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Adaptation and Evaluation of Power Operated Grain De-huller

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Abstract: Dehulling is a process employed to get rid of the outer pericarp and testa of most cereal grains, using mechanical means. Despite the increase in production, limited effort has been taken to improve grain processing technologies, particularly, for small-scale rural farmers. The use of dehuller improves the physical appearance and the functional property of grain. A grain de-hulling machine consists of a hopper and a power-operated mechanism. The performance of the adapted machine was evaluated in terms of de-hulling efficiency, Percentage of breakage, and de-hulling capacity. The maximum de-hulling capacity (500.00 kg/hr and 571.42 kg/hr) was obtained at an operating speed of 2500 rpm and 20 kg of hopper loading for barley and rice respectively. The maximum de-hulling efficiency (99.21% and 97.02%) was recorded at 10 kg of hopper loading and 2500 rpm of the operating speed for barley and rice respectively. The maximum percentage of breakage (2.85%) was recorded at 20 kg of hopper loading and 2500 rpm of the operating speed for barley. For rice, the maximum percentage of breakage (5.02%) was recorded at 20 kg of hopper loading and 2500 rpm of the operating speed. De hulling efficiency, in general, increased when increasing the speed of the machine and decreased when increasing the feeding rate. The broken percentage of the grains increases when the speed of the machine increases and decreases as the feeding rate increases for each grain. The dehulling capacity of the machine increases as both the feeding rate and the operation speed increase for each grain. The adapted machine was good for barley at 2500 machine speed and 20 kg of hopper loading. Since maximum grain breakage was recorded for rice, it is recommended for further modification.

Keywords: Barley, De huller, Grain, Rice.

Research Paper

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INTRODUCTION

Dehulling is a process employed to get rid of the outer pericarp and testa (hull) of most cereal grains, grain legumes, nuts, and oil seeds using mechanical means (Awika *et al*., 2003). The basic ways of hulling include a traditional method, an animal-powered miller, the use of a pedal-powered huller, a mechanized method, and the use of rubber rolls to separate the chaff from the seed grains. The traditional method of hulling involves the use of mortar and pestle. It is tedious, has low efficiency, and the separation of chaff from grain is done by winnowing (Poonam, 2014). Automated machines can be used for large-scale production as their production rate is higher and have less seed loss but these machines are very costly; farmers cannot afford to buy those (Meghashyam *et al*., 2014).

Despite the increase in production, limited effort has been taken to improve grain processing technologies, particularly, for small-scale rural farmers. Processing whole grains by dehulling increases the versatility of grain in food use, both for domestic use and industrial purposes.

Grain dehulling results in better market results and improves the economic and nutritional status of farmers. De-hulling by hand pounding is very tedious and time-consuming. Hand-pounding is also inefficient because there would be a considerable loss of grain and nutritional values. Mechanical dehulling by using a dehuller is a very convenient and quicker process. The use of dehuller improves the physical appearance and the functional property of grain making it suitable for use in various products which are usually prepared with other finer grains. This activity was to evaluate the efficiencies of power-operated grain de-hulling to suit local barley and rice varieties to improve the quality of locally produced barley and rice.

Objective

- To adapt and evaluate performance of power-operated grain de-huller

MATERIALS AND METHODS

Materials

The materials used for the construction of the power-operated grain de-huller were Sheet metal, angle iron, bolt, nut, round bar, and bearings.

Methodology

Description of Machine and Working principle

A grain de-hulling machine is adapted from Asela agricultural engineering research center. It consists of a hopper, frame, dehulling chamber and a power-operated mechanism. Grains were fed from the hopper into the machine. The rollers are rotated and thus the rollers apply a certain amount of impact on the grains due to friction occurs between grains and rollers. Then the husk is separated from the grains. Then grains were collected in a vessel.

Figure 1: Grain de huller evaluated for barley and rice

Data Collected

Time taken, total weight of the grains, weight of dehulled grains, weight of unhulled grains

Performance Evaluation

The performance of the adapted machine was evaluated in terms of de-hulling efficiency, Percentage of breakage, and de-hulling capacity.

De-hulling efficiency and Percentage of breakage

Three random samples of 1 kg were collected from the kernel outlet and the samples were separated into three major division's namely whole kernels, broken grains, and un-hulled grains. The de-hulling efficiency and broken grain percentage were calculated using the equations below (Jayadeep *et al.*, 2009).

$$n = \left(\left(1 - \frac{Mu}{Mt}\right) * \left(1 - \frac{Mb}{Mt}\right)\right) * 100$$

Broken percentage (%) = $\frac{\mathrm{Mb}}{\mathrm{Mt}} * 100$

Where; n = De-hulling efficiency, %, M_u= Mass of the unhulled grain, g, M_b= Mass of broken grain, g, Mt = Total mass of the grains taken for de-hulling, g

De-hulling capacity (kg/hr)

The weight of grains (whole and damaged) that were dehulled and received per hour at the main grain outlet is called capacity. At the end of each test, the total de-hulled grain was collected from the main grain outlet. The capacity was calculated from the following equation.

$$\mathrm{Dc} = \frac{\mathrm{Wg}}{\mathrm{t}} * 60\mathrm{min/hr}$$

Where: D_c= De-hulling capacity (kg/hr), W_g =Weight of de-hulled grain at the main outlet (kg), t =Recorded time of de-hulling (min)

Experimental design

The experimental design is a split-plot design. The treatment for evaluation of the machine is two-grain types (barely and rice), three engine speeds, and three hopper loading with three replications. The least significant difference (LSD) will be used at 0.05.

