Original Research Article

On Farm Performance Evaluation of back pack weeder for weeding operation: A case of Busia County,Kenya

Abstract

This research work involved performance evaluation of back pack weeder in four representative farms in Busia County. The four demo plots were sampled in different sub counties based on the condition of small scale farmer accessibility and also a representative of each sub-county. In all the plots cassava was planted using the right agronomic requirements. The choice of the crop was depended on farmers and stakeholders preference to the most profitable and mechanizable crop in the county. This was done using the ranking method in order to achieve the crop with the highest interest in terms of profitability and mechanization need. Cassava mechanization in Busia is very low especially in weeding and harvesting and this calls for great intervention with suitable technologies which must always match the characteristic of the land in terms of soil type and terrain among other factors. Machinery evaluation is always very significant as it gives the performance rate of agricultural machinery and quality of operation based on the farm in which they are used.It is for this reason that the back pack weeder was preferred and evaluated against manual weeding for the farmer to understand the use and maintenance as well as its benefits compared to manual weeding using a jembe. The use of a back pack weeder for weeding in cassava as opposed to manual weeding using a jembe proved that it can improve weeding quality and also reduces elapsed time and the costs involved in the weeding operation. The evaluated parameters wereweeding efficiency, fuel consumption, operation time, plant damage, effective field capacity and field efficiency.

The results show that weeding efficiency, fuel consumption, operation cost, theoretical efficiency, effective field capacity and efficiency on the first farm were; 97.1% for machine and 98% for manual, 0.4 ltr/hr, Kes.1361/ha,0.02 ha/hr, 0.016 ha/hr and 80% effectively.

Keywords: Back pack weeder, weeding, weeding efficiency, field capacity, efficiency.

1. Introduction

Cassava (*Manihot esculenta* Crantz) is one of the main cereal crop produced and consumed all around the world. Itis an important staple food for consumption and income generation for farming communities in Western Kenya. It enhances household food security and is a source of income. It provides livelihood to 100 million people globally (Legg.et. al., 2004). In Kenya, cassava is grown in Western, Eastern/Central and Coastal regions. Despite the huge importance, production and productivity of the crop has continued to decline due to infestation by stubborn weeds and diseases. It is well known that poor weeding reduces root yield.Reviewed effect of weed control on cassava root yield that full time of weed infestation causes root yield loss of about 46-95% (Sastry & Zitter, 2014). Weeds waste excessive proportions of farmers' time, thereby acting as a brake on development.

Weeding is one of the most important farm operations in crop production system. Weeding is an important but equally labour intensive agricultural unit operation.It can be eradicated by hand weeding, chemical means, by using herbicides or by mechanical weeders. Hand weeding is the most efficient method in weeding but is not well suited due to more time consumption coupled with labour intensive operation and expenditure. Chemical method, show promising results in weed eradications but restricted due to its ill-effect on human beings and environment (*AGRONOMIC CROPS: Management practices*, 2019). Mechanical weeding promotes the plant growth as a result of increased soil aeration, root length and better tiller production. This may be done by traditional hand aided weeding tool; manual operated mechanical weeder and power weeders (National Bank for Agriculture and Rural Development., & SRI International Network and Resources Center, 2016)

As a recommendation to control weed, an engine operated back pack weeder with a straight shaped cutting blades system for moist and dry land was evaluated. A power weeder was evaluated and performance was compared with conventional manual weeding with hoe/Jembe.

2. Material and Methods

The study was undertakenat four farmers' fields in Busia County, where in each of the four fields a back pack weeder was evaluated against manual weeding. The weeder was evaluated with 4 days of weeding in the month of December 2020 during which the moisture content of the soil was at 20%. Data was collected from 2 sub-plots within the main demo plot so as to achieve the parameters for the two methods of weeding. This was achieved by sampling the sub-plots within each demo-plot and applying both the mechanical and manual weeding. The data collected was then compared for the two types of weeding and inferences made. The details of experimental methodology and measurement techniques adopted during the research were described in the different sections.The weeder that was evaluated is shown in figure 1.

Figure 1. Back pack weeder

2.1.Crop Cultivation

Cassava crop is being raised as per recommended agronomical practices in different regions with different soil textures and land terrain. Accordingly, plots of areas 1560 m^2, 1376 m^2, 988m^2 farm is situated at Munongo, Tangakona, Siteko and Aten respectively at Longitudes (34.1242°, 34.2329°, 34.1173°, 34.1870°) E and latitudes (0.3795°, 0.4788°, 0.4356°, 0.5394°) N at an altitudes of 1177, 1237, 1189, 1178 M above sea level were sowed in the month of October, 2020. The study area is fairly hot (21-23°C) and moist (760 to over 1,750 mm precipitation annually) throughout. The soils of the experimental farms varies from sandy loam texture to clay loam texture.

