Development of a Speed Selection System for a Mechanical Weeder

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Abstract - A speed selection system was designed and incorporated into an existing mechanical row weeder. A 2-stroke, air-cooled, 9.85hp motorcycle engine was used as the power source for the weeder. The motorcycle gear system was adapted to supply four different speeds which can be engaged or disengaged using a fabricated clutch. Power is transmitted via chain and sprocket and belt and pulley drives. Other components of the weeder are frame, tyres, transmission system, rotary blades, circular plates and shaft. Test result shows that effective field capacity of the weeder ranged from 0.013ha/hrat gear 1 and cutting speed of 642rpm to 0.042ha/hr at gear 4 and cutting speed of 1031 rpm. The maximum weeding efficiency of 80% was achieved at gear 4 but with higher fuel consumption of 0.8 liters/hr.

***Keywords: Speed, Weeder, Weeding, Herbicide*.**

I. INTRODUCTION

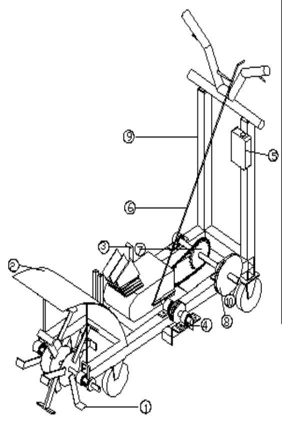
Among the activities involved in crop production such as land preparation, weeding, fertilizer application, and harvesting, weeding is the most labour intensive operation [5]. Weeding accounts for about 25% of the total labour requirement (900-1200 man-hours/hectare) during a cultivation season [6]. Manual weeding is common in Nigeria where about 75% of the population is engaged in farming. This method is labour intensive and is one of the major problems of farming in Nigeria. The use of herbicides in killing weeds has been the usual practice of some farmers but the recent upsurge in environmental awareness of the public, interest organic food production and some health problems with the use of herbicides not to be a better alternative. Duval [3] reported that mechanical weed control allows farmers to reduce or even eliminate herbicide use. He gave a comparison of mechanical weeding versus herbicides use and concluded that mechanical weeding reduces cost of weed control, aerates the soil, reduces pollution, breaks soil crust and contribute to a better environment.

Ajewole[2] reported various attempts made by educational institutions in Nigeria in designing and fabricating mechanical weeders. For example, Ademosun et al [1] reported the development of some machines for weeding while Olukunle and Oguntunde[4] designed and fabricated a row crop weeder which uses nail brushes to remove weeds. Ajewole [2] also reported the design and fabrication of an inter-row weeder using helical blades. Despite all these attempts there has always been one problem or the other with these weeders which has made Nigerian farmers not to quickly adopt them for weeding operations. Among the problems is the inability of the weeder designers to incorporate speed control and clutch system which can make the user to engage or disengage the drive mechanism from cutting blades. This paper therefore reports the development of the speed selection and control system which will make the weeder to be easily operated by farmers and enable them to disengage the cutting blades from the drive unit when they are not working in the weed area.

II. MATERIALS AND METHODS

A. Design Drawings

The isometric and orthographic drawings of the weeder are presented in Fig. l and Fig. 2 respectively.



BILL OF MATERIALS				
PART NO	QTY	ITEM	DESCRIPTION	MATERIAL
10		sprocket shaft	25 DIA	mild steel
9		iron pipe	5 x 50	mild steel
8	1	pulley	180dia	mild steel
7	1	sprocket	47 teeth	mild steel
6	1	gear selector		stainless steel
5	1	fuel tank		mild steel
4	1	pilo bearing	25 dia	mild steel
3	1	ignition		mild steel
2	1	shield	340 height	mild steel
1	1	blade		mild steel