RESULTS AND DISCUSSION

De Hulling Capacity

The maximum de-hulling capacity (500.00 kg/hr) was obtained at an operating speed of 2500 rpm and 20 kg of barley in 2.40 minutes. The minimum de-hulling capacity (222.22 kg/ hr) was recorded at an operating speed of 1500 rpm and 10 kg of barley in 2.70 minutes. The maximum de-hulling capacity (571.42 kg/hr) was obtained at the operating speed of 2500 rpm in 2.10 minutes of 20 kg of rice. The minimum de-hulling capacity (250.00 kg/hr) was obtained at the operating speed of 1500 rpm and 10 kg of rice in 2.40 minutes. Tables 1 and 2 show that as the feeding and operating speed increase the de-hulling capacity increases.

De hulling efficiency

The maximum de-hulling efficiency (99.21%) was recorded at 10 kg of hopper loading and 2500 rpm of the operating speed for barley. The minimum de-hulling efficiency (89.00%) was recorded at 20 kg of hopper loading and 1500 rpm of the operating speed for barley. The maximum de-hulling efficiency (97.02%) was recorded at 10 kg of hopper loading and 2500 rpm of the operating speed for rice. The minimum de-hulling efficiency (84.57%) was recorded at 20 kg of hopper loading and 1500 rpm of the operating speed for rice.

Breakage

The maximum percentage of breakage (2.85%) was recorded at 10 kg of hopper loading and 2500 rpm of the operating speed for barley. Whereas the minimum percentage of breakage (0.91%) was recorded at 20 kg of hopper loading and 1500 of the operating speed. For rice, the maximum percentage of breakage (5.02%) was recorded at 10 kg of hopper loading and 2500 rpm of the operating speed. The minimum percentage of breakage (3.06%) was recorded at 20 kg of hopper loading and 1500 of the operating speed.

Table 1: Effect of operating speed and hopper loading on performance of de-hulling machine on barley

Grain type	Hopper loading (kg)	Operation speed (rpm)	Capacity (kg/hr)	Efficiency (%)	Time taken (min)	Breakage (%)
Barley	10	1500	222.22^{i}	91.22^{e}	2.70^{cd}	1.42^{e}
		2000	240.00^{h}	96.11^{c}	2.50^{e}	1.99^{cd}
		2500	285.71^{g}	99.21^{a}	2.10^{f}	2.85^{a}
	15	1500	310.34^{f}	90.33^{e}	2.90^{b}	1.02^{f}
		2000	339.62^{e}	95.04^{d}	2.65^{d}	1.96^{d}
		2500	479.75^{d}	98.01^{b}	2.37^{e}	2.51^{b}
	20	1500	387.10^{c}	89.00^{f}	3.10^{a}	0.91^{g}
		2000	428.57^{b}	94.07^{d}	2.80^{bc}	1.49^{e}
		2500	500.00^{a}	96.79^{c}	2.40^{e}	2.06^{c}
CV			0.21	0.62	2.96	2.73
LSD (0.05)			1.32	1.01	0.13	0.08

The mean followed by the same letter in the column has no significantly different.

Table 2: Effect of operating speed and hopper loading on performance of de-hulling machine on rice

Grain type	Hopper loading (kg)	Operation speed(rpm)	De-hulling Efficiency (%)	De-hulling Capacity(kg/hr)	Time taken(min)	Breakage (%)
Rice	10	1500	88.79^{e}	250.00^{i}	2.40^{cd}	3.59^{g}
		2000	94.31^{bc}	272.73^{h}	2.20^{ef}	4.14^{d}
		2500	97.02^{a}	333.33^{g}	1.80^{h}	5.02^{a}
	15	1500	86.48^{f}	346.15^{f}	2.60^{b}	3.16^{h}
		2000	93.37^{c}	391.30^{e}	2.30^{de}	4.12^{e}
		2500	95.85^{ab}	466.32^{d}	1.93^{gh}	4.67^{b}
	20	1500	84.57^{g}	428.67^{c}	2.80^{a}	3.06^{i}
		2000	91.07^{d}	480.00^{b}	2.50^{bc}	3.66^{f}
		2500	94.17^{c}	571.42^{a}	2.10^{fg}	4.20^{c}
CV			1.00	0.24	4.84	0.67
LSD (0.05)			1.58	1.71	0.17	0.05

CONCLUSION AND RECOMMENDATION

Conclusion

Based on the performance evaluation made and results obtained, the following conclusions can be drawn:

The maximum de-hulling capacity (500.00 kg/hr) was obtained at an operating speed of 2500 rpm and 20 kg hopper loading of barley in 2.40 minutes. The minimum de-hulling capacity (222.22 kg/ hr) was recorded at an operating speed of 1500 rpm and 10 kg hopper loading of barley in 2.70 minutes. The maximum de-hulling capacity (571.42 kg/hr) was obtained at the operating speed of 2500 rpm in 2.10 minutes of 20 kg of hopper-loading rice. The minimum de-hulling capacity (250.00 kg/hr) was obtained at the operating speed of 1500 rpm and 10 kg of rice in 2.40 minutes.

The performance of the machine was significantly affected by the feeding rate and speed of the machine. De hulling efficiency, in general, increased when increasing the speed of the machine and decreased when increasing the hopper loading. The dehulling capacity of the machine increases as both the hopper loading level and the operation speed increase for each grain.

Recommendation

The adapted machine was good at 2500 rpm speed and 20 kg hopper loading for both crops.

Since maximum grain breakage was recorded for rice, further modification is recommended.

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