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Modeling, Construction and Performance Test of Manually Operated Mechanical Rice Weeder

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***Abstract*— Modeling, construction and performance test of a mechanical rice weeder is conducted. The weeder is fabricated to substitute cutlass, hoes, and sickles that required high drudgery, time-consuming and labor intensive. As a solution to these problems, mechanical rice weeder was designed, constructed, and tested. The mechanical rice weeder was made of two implements attachment i.e. the primary cutting edge which is in front to loose soil above and the secondary cutting edge which is behind to do cutting and lifting of weeds. The weeding and overall working efficiency of the weeder on a black cotton paddy field was 73.9% and 83.33 %, respectively.**

Keywords- mechanical weeding; field performance; drudgery

I. INTRODUCTION

Modern farming involves the use of several inputs to the production cycle. These include seeds, irrigation water, fertilizer, herbicide or insecticide and farm equipment. A successful farmer strives to make judicious use of these inputs in order to maximize production with minimum cost. Farm equipment does not multiply production (as seeds do) but acts as a device to ensure that other inputs give that the desired results. In a way farm equipment may be called an “input” for other inputs. Thus, it may be said that farm equipment and the techniques associated with its use broadly constitute the field of agricultural mechanization.

Hand weeding (Figure 1) requires huge labor force and accounts for about 25 percent of the total labor hour requirement which is usually 900 to 1200 man’s hour per hectare [1]. Moreover, the labor requirement for weeding depends on weed flora, weeding intensity, time of weeding and efficiency of workers. Often several weeding operation is necessary to keep the crop free from weeds. Reduction in yield due to weed alone was estimated to be 16 to 42 % depending on crop and location which involves one-third of the cost of cultivation [2].

Figure 1. Manual weeding on the Fogera plane of Ethiopia.

Competition in the early stage of growth and failure to control weeds in the first three weeks after seeding, reduce the yield by 50 percent [3]. Weeds compete with crops for nutrients and other growth factors and in the absence of an effective control measure, remove 30 to 40 percent of applied nutrients resulting in significant yield reduction [4]. Delay and negligence in weeding operation affect the crop yield and the loss in crop yields due to weeds in upland crops varying from 40 to 60 percent and in many cases cause complete crop failure [5].

Mechanical weed control not only uproots the weed between the rice rows but also keeps the soil surface loose, ensuring better soil aeration and water intake capacity. Manual weeding can give a clean weeding but it is a slow process [7].

The aim of the present study was to design, construct and test manual manually operated mechanical rice weeder to increase rice productivity, reduce the drudgery of farmers in weed control and prevent weed problem for rice production.

II. Materials and Methods

A. Description of the Machine

The machine (Figure 2) is light, simple in design, easy to operate, better to handle, reduce drudgery, can be manufactured from locally available materials and can be easily maintained. It composes the following main parts:

Figure 2. Manually operated mechanical rice weeder.

1. Handle – transmit force to the rotary blades
2. Main frame-supports the two shafts of cutting blades and also determine the width of the machine. Also serves as the attachment place of the whole parts.
3. Handle adjustment-used to adjust the height and angle position of the handle to make it easy to operate for every one with different heights.
4. Skid assistance-used to guide the machine.

B. Principles of Operation

The principles of the operation of the machine is easy and requires only one man/ woman to operate it easily. Weeding is accomplished by just pushing the machine in a row. Rice must be planted in rows either by transplanting or row seeding. Since the blades directly attached to the shaft on the main frame, it will rotate when we push forwarding the row. As we push the machine forward straight the row the rotary knife blade cut the weeds primarily and the rotary flat blade followed to cut weeds escapes from the primary cutting.

C. Methods

The force required for uprooting some weeds determined by using rope by pulling through spring balance and the force at the point of weed removal is recorded. The machine was design based on the principle of weed stem failure due to shear and soil or root failure due to impact and abrasion. The machine design calculations was by the use of first principle of mechanics to determine the force requirement by the shaft and blade, bending moment, tensional requirement to determine the machine shaft size and other component parts and assembling drawing of the machine would carried out.

Construction(fabrication) which includes metal cutting, bending, shaping and welding is also carried out at the work shop. The machine is tested at average human being speed on wet and flooded soil and at different position on the soil.

Field test is conducted to determine and check any malfunctioning parts and defects in the design. To determine weeding efficiency in four places of each plots, wooden frame of 1 m × 1 m is through in the field randomly and the number of weeds is counted. This action would done before and after weeding by the machine. The weeding efficiency of the weeder is calculated using equation 1 [8].

$$WE = \frac{N_1 - N_2}{N_1} \qquad (1)$$

Where, WE is the weeding efficiency of the weeder (%), N_1 and N_2 are the number of weeds before and after weeding respectively.

In order to determine the damaged plant as quality work done [9] in four position of each plot, wooden frame of 1 m × 1 m is sampled in the field randomly and number of damaged plants are counted. Then the percentage of damaged plants was calculated.