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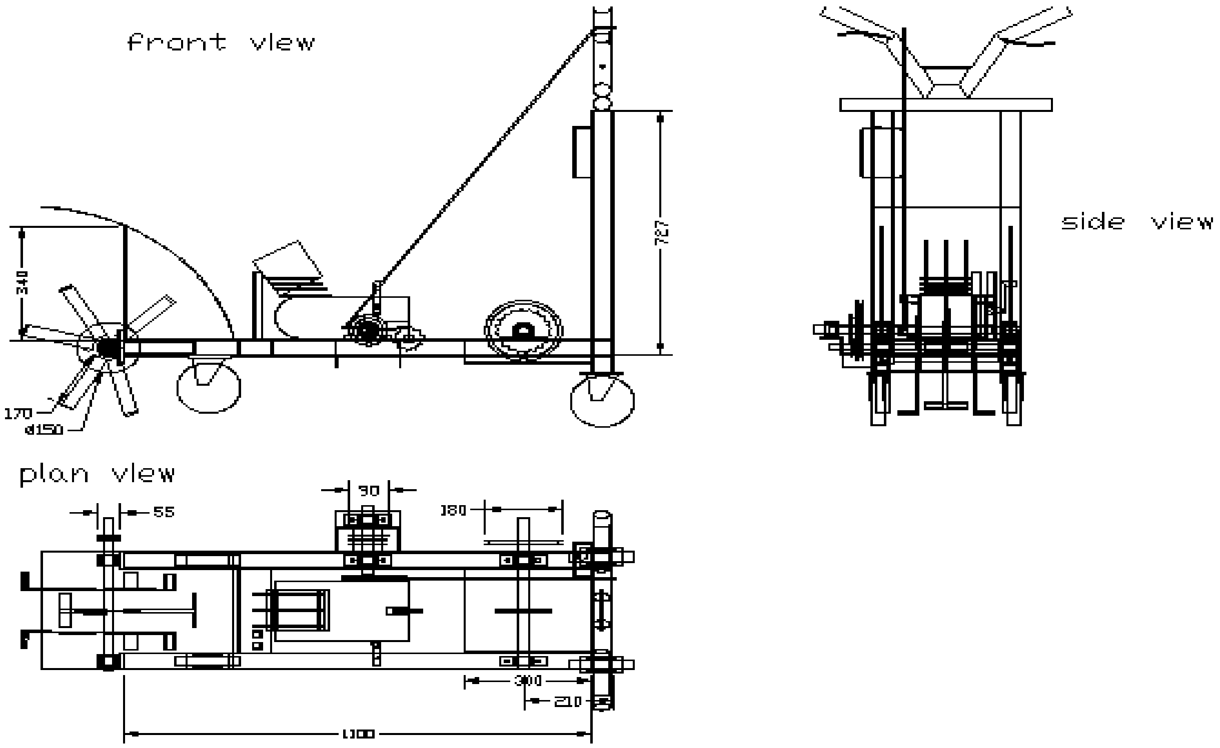

Fig.2: Orthographic view of the mechanical weeder

B. Design Components

The components of the weeder are described as follow:

(a)Frame: The frame of the machine is the part on which all other components are assembled such as shall, cutting blade, engine, transmission system and guard. The materials .selected for the frame was used to withstand load while working on the field. The machine frame was built of square hollow pipe of dimensions 120cm x 35cm. The vertical part of the frame was of dimensions 87cm x 35cm and it was welded to the base.

(b) Operating handle: The handle was attached to the frame. This part enables the operator to push and pull the weeder and it can be adjusted to suite the ergonomic working height of the operator .The handle is made up of a galvanized cylindrical pipe of 25mm and a motorcycle handle was welded to the cylindrical pipe.

(c) Cutting blades: There are three sets of cutting plates supported by a shaft mounted on the front of the mainframe. Each gang has four L-shape blades of mild steel bars (140 x 80 x 6mm) bolted to a circular mild steel plate (152mm x 152mm x 5mm) but the middle gang has eight (8) L - shape blades in opposite direction. The cutting blades are arranged in a form in which they are interwoven and driven by belt drive from the output shaft. The cutting was done progressively, one blade after the others. This of course help to minimize the power required to cut into the soil. The blades could provide maximum cutting depth which was deep enough to cut and bury weeds and prevent re growth.

(d)Motorcycle Engine: A motorcycle engine of capacity 9.85 and 7500 rpm maximum speed and of Jincheng model was used as the power source to drive the machine, with different gear speeds which can be selected depending on types and heights of weeds to be cut. The output speed can be selected from gear one to four and it can be engaged or disengaged by the clutch lever bolted to the control handle and using lever rod attached to the handle to facilitate engagement and disengagement of the transmission system from the machine. The quantity of fuel that goes into the engine pump can be controlled with engine speed and throttle.

(e) Guard plate: The guard plate acts as a shield which covers the blades on the gang. The shield helps to direct the cut weeds and soil away from the operator and engine.

(f) Shaft: This is the shaft that transmits rotational power from engine to the cutting blades. The shaft is of 30mm diameter and 25mm diameter by 400mm length.

(g) Transmission system: Power was transmitted to the weeder blades through chain and sprocket, and belt and pulley arrangement. The need for chain and sprocket depends on power required and the output shaft of the crankshaft of internal combustion engine. The chain and sprocket can be changed to belt and pulley by welding a small diameter pulley to the crankshaft.

