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Performance Evaluation of an Indigenous Rotary Power Weeder

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Abstract
A rotary power weeder was developed and evaluated. The weeder is to reduce drudgery and ensure a comfortable posture of the farmer or operator during weeding and increase production. The weeder's component parts are: frame, rotary hoe (disk), tines, power and transmission unit. The results of field performance evaluation showed that the field capacity and weeding efficiency of the rotary power weeder were 0.0712 ha/hr and 73%. The cost of operation with this weeder was estimated to be N 2,700.00 as against N 12,000.00 by manual.

Keywords: Rotary weeder; weeding efficiency; field capacity; weed density

1 Introduction

A weed is essentially any plant which grows where it is unwanted. A weed can be thought of as any plant growing in the wrong place at the wrong time and doing more harm than good [1]. Weeds waste excessive proportions of farmers' time, thereby acting as a brake on development [2]. Weeding is an important but equally labour intensive agricultural unit operation. There is an increasing interest in the use of mechanical intra-row weeder because of concern over environmental degradation and a growing demand for organically produced food. Today the agricultural sector requires non-chemical weed control that ensures food safety. Consumers demand high quality food products and pay special attention to food safety. Through the technical development of mechanisms for physical weed control, such as precise inter-and intra-row weeder, it might be possible to control weeds in a way that meets consumer and environmental demands. Njoku [3] reported that uncontrolled weeds growth reduces yield of the principal crops while untimely weeding reduces the returns from the overall investments in the production of crops. However, some weeds have beneficial uses but not usually when they are growing among crops. Weeds decrease the value of land, particularly perennial weeds which tend to accumulate on long fallows; increase cost of cleaning and drying crops (where drying is necessary). Weeds accounts for about 50-70% reduction in yield; particularly in the humid tropics where torrential rainfall significantly interrupt work on the farms in the season. The situation necessitates the introduction of an appropriate machine for effective weeding control. Manual weeding is common in Nigeria. The use of sort handle hoe is effective and it is the most widely used weed control method. It is reported that manual weeding is labour-intensive, accounting for about 80% of the total labour required for producing food in Nigeria [4]. Nganilwa et al. [5] observed that a farmer using only hand hoe for weeding would find it difficult to escape poverty, since this level of technology tends to perpetuate human drudgery, risk and mystery. Busari [6] concluded that the use of herbicides has possible effect on desert encroachment and other adverse impact, while Gobor and Lambers [7], asserted that the need for non-chemical weed control techniques has steadily increased in the last fifteen years, as a consequence of the environmental pollution originated by the intensive application of pesticides in agriculture.

Few authors [8-12] have reported for mechanization of agriculture to succeed it must be based on indigenous designs, development and manufacture of most of the needed machines and equipment, to ensure their suitability to the crops as well as to the farmers' technical and financial capabilities. In line with this, this work evaluates the performance of a rod tine power weeder and compare with those of cable tine, plastic strand tine and line yard tine weeder earlier developed in the Department of Agricultural and Biosystems Engineering, University of Ilorin.

2 Material and Method

A rotary power weeder (Figure 1) was developed. It comprises frame, rotary hoe (disk), tines, power and transmission unit.

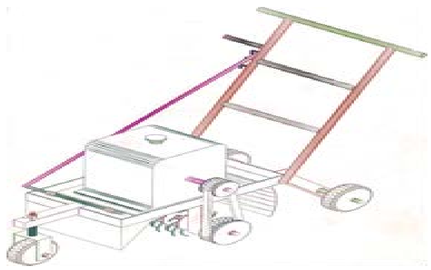

Figure 1 Isometric View of Rotary Power Weeder

The components of the weeder are as follow:

1) **The Frame:** This is made up of 30mm×30mm mild steel angle iron of 5mm thickness. The dimensions required (i.e. 600mm and 350mm) were marked out and cut. Hacksaw blade was used to chafer the edges of the contact points for effective joining. The cut out part welded together to form the frame of the weeder
2) **The Rotary Hoe (Disk):** The disk is a circular plate cut out of 12mm thick mild steel plate. There are five disks in the weeder, (θ128mm). A 50mm hole is drilled at the centre of each disk for shaft to pass through. Circular pipes of 60 mm length were drilled and welded on the disks to hold the disks on the shaft
3) **The Tines:** This is a metal rod made from mild steel of 13mm diameter. They are curved into shape and welded radially on the disk as shown in Fig 5. Twelve tines per disks were considered good for effective dislodging of weeds. The length of each tine is 138mm long.
4) **Power and Transmission units**: The machine is to be powered by a 5-hp internal combustion engine. Belt and Pulley arrangement shall be employed for transmission of power.

2.1 Methodology

The machine was operated and the following performance feature was noted:

1) Weeding index
2) Weeding efficiency
3) Field capacity

To carry out the evaluation, the performance of the constructed weeder was conducted on the experimental field of Department of Agricultural and Biosystems Engineering, University of Ilorin by investigate the effect of weed density on performance of four weeding tools.

The experimental area was infested mostly with weeds like *Trifolium repens* (clover), *cryperus eragrotis* (umbrella sledge), *cyperus rotumdus* (Nut grass), *cynodon dactrylon* (couch grass), *cynosures echinatus* (Dog's Tail), *phyllanthus amarus* (Petty spurge), *Lactuca taracifolia* (Wild lettuce), *Sida acuta* (broom weed), *Imperata cylindrical* (logongrass), *Amarantus spinosus* (thorny pig weed) and *Eleusine indicae* (goose grass).

