DEVELOPMENT AND PERFORMANCE EVALUATION OF A HAND-PUSHED WEEDER

Attanda, M. L.; Muhammad, A. I. and Shema, A.

Department of Agricultural Engineering, Bayero University Kano, Nigeria.
attandaml@gmail.com

ABSTRACT

A hand-pushed mechanical weeder was developed and evaluated to determine its performance indices. The field performance was compared with traditional hand-held hoe on a variety of TZPB-SR maize crop grown field. The means of forward speed, actual field capacity and weeding efficiency are 0.092 m/s,0.028 ha/hr and 75.17% for the developed weeder as against 0.013 m/s, 0.0059 ha/hr and 77.98% for the manual hoe respectively. The mean effective operation time for the developed weeder on a $9 x10^{-4}$ ha field of a sandy loam soil at 14.85% moisture content was found to be 91 second with 164 number of weeds removed while that of traditional hoe was found to be 189 seconds with 153 number of weeds removed on the same size of field.

Keywords: Weeder, cutting width, forward speed, field capacity, weeding efficiency, effective operation time

1. INTRODUCTION

A weed is essentially any plant which grows where it is unwanted and tends to thrive at the expense of the desired crops (Kwesi and Datta, 1991). The higher competitive nature of weeds compared to crops is posing serious threat to crop yield. Weed infestation on Nigerian soils is quite high, particularly during the raining seasons when soil moisture is high and plant growth conditions are optimum (Muhammed and Attanda, 2012). Biswas *et al.* (1999) have shown that weeds cause between 50 to 70% reduction in crop yields. Olukunle and Oguntunde (2006) reported that weeds management is an important component of crop production techniques as elimination of weeds is expensive and hard to achieve. Methods employed or developed in weed removal from the crops on the farm, include handpick, thinning, mechanical means, flaming, desiccation, manual use of hoes, and by the use of different forms of herbicides (chemicals). The most common means of weeding operations in Nigeria is hand hoe which is very cheap, but involves drudgery and time consuming which, invariably, the major problem facing famers in weeding operation. Nkakini et al. (2010) stated that the problems usually associated with traditional methods of weeding practices are low efficiency and farmer bending over resulting in tremendous loss of energy. Nganilwa et al. (2003) opined 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 misery. Mechanical weed control is very effective as it helps to reduce drudgery involved in manual weeding, it kills the weeds and also keeps the soil surface soft and loose ensuring soil aeration and water intake capacity thereby contribute significantly to safe food production (Pullen and Cowell, 1997).

Weed control is one of the most difficult tasks in crop production that accounts for a considerable share of the cost involved in agricultural production. Olaoye and Adekanye (2011) stated that it is impossible to obtain good yield from crops without adequate weed control. Farmers generally expressed their concern for effective weed control measures to arrest the growth and propagation of weeds. Apart from the high cost of importing the foreign machines such as mechanical weeders, which most of our local farmers cannot afford the technicality of their operation and maintenance is beyond our peasant farmers despite that they are not designed and developed for our soil conditions. Arising from this is the prominence of using traditional method of hand hoes of weed control than the mechanical methods amongst our rural farmers. Hence, its adverse effects on the farming system involve energy and time consuming, low production output, thereby making farming an age old profession. However, performance evaluation of a locally developed hand push mechanical weeder to ensure that there is a suitable replacement to either energy sapping method of manual hoe of weeding operation or expensive foreign weeders which are beyond of peasant farmers should be a welcome development. Evaluation of performance of an implement shows the level of its effectiveness and it adoption to a particular function which indicates the output in relation to specific time. This study therefore, carried out performance evaluation tests on a locally developed hand push mechanical weeder to determine it field performance and also compare the performance and that of traditional method of hand hoe on the soil of the research farm, Department of Agricultural Engineering, Bayero University, Kano.

1. MATERIALS AND METHODS

2.1 Description of the Developed Hand-Pushed Weeder

The mechanical weeder is manually pushed whi ch consist of a frame made from hallow pipes of different diameters (Figure 1). The weeder has two conical rotors mounted in tandem with opposite orientation. It has a smooth and serrated blades mounted alternately on the rotor that uproots and burry weeds because the weeder create a back and forth movement in the top 3 cm of soil.

