 General observation

Effects of the independent variables, speed, feed rate and kernel moisture content on the performance indices, output capacity, cleaning efficiency, visible mechanical grain damage and kernel scatter losses are highly significant as shown in Table 1 and discussed below. The three factor interaction is significant for all the indices except for cleaning efficiency. Similarly, all the two factor interactions have significant effects on the indices except speed versus feed rate interaction effect on cleaning efficiency. The trends agree with those reported by Ahmad (2015), Hassan (2016) and IAR (2018).

Table 1: Summary of the Analysis of Variance for the Effects of Variables on the Performance Indices for modified Soyabean thresher

Source	DF	Output	Cleaning	Damage	Loss
Replication, R	2	1.85 ns	1.05 ns	1.94 ns	2.11 ns
Speed, S	2	1175.74**	162.55 **	636.95 **	2525.87 **
Feed rate, F	2	2688.03 **	82.97 **	1750.43 **	1629.72 **
Moisture Content, M	2	1043.39**	84.67 **	21740.00 **	5257.04 **
S*F	4	68.96 **	2.00 ns	17.66 **	32.15 **
S*M	4	52.69 **	8.81 **	64.37 **	251.77 **
F*M	4	41.93**	5.62 **	49.36 **	15.38 **
S*F*M	8	28.29**	1.65 ns	14.46 **	20.47 **
Error	52				
Total	80				

Key: ns: not significant; **: highly significant (i.e. at 1%);

3.2 Effect of cylinder speed on performance indices

At constant moisture content and feed rate, the following trend was observed: As the cylinder speed was increased from 800 to 900 rpm, the output capacity, cleaning efficiency, grain damage and scatter loss values increased (Table 2). The increase in Output capacity with increase in speed agrees with the finding of IAR (2018), Hassan (2016) and Ahmad (2015). The reason for higher outputs capacity at higher speeds may be due to the fact that at higher speeds, there are more impacts of the pegs on crop material. This enhances detachment of more kernels which increases outputs capacity. The increase in cleaning efficiency with increasing cylinder speed, all other factors being constant, could be attributed to the fact that according to the design, the cleaning fan pulley is directly being driven by the cylinder pulley. Hence an increase in cylinder speed enhanced higher cleaning. When other factors are kept constant, the increase in grain damage as the speed increases could be explained by the fact that at higher speeds, there is no much build up of the straw-grain material in the threshing chamber that could provide the needed cushioning effect on the grains. As such, the grain damage increases. The increase in grain losses at higher speeds may be due to the fact that at increased speed there was no corresponding increase in separation rate leading to increased losses of grain. These observations are corroborated by findings from others (Fernando *et al*., 2004; Vajasit and Solokha, 2006 and Sseiz *et al*., 2007).

Table 2: Results for Fischer tests for further analysis of significant means (speed)

Speed, rpm	Output Capacity Kg/h	Cleaning Efficiency %	Kernel Damage %	Scatter Loss %
900	150.8 a	98.47 a	7.104 a	3.117 a
850	140.2 b	98.25 b	6.470 b	2.759 b
800	115.7 c	97.03 c	5.567 c	2.466 c

3.3 Effect of crop feed rate on performance indices

At constant moisture content and cylinder speed the following trend was observed: As the feed rate was increased from 200 to 400 kg/h, the Output capacity increases (Table 3). This agrees with the findings of IAR (2018), Hassan (2016), Ahmad (2015) and Amadu (2012). The increase in output capacity with increase in feed rates may be due to the fact that at higher feed rates, more quantity of materials is been used at the input, thus increasing the output. Cleaning efficiency decreases with increase in feed rates (Table 3).The decrease in cleaning efficiency with increased feed rates could be attributed to the higher volume of material at higher feed rates, which in turn reduces the fan performance. This agrees with Dangora (2015). Grain damage decreases with increase in feed rate. The significant decrease in grain damage at higher feed rates, keeping other factors constant, could be due to the dense crop stream material to cushion the beater impacts thus shelving the grains from the beating impulse. Scatter loss increase with increased feed rates. This agrees with finding of IAR (2018) and Amadu (2012).The increase in scatter loss with increase in feed rates may be due to the fact that at higher feed rates, there is more material other than grains on the sieve which will cause delay in separation which will increase scatter loss.

