

PERFORMANCE EVALUATION OF ICRISAT IK00006 MULTI CROP THRESHER

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ABSTRACT

Threshing is one of the most critical parts of post-harvest operations which affect the quality and quantity of crop production. Assorted Motorized stationary threshers are fabricated in Nigeria. The objective of this study was to evaluate 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 of threshing efficiency, cleaning efficiency, output capacity, scatter loss and breakages. The independent variables used were the concave cylinder speed, rpm and feed rate, kg/min. The work was conducted using a factorial experiment in a completely randomized design. GENSTAT 17.1 version statistical software was used to run the Analysis of variance, ANOVA. Means that were significant were further analyzed using the least significant difference, LSD. The mean performance values for IK00006 machine for sorghum crop ranged from 113.67 – 204.9 kg/h, 3.88 – 11.23 %, 71.54 – 83.31 %, 81.76 – 91.26 % and 0.00 – 0.02 %; for millet crop it ranged from 58.15 – 107.48 kg/h, 11.98 – 37.73 %, 60.42 – 68.13 %, 55.47 – 81.31 %, and 0.05 – 0.14 %; for maize crop it ranged from 376.28 – 670.80 kg/h, 22.05 – 30.42 %, 85.68 – 92.46 % and 0.30 – 1.67 %, for output capacity, scatter loss, cleaning efficiency, threshing efficiency and breakages, respectively. Machine IK00006 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 676.80kg/hr, 100.00%, 74.70%, 27.8% and 1.38% respectively. The best combination for threshing of Sorghum with machine IK00006 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 204.9kg/hr, 86.77%, 78.85%, 6.41% and 0.00%, respectively. The best combination for threshing of Millet 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 107.48kg/hr, 76.77%, 60.42%, 32.84% and 0.05%, respectively. The mean annual operational cost for this machine was found to be ₦ 141, 556:10, ₦ 143,044:40 and ₦ 141, 391:10 for the threshing of Sorghum, Millet and Maize respectively.

Keywords: Motorized, Multi-crop, Threshing efficiency, Output capacity, Scatter loss

1 INTRODUCTION

Maize (*Zea mays*) is the preferred staple food of more than 1.2 billion consumers in Latin America and sub Saharan Africa, where 30 – 50 % of the populations are malnourished [1] Maize is another world's most versatile seed crop. Its production in the southern states of the United States of America also expanded greatly just as it was in Africa and Asia [2] In Nigeria, maize was threshed originally by bare hands. Other popular method was the use of pestle and mortar. This method is still used in the rural areas today. The above methods are unsatisfactory because of their low output, tediousness and their requirement of extra strength. Millet is one of the oldest human foods and believed to be the first domesticated cereal grain. [3, 4] ranked pearl millet as the most important cereal in the southern Sudan and northern Guinea. Millets are good sources of minerals such as calcium, iron, zinc, copper and manganese [5]. Products from millet vary depending on people's taste and cultural preference. One of the common traditional products made from millet in Nigeria is 'kunu', a nonalcoholic beverage. Millet has also been found to be the most preferred staple in the semi-arid tropics of the region. The most important characteristic of millet is its unique ability to tolerate and survive

under adverse condition of continuous or intermittent drought as compared to most other cereals like maize and sorghum [6]. According to [7], in order to increase millet production, it is necessary to modernize the production techniques and optimize the processing conditions with a view to realizing some basic quality requirements such as improved flavor and increased shelf life. Sorghum is produced in large quantity in Nigeria up to about 6.851 million tons per year [8]. It is the second largest cereal crop cultivated after maize in Nigeria [9], and it has a great market potential for domestic and industrial uses. It is the crop of choice for dry region and areas with unreliable rainfall. Nigeria is one of the major sorghum producing country in the world ranking as the second largest sorghum producer in the world [10]. Threshing is the first and most important postharvest operation for grain crops. It involves, among other things, the detachment of grain kernels from the heads, cobs or pods as the case may be. Traditional methods are laborious, the output is low, high losses are also recorded [11]. Mechanical or power threshers have been introduced and are popular in most developing countries to overcome those difficulties¹¹. The ideal threshing unit (processor) is the one that produces a perfect threshing of maximum crop through put with optimum grain separation, while it preserves the natural shape and quality of the grain and minimize grain loss [12].