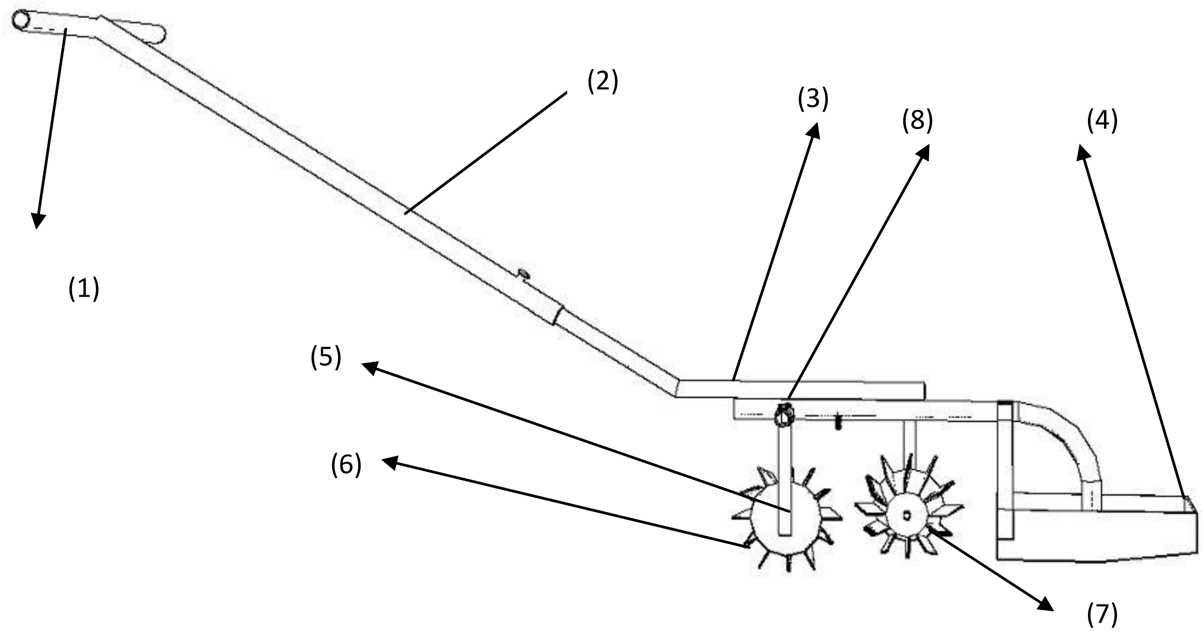

Figure 1: Schematic diagram of the developed weeder: 1. Handle; 2. Adjusting knob; 3. Main frame; 4. Float; 5. Cone brackets; 6. Blade; 7. Cone; 8. Width adjusting knob

The weeder weeds in a single forward pass without a push pull movement. It main features includes;

The main frame: Constructed from circular hollow steel pipes of 25 mm diameter with an adjustable length of 2140 mm. Another steel pipe (of same diameter) was welded to the frame with brackets of 145 mm length to hold the cones, on to which the blades were mounted.

Handle: The handle was made of hollow circular steel pipe of 25 mm diameter and length of 400 mm.

Cones: The rotating cones were constructed from 2 mm sheet of metal and have diameters of 100 mm and 50 mm for outer and inner section of the cone respectively and 10 mm for bolts' hole. The arrangement of the cones was such that cutting was done progressively, one cone after the other.

Cone brackets: There are two pairs of cone brackets of 145 mm length attached to the L-shaped frame with the help of bolt and nuts that supports the cones. They are made from hollow steel pipe of 16 mm diameter.

Cutting blades: There are two sets of the cutting blades mounted on the cones. Each cone has twelve blades out of which six are serrated and are arranged in circular planes of the cone at an angle 30° to each other. The blades were made of steel of 140 X 35 mm in length and width with

1.5 mm thickness welded to the circular surface of the cone of 100 mm diameter that carries a centre-hole of 10 mm diameter for the cone shaft. The cutting edge of the blades was bevelled at an angle of 92° to minimize the effort required in cutting the soil.

Float: A float is in front of the weeder blades whose function is to control the depth of soil cut, parking and stability when the weeder is working. The float is also capable of pressing the weeds in the horizontal direction; this is to allow the blades to cut the weeds easily. It was constructed using a 1 mm sheet of metal to give the required shape and size.

2.2 Location of the Experiment

In order to evaluate the performance of the developed hand-pushed weeder, field investigations were conducted during 2011 cropping season at Agricultural Engineering Departmental Research and Demonstration Farm, Bayero University, Kano located at Ungoggo Local Government of Kano State. Kano lies between latitude 10°33'' and 12°37'' north of the equator and longitude 7°43'' and 9°35'' of Greenwich. The State lies in the Sudan savanna region with dry and rainy season, the average annual rainfall is 420 mm.

