



PERFORMANCE EVALUATION OF ICRISAT IK00007 MULTI CROP THRESHER

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ABSTRACT

The study evaluated the performance of the multi-crop motorized stationary thresher acquired by the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), Nigeria. The performance indices used were threshing efficiency, cleaning efficiency, output capacity, scatter loss and breakages. The independent variables used were the concave cylinder speed, revolution per minute (rpm) and feed rate, kg/min. The work was conducted using a factorial experiment in a completely randomized design (CRD). Data obtained were subjected to Analysis of Variance (ANOVA) using GENSTAT 17.1 version statistical software and least significant difference (LSD) was adopted in separating the means. The mean performance values of IK00007 machine for sorghum crop ranges from 102.71 – 157.33 kg/h, 72.36 – 93.30 % , 64.52 – 79.49 % , 17.33 – 27.80 % , and 0.12 – 0.67 % ; for millet crop it ranges from 34.10 – 78.12 kg/h, 57.77 – 92.07 % , 41.76 – 64.55 % , 13.35 – 27.99 % , and 0.23 – 0.38 % ; while for maize crop it ranges from 298.23 – 580.00 kg/h, 70.26 – 100.00 % , 61.20 – 91.60% , 22.74 – 43.06 % , and 0.70 – 1.27 % for output capacity, threshing efficiency, cleaning efficiency, scatter loss, and breakages, respectively. Machine IK00007 can be best used in threshing maize at a combination of feed rate of 40 kg/min and a speed of 950 rpm. With this, the mean values for output capacity, threshing efficiency, cleaning efficiency, scatter loss and grain breakages are 580.60 kg/h, 100.00%, 86.22%, 39.43% and 1.06% respectively. The best combination for threshing of sorghum with the machine (IK00007) is at the feed rate of 12 kg/min and a speed of 950 rpm. With this, the mean values for output capacity, threshing efficiency, cleaning efficiency, scatter loss and grain breakages are 157.33 kg/h, 86.20%, 76.07%, 22.39% and 0.47%, respectively. The best combination for threshing of millet with the machine (IK00007) is at the feed rate of 8 kg/min and a speed of 950 rpm. With this, the mean values for output capacity, threshing efficiency, cleaning efficiency, scatter loss and grain breakages are 78.12 kg/h, 77.68%, 56.20%, 25.04% and 0.27% respectively. The mean annual operational cost for IK00007 machine was found to be ₦ 118,936.3, ₦ 116,637.4 and ₦ 117,313.9 for the threshing of sorghum, millet and maize respectively. It is concluded that all independent factors has significant effects on the dependent performance indices. Specifications for the combination of operational machine parameters to give best performance have been obtained. The assessment of the operational cost of the thresher was conducted.

**Keywords:** Capacity, Efficiency, Grain, Output and Threshing

INTRODUCTION

Sorghum is globally cultivated and it is ranked as the fifth most important cereal after maize, wheat, rice and barley (Dharmaputra *et al.*, 2012). In Africa, Sorghum is the second most important cereal after maize where about 20 million tons per annum are produced. The largest producers of sorghum in Sub-Saharan Africa include Nigeria, Sudan, Ethiopia, Burkina Faso and Tanzania. These countries produce about 75% of the total production in the whole region



(ASARECA, 2011). Worldwide production of maize as at 2008 was 785 million tons with Africa producing 6.5% and the largest producer is Nigeria with nearly 8 million tons (IITA, 2009). Millets are extremely important in the semi-arid tropics of Africa and produced in 18.50 hectares by 28 countries covering 30.0% of the continent (Obilana *et al.*, 2002).

Threshing (detaching the kernels from the ears, cobs or pods) is accomplished by a combination of impact and rubbing action. While the conventional tangential threshing unit threshes mostly by impact, other threshing devices like rotary threshing units act more by rubbing (Kutzbach and Quick, 1999). Power threshers could be single crop or multi-crop. Threshing unit mainly consist of cylinder drum and concave. The threshing drum usually consists of a long cylindrical shape member to which a series of pegs, knives or rasp bars are attached on the surface. The threshing, drum is mounted on two bearings and rotates in a perforated trough “concave”. During threshing, crop is fed between the threshing drum and the concave, where it is subjected to a high degree of impact and frictional forces which detach the grains from materials other than grains.