Table 3: Results of Fischer tests for further analysis of significant means (feed rate)

Feed rate,. kg/h	Output Capacity Kg/h	Cleaning Efficiency %	Grain Damage %	Scatter Loss %
400	163.66a	97.37c	5.22c	3.05a
300	133.67b	97.91b	6.16b	2.77b
200	109.32c	98.48a	7.76a	2.53c

3.4 Effect of grain moisture content on performance indices

At constant feed rate and cylinder speed, the following trend was observed: As the grain moisture content was reduced from 13.64 to 9.12 %, the output capacity was decreased (Table 4). This agrees with the finding of Ahmad (2015), Hassan (2016) and IAR (2018). With less moisture, the crop stream build up tend to be less. Separation could thus be enhanced and therefore an increased output. Cleaning efficiency increases with decrease in moisture content (Table 4). This agrees with findings of Amadu (2012) and IAR (2018). The increase in cleaning efficiency with decreases in moisture may be due to the fact that at lower moisture, the materials other than grain are lighter and hence easily blown off by fan, thus increasing the cleaning efficiency. Grain damage increases with decrease in moisture content (Table 4). This agrees with the finding of Oluwale *et al.,* (2007), Amadu (2012). This is due to the fact that at lower moisture content the internal binding is weak thus, easily susceptible to impacts which implies higher damage. Scatter loss increases with decrease in moisture content. This agrees with Amadu (2012), for soybean threshers. The increase in scatter loss with decrease in moisture content may be due to the fact that at reduced moisture content density of the materials other than grains is lower. Therefore, the chaff and other foreign materials could not provide the cushioning effects hence, the grain easily scatter.

Table 4: Results of Fischer tests for further analysis of significant means (Kernel Moisture Content, % wb)

Kernel Moisture Content, % wb)	Output Capacity Kg/h	Cleaning Efficiency %	Grain Damage %	Scatter Loss %
13.64	153.30a	97.32c	3.86c	2.24b
11.30	133.84b	98.00b	4.56b	3.05a
9.12	119.51c	98.44a	11.52a	3.05a

3.5 Effects of interactions and best performance combinations

The effects of interaction of dependent variables on performance indices are shown in Table 5.

It could be seen that the highest output capacity (211.10 kg/h) of the modified soyabean thresher was obtained at the combination of 400 kg/h, 13.64 % and 900 rpm feed rate, grain kernel moisture content and cylinder speed, respectively. This combination could best be adopted by those who are primarily interested in output capacity, for example, commodity market entrepreneurs and food processors. Seed processors, however, would best adopt the combination which gave the least grain damage due to viability issues. In this case the combination of feed rate, moisture content and speed, (400 kg/h, 9.12 % and 800 rpm, respectively), gave the least seed damage (1.83 %).

Table 5: Results of Fischer tests for further analysis of significant means (significant interactions)

Output Capacity Kg/h	Cleaning Efficiency, %		Kernel Damage %	Scatter Loss %
F3M3S3= 211.10a	F1M3= 98.85a	M3S3= 98.95a	F3M1S1= 1.83b	F1M1S1= 1.79c
F3M3S2= 195.90b	F1M2= 98.48b	M3S2= 98.63b	F3M1S2= 2.17a	F2M1S1= 1. 95b
F3M3S1= 190.20c	F2M3= 98.37c	M2S3= 98.48c	F2M1S1= 2.20a	F1M1S2= 2.05a

Key:
S1= 800 rpm. S2 = 850 rpm, S3 = 900 rpm
F1 = 200 kg/h, F2 = 300 kg/h, F3 = 400 kg/h
M1= 9.12 %, M2 = 11.30 %, M3 = 13.64 %,

CONCLUSION

A comprehensive evaluation of the modified soyabean thresher was performed. Effects of the independent variables, speed, feed rate and grain moisture content on the performance indices, output capacity, cleaning efficiency, visible mechanical grain damage and grain kernel scatter losses, are highly significant. Highest output capacity (211.10 kg/h) of the modified soya bean thresher was obtained at the combination of 400 kg/h, 13.64 % and 900 rpm feed rate, kernel moisture content and cylinder speed respectively. Lowest mean grain damage of 1.83 % was obtained with the combination of 800 rpm, 400 kg/h and 13.64 % speed, feed rate and moisture content (wet basis) respectively.

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