Prior to each weeding schedule, weed density in each experimental unit was determined by laying-out a squared grid (0.3m×0.3m) in the plot and weeds in the grid were counted. Three such determinations were made for each experimental unit Experimental factors used in the field evaluation of the constructed rotary power weeder were five (5) levels of speeds (1804, 2004, 2435, 2261 and 3506 rpm) in three blocks were employed.

2.2 Performance Indicators

Performance indicators used for this experiment includes the following:

2.2.1 Weeding Index

Weeding index is a ratio between the number of weeds removed by a weeder and the number present in a unit area and is expressed as a percentage [13].

$$I_w = (W_1 - w_2)/W_1 \quad (1)$$

Where,
I_W = weeding index
W_1 = weeds before weeding
W_2 = weeds after weeding

A spot of 27m x 2m meter is selected out of the main plot for sampling. Weeds in the spots will be counted before and after weeding using the constructed rotary weeder. The time taken to perform this operation will be noted. Equation 1 is used to calculate weeding index.

2.2.2 Weeding Efficiency

The weeder is tested on the same field to determine weeding efficiency. It is calculated by using equation 2.

$$\Sigma = (W_1 - W_2)/W_1 \times 100 \quad (2)$$

where,
W_1 = number of weeds before weeding
W_2 = number of weeds after weeding
Σ = weeding efficiency

2.2.3 Field Capacity

The weeding tools were tested on the same plots to determine the field capacity of each of them. Field capacity is the amount of area that a weeding tool can cover per unit time as shown in equation 3**.**

$$FC = (60 \times 4)/(t \times 10{,}000) \quad (4)$$

Where,
FC= Field capacity (ha/h)
A = Area covered (m^2)
t = Time taken in minutes

3 RESULTS AND DISCUSSION

3.1 Weeding Efficiency

This was determined by counting the number of weeds before and after using the developed weeder on the 3blocks (replicated three times). Detail records are presented in Table 1 and 2. Table1 shows that higher engine speed leads to higher weeding efficiency. However, Table 2 shows the relationship between forward speed and weeding efficiency, it was observed that operating the weeder at higher speeds above 0.8 m/s was characterized with rough weeding. 2261 rpm is ideal speed for this weeder as shown in Figure 2.

3.2 Effect of Engine Speed on Weed Density

Table 1 shows the number of unremoved weeds after weeding trials at different levels of engine speed. It shows that engine speed has a proportional effect on iron rod tine, i.e. engine speed influenced the efficiency of the weeder.

3.3 Field Capacity

The field capacity of the power weeder at various levels of speed was observed to range from 0.068 ha/hr and 0.079 ha/hr. as shown in Figure 3.

Table 1 Number of weeds removed and efficiencies at various engine speeds

Engine speed (rpm)	Blocks	Weed Density		Number of weeds removed	Efficiency (%)
		Before weeding	After weeding		
1804	1	520.22	241.49	278.73	53.67
	2	554.33	241.85	312.48	56.37
	3	602.89	277.75	325.14	54.89
2004	1	577.85	245.70	332.15	58.48
	2	615.78	265.96	349.82	57.81
	3	668.15	290.51	377.64	57.52
2261	1	652.00	274.69	377.31	58.87
	2	694.75	291.03	403.72	59.11
	3	753.87	315.27	438.60	59.18
2435	1	703.19	262.07	441.12	63.73
	2	746.30	277.69	468.61	63.79
	3	811.84	302.74	509.10	63.71
3506	1	1012.45	257.05	755.40	75.62
	2	1074.53	310.53	764.00	72.10
	3	1168.77	334.15	834.62	72.41

Table 2 Time taken, speed and efficiencies for various engine speeds (Rod tine weeder)

Engine speed (rpm)	Distance moved (m)	Time taken (Seconds)				Forward Speed (m/s)				Efficiency (%)			
		Block 1	Block 2	Block 3	Mean	Block 1	Block 2	Block 3	Means	Block 1	Block 2	Block 3	Mean
1804	27	55.09	52.33	52.88	53.35	0.4901	0.4551	0.5102	0.4851	53.67	56.37	54.89	54.98
2004	27	51.00	51.44	52.44	51.63	0.5294	0.5249	0.5149	0.5231	58.48	57.81	57.52	57.94
2261	27	47.35	46.23	46.75	46.78	0.5702	0.5840	0.5775	0.5772	58.87	59.11	59.18	59.05
2435	27	45.48	45.41	45.49	45.46	0.5937	0.5946	0.5935	0.5939	63.73	63.79	63.71	63.74
3506	27	31.74	32.00	31.85	31.86	0.8507	0.8438	0.8477	0.8474	75.62	72.10	72.41	73.37

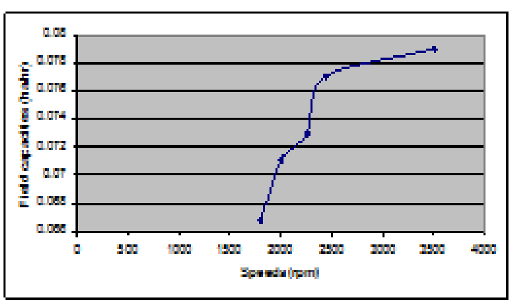

Figure 2 Weeding efficiencies for engine

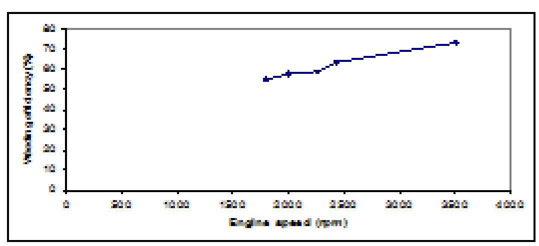

Figure 3 Weeding efficiencies for engine speeds

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