For cereals, mechanical threshers are classified into axial-flow and cross-flow threshers. In the axial-flow threshers, the crop is made to flow along the longitudinal length of the cylinder. This is to allow for multiple impacts between the cylinder and the concave as the crop is moved along the length of the cylinder. This is said to improve the threshing efficiency of the thresher (Simonyan and Imokheme, 2008). However, in the cross-flow threshers, the crop is threshed as they are forced to transversally move between the cylinder and the concave.

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 (Kamble *et al.*, 2003; Abarchi, 2011 and Gbabo *et al.*, 2013) 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 of the threshing of the different crops. Also, rasp-bar and spike tooth cylinder have been used for threshing different crops and the thresher in which they are used evaluated. Kamble *et al.* (2003) used spike bar for threshing of millet and obtained a threshing efficiency range of 78.10 to 96.80 % for the different levels of test variables. The objective of the research was to carry out performance evaluation of a multi-crop thresher for millet, sorghum and maize. The machine was acquired by the International Crops Research Institute for the Semi-Arid Tropics, ICRISAT, Kano-Nigeria.

## MATERIALS AND METHODS

**Materials:** The materials used in conducting the research include: Digital Weighing balance (0.01g precision), Tachometer (Model TS 6000 and sensitivity of 5V per 1000 rpm), Maize (QPM), Millet (super SOSAT), Sorghum, (CRS-01), Oven (model (SM 150 temperature range 195 – 225<sup>0</sup>C), Measuring cylinder (1000 mls), Digital stop watch, Fuel (diesel).

**Description of Model IK00007 machine:** The thresher consists of hopper, threshing unit, which comprises shaft, threshing drum and beaters; sieve, grain delivery, chaffs outlet, blower and prime mover. The method of feeding is tangential to the drum, it has cylindrical pegs on a cylindrical drum it has rectangular fan blades attached on a shaft, it has reciprocating sieve assembly It has three outlets; clean grain outlet reciprocating sieve assembly and chaffs outlet It also has rectangular stand without tyres. It has two pulleys attached to the fan blade: pulley from blower

shaft to reciprocating sieve assembly, pulley from blower to prime mover. Also, another pulley is joined from drum shaft to prime mover. Prime mover rated output is 4.84kW, speed, 2200 rpm and Net weight is 60 kg (Plate I).



**Plate I:** *Picture of IK00007 ICRISAT Multi-crop Thresher*

**Methods:** The moisture content of the grain was determined using oven drying in which the sample was dried at 130°C for 18 hours and moisture content on wet basis was being obtained from the equation below ASAE (1982):

$$Mc = \left( \frac{W_i - W_d}{W_i} \right) 100 \quad \dots(1)$$

Where:

Mc = moisture content, wet basis (%)

Wi = initial weight of sample (kg)

Wd = dried weight of sample (kg)

**Treatments and Experimental Design:** The treatment consist of three (3) levels of speed (S) and two (2) levels of feed rate (F) these were factorially combine and laid out in a completely randomized design, CRD and replicated three times with moisture content (M) as a constant. Speeds used, selected based on experience and available literatures, are 750, 850 and 950 rpm for all the machines and the crops. Feed rates of 30 and 40 kg/min were used for maize. For sorghum trials, feed rates of 8 and 12 kg/min were used; and for millet, 6 and 8 kg/min. The machine was evaluated using the following performance indices while the expressions used were as given by NSAE/NCAM/SON, (1995) and Ndrika, (1994).