C. Engine capacity testing

The engine was test run to determine its capacity. The maximum speed of the engine and the rotary cutter, idle speed of the engine and the rotary cutter, maximum power of the engine and power required by the weeder were determined. A digital tachometer was used to measure the rotational speed of the blades and the engine. The engine power and weeder power were calculated using the formulas given by Yadav and Pund[6] as follows:

Engine power, $$P = \frac{2\pi NT}{60} \quad (1)$$

Weeder power, $$P = \frac{D \times S}{75} \quad (2)$$

Where T = Torque (Nm), N = Speed of the engine (rev/min), S = Average weeding speed, D = Draft (N), Draft, D = w x d x R_s, w = width of cut (m), d = depth of cut (m) and R_s = soil resistance (N/m^2)

D. Field Test

The field test was carried out in order to determine the efficiency of the machine at each selected gear and speed and to know the weeding capacity (ha/hr) so as to make comparison with weeder having no speed control.Small area of level ground was marked out by using tape to measure it. The plot area was one square meter (four rows) for each gear system of the machine to be tested. The fields were full of weeds of about 20cm height and the moisture content of the soil was about 40% w.b. As the weeding operation started, a stop watch was switched on. Time of operation was recorded when the area of each plot was completed. Turning time, fuel consumption, quantity of cut survived weed were also measured. The same procedure was repeated for different gears. The depth of cut is considered to be good for uprooting the weeds at 5mm depth. After the field test procedure had been completed, the weeding efficiency was calculated for each gear speed from the following relationship:

$$E_f = \frac{W_c}{W_c + W_s} \times 100 \quad (3)$$

Where E_f = weeding efficiency (%), W_c = weight of cut weeds (g), W_s = weight of survived weeds (g)

The effective field capacity was determined for each gearsusing the following relationship:

$$\text{EFC} = S \times W \times E_f \times \frac{10^4}{3600} \text{ (ha/hr)} \quad (4)$$

Where, S = average weeding speed (ms^{-1}), W = Effective weeding width (m) and E_f =field efficiency (%)

III. RESULTS AND DISCUSSION

The result of the testing of weeder's engine capacity is presented in Table I while the average result of the field test of the weeder is presented in Table II. The graph of the efficiencies obtained at different gears is also shown if Fig. 1. During the field test of the weeder it was discovered that the field capacity was influenced by the forward speed. The field capacity increased with forward speed to a point (about 0.06msec^{-1}) in gear 1 when further increase in speed caused a reduction in the weeding efficiency. The forward speed at gear 4 (about 0.095msec^{-1}) gives the highest field efficiency of 80% but with higher fuel consumption rate.

Table I: Engine Capacity Test Result

Parameters	**Gear 1**	**Gear 2**	**Gear 3**	**Gear 4**
Maximum speed of engine (rpm)	1870	3750	5620	7500
Idle speed of weeder (rpm)	222	332	423	623
Maximum power of engine (kW)	1.836	3.672	5.510	7.350
Power required by weeder (kW)	0.629	0.746	0.875	1.010
Maximum speed of weeder (kW)	642	762	894	1031

Table II: Average field test parameters at different gears selected for the weeder

Parameters	**Gear 1**	**Gear 2**	**Gear 3**	**Gear 4**
Time take to weed (sec)	68.00	57.00	49.00	42.00
Speed (m/s)	0.059	0.070	0.082	0.095
Turning time (sec)	4.00	4.00	4.00	4.00
Weight of cut weed (g)	0.015	0.013	0.011	0.009
Weight of uncut weed (g)	25.00	32.00	37.00	34.00
Fuel consumption (litre)	37.50	26.18	17.40	8.50
Efficiency (%)	40.00	55.00	68.00	80.00
Effective field capacity (ha/hr)	0.013	0.021	0.031	0.042

IV. CONCLUSION

A speed control and selection system was developed and incorporated into an existing mechanical weeder and different cutting speeds were obtained at different gears. The maximum speeds of the engine were determined to be 1870, 3750, 5620 and 7500 rpm from gear1 to gear 4 respectively, while the maximum weeding efficiency at gear 4 was determined to be 80%. The weeder was considered to be fuel economic as its fuel consumption is 0.8L/hr at maximum speed and the maximum effective weeding capacity at gear 4 was 0.042 hahr^{-1}. The cost of producing the machine was N68,000.00. but if it were mass - produced, the cost would be affordable to local farmers.

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