2.3 Experimental Field Layout

Two experimental plots of the same dimensions of 18 m x 9 m each were used for both the hand-pushed weeder and the traditional hand-held hoe for the field test on which maize seeds were sown. Each plot has six furrows of 3 m wide by 9 m long to allow for six replications of each method of weeding investigated. Both plots were subjected to the same land preparation and cultural operations. The top soil of the experimental field was classified as sandy clay loam.

2.4 Field Measurements

Hand-held direct soil moisture tester was used to determine the soil moisture content. The soil moisture tester head was put directly into the soil for 5 to 10 seconds to obtain the values of the moisture contents with exact moisture content in percentage displayed on the tester screen. The method of Nkakini et al. (2011) was adopted to determine the number of weeds before and after weeding by counting the number of weeds in the 9 m^2 mapped out area of the furrow plots before and after the weeding operations. Determination of the working width was achieved by measuring the distance between the two extreme ends of the cone rotors for mechanical weeder and the distance between the two edges of the blade for the manual hoe with a measuring tape. The total work time is simply the time taken between the start of the weeding operation at one end of the row and the finishing of the weeding at the other end of the row using a stop watch. It also, includes the time taken for turning at the end of the row, reset of the weeder and any breakdown or adjustments during the operation. While the effective operation time was determined from the time it takes both implements to weed the mapped out area of the furrow plots.

2.4.1 Performance Evaluation Index

The following were the indices of the performance evaluated in the field experiment:

Forward speed (S): This is the measure of the distance covered per unit time of the operation.

$$S = \frac{D}{x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where: S = forward speed (m/s); D= distance covered (m); x= time taken in second (s) (Nkakini et al., 2010).

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Theoretical field capacity (FC_T):

FC_T = $S \times W_w \times 0.36$ …………………………(2)

Where: FC_T = theoretical field capacity (ha/hr)

S= forward speed (m/s); W_w = working width (m) (Nkakini et al., 2010).

Actual Field Capacity (FC_E):

$$FC_E = \frac{A}{10^4} x \frac{3600}{t} \quad \ldots\ldots\ldots\ldots \text{(3)}$$

Where: FC_E = actual field capacity (ha/hr); A = area weeded (m^2); t = time taken to weed (sec) (Olaoye and Adekanye, 2011).

Weeding Efficiency (E_W)

$$E_w = \frac{w_1 - w_2}{w_1} x100 \quad \text{----------------------- (4)}$$

Where: E_w = weeding efficiency (%); w_1 = number of weeds before weeding counted in the plot; w_2 = number of weeds after weeding counted in the plot (Nkakini et al., 2010).

2. RESULTS AND DISCUSSION

The field performance evaluation results obtained with both the developed weeder and the traditional hoe and comparative operation time for the both implements are shown in Tables 1 and 2. Table 1 shows the mean travelling speed (forward speed) for the developed hand-pushed weeder to be 0.092 m/s while that of the hand hoe was 0.013 m/s. The mean test showed that the means of the forward speed of the developed weeder are not significantly different while that of the traditional hoe showed clear significant difference at 5%. This suggest that the weeder's (developed) forward movement is uniform which is an impetus to field efficiency of an implement as against the traditional hoe with inconsistence in forward speed, probably due to fatigue and drudgery of the human nature. At these forward speeds of the both implements the mean actual field capacity of the developed weeder is significantly higher than mean actual field capacity of the hand hoe of area of the same size weeded.

Table 1: Comparative field performance evaluation

Furrow Number	Length of Furrow (m)	Forward speed (m/s)		Actual Field Capacity (ha/hr)		Weeding Efficiency (%)	
		Hoe	Weeder	Hoe	Weeder	Hoe	Weeder
F1	9	0.011	0.092	0.0061	0.026	79.59	74.82
F2	9	0.014	0.091	0.0058	0.029	78.77	76.36
F3	9	0.009	0.092	0.0054	0.028	77.97	75.97
F4	9	0.016	0.091	0.0059	0.030	76.51	73.94
F5	9	0.012	0.093	0.0062	0.028	77.27	74.53
F6	9	0.015	0.092	0.0059	0.027	77.79	75.41
Mean (x)	9	0.013	0.092	0.0059	0.028	77.98	75.17

Table 2 shows the effective operation time of the two implements in term of the area of the field weeded. The results show that for an area of 9 m^2, the developed weeder removed 164 weeds in 91 seconds. On the other hand, with equal size of mapped out area of the plot the manual hoe was able to removed 153 weeds in 189 seconds. This reveals that it takes the developed weeder less time to perform the intended work (weeding) on the field when compared with that of traditional hoe. Nkakini et al. (2010) and Rangasamy et.al. (1993) observed the same trend of field time for a developed weeder and traditional hoes.