**Threshing efficiency, Te (%)**

$$Te = \left( 1 - \frac{Q_u}{Q_t} \right) \times 100 \quad \dots(2)$$

Where:

Qu = Quantity of unthreshed grains in sample (kg)

Qt = Total quantity of grain in sample (kg)

**Cleaning efficiency Ce (%)**

$$CE = \left( \frac{W_t - W_c}{W_t} \right) \times 100 \quad \dots(3)$$

Where:

CE = cleaning efficiency, %

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

Wc = Weight of chaff at the main outlet of the thresher (kg)



**Mechanical (visible) grain damage MD (%)**

$$MD = \frac{Q_b}{Q_t} \times 100 \quad \dots(4)$$

Where:

MD = Visible grain damage, %

Q<sub>b</sub> = Quantity of broken grains in sample (kg)

Q<sub>t</sub> = Total quantity of grain in sample (kg)

**Scatter Loss, SL (%)**

$$SL = \frac{Q_l}{Q_t} \times 100 \quad \dots(5)$$

Where:

Q<sub>l</sub> = Quantity of grains scattered around the thresher after threshing operation (kg)

Q<sub>t</sub> = Total quantity of grain in sample (kg)

**Output capacity, T<sub>c</sub> (kg/hr)**

$$T_c = \frac{Q_s}{T} \quad \dots(6)$$

Where: Q<sub>s</sub> = Quantity of threshed grain collected after a threshing operation (kg) T = Time taken for a complete threshing operation (h).

**Machinery Operational Costs**

**Fixed Costs, FC:** These include depreciation, interest shelter, taxes and insurance.

**Depreciation**

Three methods are commonly used to determine the amount of depreciation (Fairbanke *et al.*, 1971, Farris *et al.*, 2010). These are:

**(i) Straight Line Depreciation.**

$$AAD = \frac{(\text{cost price, } P) - (\text{salvage value, } S)}{\text{years owned, } N} = \frac{P-S}{N} \quad \dots(7)$$

Where; AAD = Annual Average Depreciation; P = Purchase price, S = Salvage value, N = estimated life

**(ii) Sum of the digits Depreciation, SDD**

$$SDD = \frac{(\text{cost price}) - (\text{salvage value})}{\text{years owned}} \{L - (Y - 1)\} \quad \dots(8)$$

Where (L) is the life of machine, in years and (Y) is the age at which depreciation is determined.

**(iii) Declining balance depreciation**

$$RV = c(1 - \frac{r}{L})^Y \quad \dots(9)$$

Where

RV = remaining value,

c = cost of the machine,

r = rate of depreciation compared to the straight line method,

L = the life of the machine, and

Y = the age of the machine at which depreciation is required.

**Interest**

Interest rates have varied from less than 8 percent to more than 12 percent (Bowers, 1975, Farris *et al.*, 2010).

$$\text{Interest} = \left(\frac{P+S}{2}\right) \times \frac{i}{100} \quad \dots(10)$$



### Taxes

$$\text{Taxes} = \left(\frac{P+S}{2}\right) \times \frac{t}{100} \quad \dots(11)$$

Where,

i and t are the prevailing interest and tax rates respectively

### Shelter

Farris *et al.* (2010) estimated a charge of 1-2 percent of the remaining value of the machine for shelter.

### Insurance

0.25 - 0.5 percent is charged as an annual cost for insurance when the risk is assumed by the owner of the machine.

Kepner *et al.* (1972) suggested a charge of 0.5-1.0 percent of new cost for shelter.

Variable costs, VC: (Farris *et al.*, 2010):

Variable costs (VC) = Fuel cost N/hr, + Lubricant N/hr, + Labor N/hr

Annual Cost, AC = FC % P + HW (VC)

H= hours of field work/day

W = total work days/year

## RESULTS AND DISCUSSION

### Performance Evaluation of IK00007 Machine for Threshing Different Crops

Table 1 presented the result for performance evaluation of threshing using IK00007 machine for different crops. The result showed that, feed rate and speed are highly significant on all the parameters. This agrees with many research findings (Dangora *et al.*, 2006; Gbabo *et al.*, 2013) The effect of oneway interaction; crop\*feed rate and crop\*speed are highly significant to all the performance indices but the effect of feed rate\*speed is highly significant only on capacity output, cleaning efficiency and threshing efficiency. The effect of the second order interaction (crop \* feed rate \* speed) is highly significant for all performance parameters except for breakage.