2 MATERIALS AND METHODS

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°C), Measuring cylinder (1000ml), Digital stop watch, Fuel (diesel). The thresher consists of hopper, threshing unit, sieve, grain delivery, chaffs outlet, blower and prime mover. The main power source of the machine is the prime mover with 2200 rpm and power of 8.82 kW. The prime mover provides drives through a V – belt connected to the pulley attached with set of beaters and blower. The hopper is the part where Sorghum is introduced and move into the threshing unit to remove grains from ears. The cleaned grains were collected through grain delivery while the chaffs are blown off with blower. 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 [13]:

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

Where: Mc = moisture content, wet basis (%), W_i = initial weight of sample (kg), W_d = dried weight of sample (kg). The machine was evaluated using the following expressions as given by [14, 15].

Threshing efficiency, Te (%)

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

Where: Q_u = Quantity of unthreshed grains in sample (kg), Q_t = Total quantity of grain in sample (kg)

Cleaning efficiency CE (%)

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

Where: CE = cleaning efficiency, %, W_t = Weight of total mixture of grain and chaff received at the grain outlet (kg), W_c = Weight of chaff at the main outlet of the thresher (kg)

Mechanical (visible) grain damage MD (%)

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

Where: MD = Visible grain damage, %, Q_b = Quantity of broken grains in sample (kg), Q_t = Total quantity of grain in sample (kg).

Scatter Loss, SL (%)

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

Where Q_l = Quantity of grains scattered around the thresher after threshing operation (kg), Q_t = Total quantity of grain in sample (kg)

Output capacity, T_c (kg/hr)

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

Where: Q_s = 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 [16] These are:

(i) Straight Line Depreciation.

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

Where; AAD = Annual Average Depreciation; P = purchase price, S = salvage value, N = estimated life

(ii) Sum of the digits Depreciation, SDD

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

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

(iii) Declining balance depreciation

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

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, 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 [17].

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

Taxes

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

Where, i and t are the prevailing interest and tax rates respectively

Shelter

[17] estimated a charge of 1 to 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.

[18] suggested a charge of 0.5-1.0 percent of new cost for shelter.

Variable costs, VC : [19]:

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.

3 RESULTS AND DISCUSSION

The pictorial view of the machine IK 00006 is shown in Plate 1. Table 1. Shows ANOVA for Performance Evaluation of IK00006 Machine for threshing different crops. It could be seen that the effect of crop, feed rate and speed are highly significant on threshing efficiency, output capacity, grain mechanical damage and scatter loss. This agrees with many research findings [11, 15, 20]. Their effect on cleaning efficiency, however, was not significant. This may be attributed to the nature of the fan design whose capacity could have been out of the reach to show significant difference. The effect of two ways interaction; crop*feed rate, crop*speed and feed rate*speed are highly significant to all the performance indices except for cleaning efficiency. The effect of the third order interaction (crop * feed rate * speed) is highly significant for all performance parameters except for cleaning also.



Plate I: Picture of IK00006 ICRISAT Multi- Crop Thresher

Table 1: ANOVA Table for Performance Evaluation using IK00006 Machine for Threshing Different Crops

	Breakage	Output Capacity	Cleaning efficiency	Scatter Loss	Threshing Efficiency
Crop, C	11349.27**	317600**	1.01ns	7743.06**	3780.30**
Feed rate, F	181.16**	3021.16**	0.97ns	486.06**	183.52**
Speed, S	2285.91**	15962.04**	1.00ns	2250.96**	333.38**
C × F	89.45**	1322.21**	1.00ns	19.76**	61.30**
C × S	2041.91**	3834.02**	0.99ns	689.72**	150.65**
F × S	44.38**	424.47**	1.01ns	24.46**	4.37*
C × F × S	12.05**	329.47**	0.99ns	5.54*	11.72**

** : Highly significant; * : Significant at 5 %; ns: Not significant

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 [21, 22, 23, 24, 25]. LSD ranking Table 3 shows that as feed rate increases, scatter loss, cleaning efficiency, threshing efficiency and breakage decreased while, capacity output increased for all the crops. These observations are in-line with the findings of [11, 21, 22, 23, 24, 25].