The machine performance would evaluate using actual field capacity and design field capacity of the machine. The actual field capacity was determine from the relation:

$$Actual\ field\ capacity = Effective\ width\ of\ cut \times speed\ of\ cut$$
$$Actual\ field\ capacity = 0.25m \times 1m/s = 0.25m^2/s$$

The theoretical field capacity was determined from the relation:

$$Theoretical\ field\ capacity = design\ width\ of\ cut \times speed\ of\ cut$$
$$Theoretical\ field\ capacity = 0.3\ m \times 1m/s = 0.3m^2/s$$

The average human speed was used as the speed of cut. Therefore the machine efficiency was determined from the relation:

$$Machine\ Efficiency = \frac{Actual\ Field\ capacity}{Theoretical\ field\ capacity} \times 100$$
$$Machine\ Efficiency = \frac{0.25\ m^2/s}{0.3\ m^2/s} \times 100$$
$$Machine\ Efficiency = 83.33\%$$

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The machine performance (such as the time, the effort done, the labour requirement, and the efficiency) was compared with the traditional method of weeding conducted on the same area of land.

D. Machine Performance Testing

The testing was carried out on different plot of land at different area on the same soil.

III. RESULTS AND DISCUSSIONS

Effective mechanization contributes to increase production in two major ways; firstly the timeliness of operation and secondly the good quality of work. The requirement of power for certain operations like weeding, seed bed preparation, cultivation and harvesting becomes so great that the existing human and animal power in the county appears to be inadequate. As a result, the operations are either partially done or sometimes completely neglected, resulting in low yield due to poor growth or untimely harvesting or both. Considering the cost of production, it is difficult to say whether using mechanical power will decrease the cost of production per unit yield. But it is quite obvious that the number of operations required to raise a particular crop is comparatively reduced when advanced machines like the current rice weeder are employed. This is because the job is done more effectively in single operation. There are certain operations which, if not impossible, are very difficult to be done by human or animal power, e.g. land reclamation, jungle clearance, terrace construction, sub-soiling, land leveling, ditch making and transportation of the manure and farm produce. Field test result of the mechanical weeder is presented in Table I and II.

TABLE I. TESTING RESULT OF THE MECHANICAL RICE WEEDER

Sample Number	Weed type (local names)	Weed count		Average Weeding Efficiency (%)	Field conditions
		[a]Before	[a]After		
1	*Gicha sar*	18	5	80	With water
	Yebresar	12	1		
	Kume	15	1		
	Chanfa	10	4		
	Total	**55**	**11**		
2	*Gicha sar*	20	7	62.3	With water
	Yebresar	18	9		
	Molale	2	1		
	Kazma	11	2		
	Chanfa	10	4		
	Total	**61**	**23**		
3	*Yeberesar*	25	5	74.32	Without water (mud)
	Chanfa	20	8		
	Kume	13	3		
	Chumatly	10	2		
	Sherefa	6	1		
	Total	**74**	**19**		
4	*Chumatly*	12	1	78.87	With water
	Sherefa	6	1		
	Daklisha	13	2		
	Yeberesar	17	4		
	Chanfa	9	4		
	Gichasar	14	3		
	Total	**71**	**15**		

[a]*Before and After : before and after weeding respectively*

Field conditions and weed type have an impact on the performance of the machine (Table I). Vegetatively fibrous and mature weeds resist machine operations and weeding performances.

As shown in Table II, the hand pushed weeder with assisted labour takes 300.8 manhr/ha, whereas handpicked (traditional) weeding require 534.7 manhr/ha.

TABLE II. WORKING TIME COMPARISON OF THE MECHANICAL RICE WEEDER VERSUS MANUAL LABOUR

Time taken to complete the plot in minute[b]		***Total man hr per plot (manhr/pl)***		***Man hour per hectar (manhr/ha)***	
With weeder	*Without weeder*	*With weeder*	*Without weeder*	*With weeder*	*Without weeder*
37.5	*75*	*0.752*	*1.34*	*300.8*	*534.7*

[b] *the weeding time required by a single farmer to cover an area of 5m × 5m at normal working conditions*

Comparing the actual field capacity (i.e. 0.25 m^2/s) with the theoretical field capacity (i.e. 0.3 m^2/s), it was observed that the machine efficiency (i.e. 83.33%) is safe and acceptable. The mechanical rice weeder performed well and have a mechanical advantage, saves time and the quality of work is dependable.

IV. CONCLUSIONS

The introduction of farm machinery like the rice weeder into new geographic areas offers great opportunities for increased production and a more pleasant life on rice farms. However, this opportunity is accomplished by a host of new problems and responsibilities for traditional farmers. The first responsibility of the traditional farmer is to decide if he will mechanize. The mechanical rice weeder has advantage in saving time during weeding and increasing yield over hand weeding technique. Since weeding is the main bottleneck of rice farming, it is better to assist weeding by introducing this weeder in line with the row seeding and/or transplanting operations. The machine is competent in terms of workability and timeliness. It is faster in operation than the traditional method of controlling weed and efficient in performances. Since field condition, weed maturity and weed type have an impact on the machine performance, it is better to modify the weeder to be compatible and adaptable to these scenarios.

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