**Table 1: Performance Evaluation using IK00007 Machine for Threshing Different Crops**

	Breakage	Output Capacity	Cleaning efficiency	Scatter Loss	Threshing Efficiency
Crop, C	520.65**	372200**	6602.84**	2125.57**	5378.72**
Feed rate, F	106.44**	3290.39**	463.90**	340.08*	412.26**
Speed, S	193.69**	21776.89**	1480.45**	908.46**	1004.10**
C × F	3.44*	409.82**	15.50**	12.64**	115.46**
C × S	41.57**	11480.4**	39.34**	84.64**	401.27**
F × S	1.08ns	115.03**	21.26**	1.50ns	25.40**
C × F × S	0.36ns	209.19**	16.60**	14.86**	13.98**

\*\* = Highly significant, \* = Significant, NS = not significant

### Effects of IK 00007 Machine Speed on Threshing Performance

Further analysis using LSD ranking (Table 2) shows that, as the speed increased from 750 to 950 rpm it gave higher values of breakage, capacity output, cleaning efficiency, scatter loss and threshing efficiency for all the crops. This agrees with findings of many researchers: Alonge and Adegbulube (2002); Kamble *et al.* (2003) and Gbabo *et al.* (2013). LSD ranking, Table 3 shows that as feed rate increases, scatter loss, cleaning efficiency, threshing efficiency and breakage



decreased while, output capacity increased for all the crops. These observations are in-line with the findings of Alonge and Adegbulube (2002); Kamble *et al.* (2003); Abarchi, 2011 Gbabo *et al.* (2013) and Timothy (2012).

Two-way interaction crop\*feed rate\*speed showed that Maize at 30 kg/min and at a speed of 950 rpm has the higher value of cleaning efficiency, scatter loss and threshing efficiency while, Maize at 40 kg/min and at a speed at 950 rpm has the higher output capacity. The next crop after maize is Sorghum which has the higher value of parameters at 8 kg/min and at 950 rpm then Millet at 8 kg/min at 950 rpm. It can be observed that on ranking all the indices that are significant; Maize has the highest capacity at a feed rate of 40 kg/min and a speed of 950 rpm; then sorghum at 12 kg/min at a speed of 950 rpm while the least is Millet at a feed rate of 8 kg/min and a speed of 780 rpm. Maize at a feed rate of both 30 kg/min and 40 kg/min and at all speeds of 750, 850 and 950 rpm gave the highest threshing efficiency. Sorghum at 8 kg/min feed rate and at a speed of 950 rpm and Millet at 6 kg/min feed rate and a speed of 750 rpm are not significantly different in terms of their effect on threshing efficiency. The least mean value of threshing efficiency is found with Millet at 8 kg/min at 950 rpm. It can be observed that maize at 30 kg/min at a speed of 950 rpm has the highest value of cleaning efficiency followed by Sorghum at a feed rate of 8 kg/min and at a speed of 950 rpm and the least in cleaning efficiency is Millet at a feed rate of 6 kg/min and a speed of 950 rpm. It can be observed that millet at 8 kg/min and at a speed of 750 rpm has the least scatter followed by sorghum at 12 kg/min and at 750 rpm. Maize at 40 kg/min and a speed of 750 rpm has the higher scatter grain loss.