Maize has the highest values of breakages, output capacity, cleaning efficiency, scatter loss and threshing efficiency. Three ways interaction of crop, feed rate and speed shows that the combination of Maize at 30 kg/min feed rate and a speed of 950 rpm gave the higher mean values of breakage. The least is Sorghum at 8 kg/min and at a speed of 850 rpm. Maize at 40 kg/min feed rate and at a speed of 950 rpm gave the higher output capacity while, the least on the same output capacity is Millet at 6 kg/min feed rate and at a speed of 750 rpm. Millet at 6 kg/min feed rate and at a speed of 950 rpm gave the higher mean values of grain scatter loss while, the least is Sorghum at a combination of 8 kg/min feed rate and at a speed of 750 rpm. Maize at 30 kg/min or 40 kg/min feed rate and at all speeds of 750,

850 and 950 rpm gave the higher threshing efficiency while, the Millet at 8 kg/min feed rate and at a speed of 750 rpm gave the least threshing efficiency.

Table 2. LSD Table for Ranking of Speed on Parameters for IK 00006 machine

SPD Rpm	Output Capacity	Cleaning Efficiency	Scatter loss	Threshing Efficiency	Breakage
SORGHUM					
750	120.83 ^c	5.50 ^c	73.55 ^c	82.89 ^c	0.00
850	160.07 ^b	6.48 ^b	75.11 ^b	86.58 ^b	0.00
950	202.79 ^a	8.82 ^a	81.08 ^a	89.02 ^a	0.01
MILLET					
750	67.12 ^c	12.53 ^c	63.03 ^c	61.33 ^c	0.06 ^c
850	73.42 ^b	21.50 ^b	66.28 ^b	75.77 ^b	0.075 ^b
950	105.27 ^a	35.29 ^a	64.28 ^a	79.04 ^a	0.10 ^a
MAIZE					
750	424.03 ^c	22.64 ^c	86.47 ^a	100 ^a	0.36 ^c
850	564.28 ^b	25.21 ^b	87.08 ^b	100 ^a	0.66 ^b
950	632.48 ^a	29.12 ^a	83.58 ^c	100 ^a	1.53 ^a

Table 3. Table for LSD ranking of feed rate on parameters for IK00006 machine

Feed rate Kg/min	Output Capacity	Cleaning Efficiency	Scatter loss	Threshing Efficiency	Breakage
SORGHUM					
8	157.57 ^b	8.98 ^a	78.48 ^a	87.93 ^a	0.01 ^a
12	164.89 ^a	4.88 ^b	74.68 ^b	84.39 ^b	0.00 ^a
MILLET					
6	76.21 ^b	24.37 ^a	65.86 ^a	75.60 ^a	0.09 ^a
8	87.65 ^a	21.84 ^b	63.19 ^b	68.49 ^b	0.06 ^b
MAIZE					
30	508.25 ^b	26.74 ^a	88.25 ^a	100 ^a	0.93 ^a
	572.27 ^a	24.56 ^b	83.17 ^b	100 ^a	0.76 ^b

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 followed by Sorghum at a feed rate of 12 kg/min and at a speed of 950 rpm then Millet at a feed rate of 8 kg/min and at speed of 950 rpm. It can be observed that 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 followed by Sorghum at 8 kg/min and at a speed of 950 rpm then Millet at 6 kg/min and a speed of 750 rpm. It can be observed that Maize at a feed rate of 30 kg/min and a speed of 950 rpm has the highest breakage followed by Millet at 6 kg/min at a speed of 950 rpm then Sorghum at a feed rate of 8kg/min and at a speed of 950 rpm. It can be observed that Millet at feed rate of 6 kg/min and at a speed of 950 rpm has the least scatter followed by Maize at a feed rate of 30 kg/min and at 950 rpm then Sorghum at a feed rate of 8 kg/min and a speed of 950 rpm. Machine IK00006 can be best used in threshing Maize at a 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 676.80 kg/hr, 100.00 %, 74.70%, 27.8% and 1.38 % 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 204.9 kg/hr, 86.77 %, 78.85 %, 6.41% and 0.00 %

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 107.48 kg/hr, 76.77 %, 60.42 %, 32.84 % and 0.05 % respectively.

4 CONCLUSION

Performance evaluation of acquired multi-crop threshers by ICRISAT was conducted. The entire 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. The assessment of the operational cost of the thresher was conducted.

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