Figure 2 compares the field capacities of the weeder and the hand hoe. The developed weeder has a cutting width of 0.186 m with mean actual field capacity of 0.028 ha/hr while the cutting width of the manual hoe was 0.145 m with the mean actual field capacity of 0.0059 ha/hr .

Table 2: Effective time of weeding for the developed weeder and the manual hoe

Developed weeder					Manual hoe				
Furrow Number	Area of weeding (3mx3m) (m^2)	Quantity of weed before weeding	Quantity of weed removed	Time taken to weed the area ($9m^2$) (Sec)	Furrow Number	Area of weeding(3mx3m) (m^2)	Number of weeds before weeding	Number of weeds removed	Time taken to weed the area ($9m^2$) (Sec)
F1	9	143	107	87	F1	9	181	143	189
F2	9	257	196	90	F2	9	128	101	185
F3	9	191	145	89	F3	9	235	183	205
F4	9	285	211	96	F4	9	225	172	163
F5	9	227	169	93	F5	9	214	165	196
F6	9	204	154	92	F6	9	194	151	193
Mean	9	215	164	91	Mean	9	199	151	189

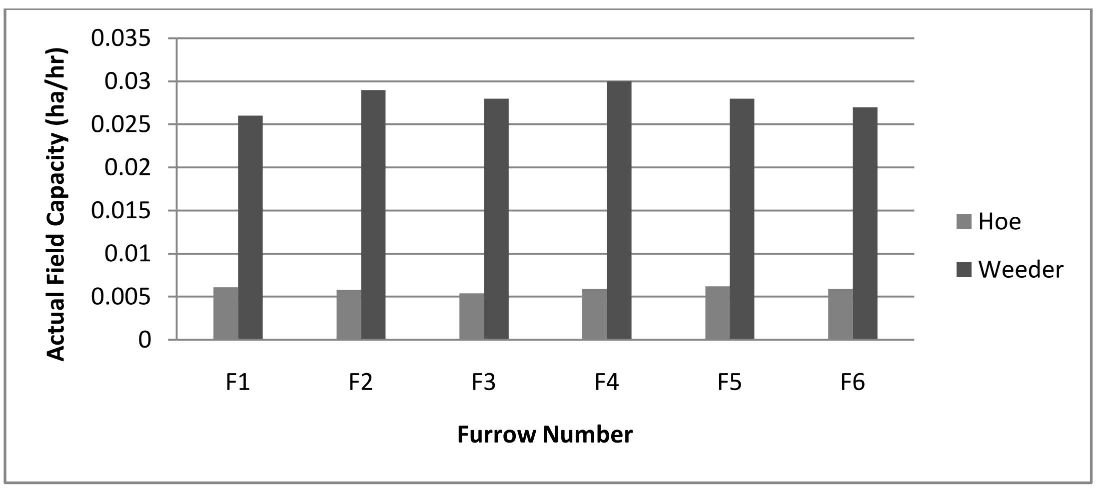

Figure 2*:* Field capacities of the two weeders

This implies that the amount of time lost during weeding operation in the field for the developed weeder is less than that of the hand hoe because the percentage of the cutting width of the developed weeder utilized is higher than that of hand hoe for the same task. However, the weeding efficiency of the traditional hoe was higher than that of the developed weeder in all the experimental furrows conducted, although the differences are not significant. Kamal and Babatunde (1999) and Rangasamy et.al. (1993)

reported similar findings for the manually operated weeder.

4. CONCLUSION

Based on the field performance evaluation results the following conclusion could be drawn:

i) The forward speed, actual field capacity and weeding efficiency of the developed weeder are 0.092 m/s, 0.028 ha/hr and 75.17% compared to manual hoe of 0.031 m/s, 0.0059 ha/hr and 77.98% respectively.

ii) The performance index of the developed weeder was compared with that of manual hoe and found to be significantly different.

iii) The effective operation time of weeding 0.0009 ha of field by the manual hoe was found to be 189 seconds twice more than the operation time of the developed weeder which was found to be 91 seconds.

iv) The construction of the developed mechanical weeder can be carried-out in any metal workshop with basic welding tools and the material locally sourced.

v) The developed hand-pushed weeder should be adapted due to its higher forward speed and effective actual field capacity which is more than that of the traditional hand-held hoe.

vi) This evaluation was conducted under rainfall planting season; the evaluation of the weeder could be investigated under irrigation farming.

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