**Table 2: Effects of IK 00007 Machine Speed on Threshing Performance for Sorghum, Millet and Maize**

<b>SPD Rpm</b>	<b>Output Capacity</b>	<b>Scatter loss</b>	<b>Cleaning Efficiency</b>	<b>Threshing Efficiency</b>	<b>Breakage</b>
<b>SORGHUM</b>					
<b>750</b>	119.14 <sup>c</sup>	17.82 <sup>c</sup>	66.45 <sup>c</sup>	75.34 <sup>c</sup>	0.18 <sup>c</sup>
<b>850</b>	130.30 <sup>b</sup>	18.93 <sup>b</sup>	73.42 <sup>b</sup>	86.67 <sup>b</sup>	0.50 <sup>b</sup>
<b>950</b>	137.85 <sup>a</sup>	25.10 <sup>a</sup>	77.78 <sup>a</sup>	89.75 <sup>a</sup>	0.58 <sup>a</sup>
<b>MILLET</b>					
<b>750</b>	36.14 <sup>a</sup>	15.77 <sup>c</sup>	42.55 <sup>c</sup>	60.65 <sup>c</sup>	0.24 <sup>c</sup>
<b>850</b>	50.96 <sup>b</sup>	17.29 <sup>b</sup>	50.34 <sup>b</sup>	64.44 <sup>b</sup>	0.28 <sup>b</sup>
<b>950</b>	73.90 <sup>a</sup>	26.51 <sup>a</sup>	60.38 <sup>a</sup>	84.88 <sup>a</sup>	0.33 <sup>a</sup>
<b>MAIZE</b>					
<b>750</b>	327.01 <sup>c</sup>	26.29 <sup>c</sup>	73.67 <sup>c</sup>	100 <sup>a</sup>	0.61 <sup>c</sup>
<b>850</b>	450.79 <sup>b</sup>	37.08 <sup>b</sup>	85.52 <sup>b</sup>	100 <sup>a</sup>	0.74 <sup>b</sup>
<b>950</b>	577.37 <sup>a</sup>	41.25 <sup>a</sup>	91.12 <sup>a</sup>	100 <sup>a</sup>	1.17 <sup>a</sup>

Machine IK00007 can be best used in threshing Maize at the combination of feed rate of 40 kg/min and at a speed of 950 rpm. With this, the mean values for Output capacity, threshing efficiency, cleaning efficiency, grain damage and scatter loss are 580.60kg/h, 100.00%, 86.22%, 39.43% and 1.06% respectively. The best combination for sorghum is at the combination of a feed rate of 12 kg/min and a speed of 950 rpm. With this, the mean values for Output capacity, threshing efficiency, cleaning efficiency, grain damage and scatter loss are 157.33kg/h, 86.20%, 76.07%, 22.39% and 0.47% respectively. The best combination for millet operation is a combination of a feed rate of 8 kg/min and speed of 950 rpm. With this combination, the mean values for output



capacity, threshing efficiency, cleaning efficiency, grain damage and scatter loss are 78.12kg/hr, 77.68%, 56.20%, 25.04% and 0.27%, respectively.

**Table 3: Effects of IK 00007 Machine Feeding Rate on Threshing Performance for Sorghum, Millet and Maize**

Feed rate Kg/min	Output Capacity	Scatter loss	Cleaning Efficiency	Threshing Efficiency	Breakage
<b>SORGHUM</b>					
8	111.62 <sup>b</sup>	21.82 <sup>a</sup>	74.80 <sup>a</sup>	86.80 <sup>a</sup>	0.50 <sup>a</sup>
12	146.57 <sup>a</sup>	19.41 <sup>b</sup>	70.29 <sup>b</sup>	81.03 <sup>b</sup>	0.33 <sup>b</sup>
<b>MILLET</b>					
6	49.90 <sup>b</sup>	22.09 <sup>b</sup>	52.97 <sup>a</sup>	74.31 <sup>a</sup>	0.33 <sup>b</sup> <sup>a</sup>
8	57.42 <sup>a</sup>	17.61 <sup>a</sup>	49.20 <sup>a</sup>	65.66 <sup>b</sup>	0.23 <sup>a</sup>
<b>MAIZE</b>					
30	438.52 <sup>b</sup>	37.28 <sup>b</sup>	86.85 <sup>b</sup>	100 <sup>a</sup>	0.93 <sup>a</sup>
40	464.92 <sup>a</sup>	32.46 <sup>a</sup>	80.02 <sup>a</sup>	100 <sup>a</sup>	0.74 <sup>b</sup>

## CONCLUSION AND RECOMMENDATIONS

Performance evaluation of acquired multi-crop threshers by ICRISAT was conducted. All the variable independent factors (cylinder speed at three levels and crop feed rate at two levels) have significant effects on the dependent performance indices (threshing efficiency, output capacity, grain damage and scatter loss) for the machine. Specifications for the combination of operational machine parameters to give best performance have been obtained. The assessment of the operational cost of the thresher was conducted. It is recommended that the machine be operated at the stated best combinations for each crop.

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