2.2.Evaluation of Performance Parameters

2.2.1. Weeding Efficiency

It is the ratio between numbers of weeds removed by power weeder to the number of weeds present in a unit area before weeding operation and is expressed as a percentage (Devasenapathy, et. al., 2008). The weeders was tested on the same field to determine weeding efficiency. It is calculated by using equation 1

$$W=\frac{W_1-W_2}{W_1}\times 100 \qquad \text{Eqn 2.1}$$

Where,
W_1 = Number of weeds present per unit area before weeding operation.
W_2 = Number of weeds counted in same unit area after weeding operation.

2.2.2. Plant Damage

It is the ratio of the number of plants damaged after operation in a 10m length to the number of plants present before operation in the same length. It is expressed in percentage. (Kumar et.al. 2014).

$$R=\frac{A}{B}*100 \qquad \text{Eqn 2.2.}$$

Where,
R = Plant damaged (%).
B = Total number of plants in 10m length before the weeding operation.
A = Total number of plants damaged in the same length after the weeding operation.

2.2.3. Actual Field Capacity

It is the actual area covered by the machine based on its total time consumed and actual working width under field condition. It is expressed as in terms of area covered per unit time of operation. It is calculated by;

$$Field\ capacity=\frac{Actual\ area\ covered}{Total\ time\ consumed} \qquad \text{Eqn 2.3}$$

2.2.4. Effective Field Capacity

Effective field capacity is the actual average rate of coverage by the machine, based upon the total operation set time. It is a function of the rated width of the machine, the percentage of rated width actually utilized, speed of operation and the amount of field time lost during the operations. Effective field capacity is usually expressed as hectare per hour (Olaoye, et.al. 2012).

$$Effective\ field\ capacity=\frac{Actual\ field\ capacity}{Theoretical\ field\ capacity} \qquad \text{Eqn 2.5}$$

2.2.5. **Performance Index of Weeder** Performance of the weeder was assessed through performance index (PI) by using the following relation as suggested by Devojee, et. al., 2020

$$PI=\frac{FC\,X\,(100-PD)\,X\,WE}{p} \qquad \text{Eqn 2.6}$$

Where,
FC = Field capacity, ha h-1,
PD = Plant damage %,
WE = Weeding efficiency %, and
P = Power, HP

2.2.6. Speed of operation

The speed of operation was calculated by observing the distance traveled and the time taken as

$$S = \frac{L}{t} \qquad \text{Eqn 2.7}$$

S = Forward speed of operation, m/s
L = Distance traveled, m
t = Time taken, s

2.2.7. **Fuel Consumption**

It is measured by topfill method; the fuel tank was filled to full capacity before the testing at levelled surface. After completion of test operation, amount of fuel required to topfill again is the fuel consumption and is expressed in litre per hour.

2.2.8. **Operational Cost**

The cost of operation was determined by straight line method using variable cost where in variable cost; repair and maintenance cost, fuel and lubricant cost, wages of operator are considered. Variable cost always varies proportionally with the amount of use. The total cost of weeding is determined by variable cost of fuel per hour.

3. RESULTS AND DISCUSSION

The performance of power weeder for the cassava crop was evaluated under field conditions. In this chapter, results were presented.

3.1.Evaluation Parameters

The Power weeder performance was evaluated against manual weeding under cassava crop in all the four demo plots. Both Machine and manual parameterslike field capacity, weeding efficiency, plant damage, and performance index and energy consumption for weeder were discussed.

3.1.1. Weeding Efficiency

The weeding efficiency of the weeder was calculated by using data on all the four plots against manual as follows;

Both the machine and manual weeding;

Unit area of weeding operation was taken as 100 m^2 which was for 10 plants for 10 ridges / lines of cassava plants.

a. **Machine weeding**:

Weeds present in the area before the weeding operation was done amounted to 351 weeds.
Weeds present in the area after the weeding operation was done amounted to 10 weeds
The efficiency of the weeder therefore becomes;

$$W = \frac{351-10}{351}$$
$$= 97.1\%$$

b. **Manual Weeding:**

Weeds present in the area before the weeding operation was done amounted to 351 weeds.
Weeds present in the area after the weeding operation was done amounted to 7 weeds

$$W = \frac{351-7}{351}$$
$$= 98\%$$

3.1.2. Plant Damage

a. **Machine weeding:**

Plant damaged (%).
Total number of plants in 10m length before the weeding operation - 10
Total number of plants damaged in the same length after the weeding operation- 2

$$R = \left(\frac{2}{10}\right) * 100$$
$$= 20\%$$

b. **Manual Weeding:**

Plant damaged (%).
Total number of plants in 10m length before the weeding operation - 10
Total number of plants damaged in the same length after the weeding operation- 1

$$R = \left(\frac{1}{10}\right) * 100$$
$$= 10\%$$

3.1.3. Theoretical field capacity

a. Machine weeding:

The cutting width of the power weeder at forward speed was 76cm. the operation speed of the weeder was derived from the distance covered in a certain period of time. In this case the weeder covered a distance of 26m in a span of 6 mins. Therefore the distance per unit time becomes;

$$Speed = \frac{26}{6/60}$$
$$= 260\, m/hr$$

$$Theoretical\ field\ capacity = [260 * 0.76]$$
$$= 197.6\, m^2/hr$$
$$= 0.02\, ha/hr$$

3.1.4. Effective Field Capacity

a. Machine weeding

The weeder covered an area of 470 m^2 in a period of 3hrs. Therefore effective field capacity is;

$$EFC = \frac{470\, m^2}{3\, hrs}$$
$$= 156.7\, m^2/hr$$
$$= 0.016\, ha/hr$$

b. Manual weeding

$$Field\ capacity = \frac{0.026\, ha}{1.5\, hrs}$$
$$= 0.017\, Ha/Hr$$

3.1.5. Field efficiency

$$FE = \frac{0.016}{0.02} * 100$$
$$= 80\%$$

3.1.6. Fuel Consumption

The weeder's fuel consumption was as follows;

Fuel at start	= 1litres
Fuel refilled to top of the tank	= 0.6 liters
Fuel consumed	= 0.6 litres

Therefore fuel consumption can be calculated in litres per hour; 0.6 ltr in 1.5hrs
In I hour it will be (0.6/1.5) which comes to **0.4 ltr/hr**

3.1.7. Operation Cost

The actual cost of operation was calculated for both the manual and machine weeding
For manual weeding;
10 casuals were used to complete an area of 780 m^2 at a cost of 300 per casual. This amounted to **3846 Kes/ha.**
For machine weeding, the cost was calculated in terms of operator cost, cost of service and cost of fuel;
Cost of operator = Kes. 500
Cost of service was 1000 for four plots which amounted to Kes. 250 per plot.
Cost of fuel per plot was 3 litres which amounted to 3*104 = Kes. 312
Total cost was 500+250+312
= Kes. 1062
Therefore cost of machine operation was 1062/0.78
= **Kes. 1361/Ha**

3.1.8. Performance Index of Weeder

$$PI = \frac{0.016 X (100-20) X 0.957}{4.7}$$
$$= 0.26$$

Where,
FC = Field capacity, ha h-1,
PD = Plant damage %,
WE = Weeding efficiency %, and
P = Power, HP

3.2.Discussion

The soil moisture content is a great influence of the weeding efficiency. As the moisture content decreases, the weeds cannot be uprooted completely by just uprooting. Instead, it may break above the ground level and allow the root portion under the soil. This may further grow and its eradication may also be an impediment in future. As the moisture content increases, there will be slippage between the soil and traction device (wheels) of the weeder. Hence the weeding efficiency is affected.In this research study, the weeding efficiency was depicted as 97.1 % for machine weeding and 98% for hand weeding, sincethe human labour removes the weeds hence the efficiency of weeding was highest.

3.2.1. Effect of Performance Parameters on Field Capacity of the Weeder

The actual field capacity increased with the increase of operational speed, due to more area covered in less time.

3.2.2. Effect of Performance Parameters on Weeding Efficiency in cassava

The weeding efficiency decreased with increasing of operating speed of the weeder. This resulted from fast movement of the machinewhich caused some of the weeds to be skipped due to reduction in bite length.

3.2.3. Effect of Performance Parameters on Plant Damage in cassava

Highest plant damage was observed at higher speed of operation. When the power weeder operates at high speed, the operator cannot control machine movement on to the plants and high impact action of the rotary tynes to the tender plant stem. Power weeder should operate at lowest speed for lowest plant damage.

3.2.4. Effect of Performance Parameters on Performance Index

Performance index of the weeder is directly related to the field capacity, plant damage, and weeding efficiency and inversely related to power exerted by the engine to the weeder. It was observed that the performance index increased with the increase of speed of operation.

4. Conclusion

Power weeder was evaluated for its performance in cassava crop. This test was conducted at different soil textures and moisture contents of soil and different speeds of weeder. The evaluated parameters wereweeding efficiency, fuel consumption, operation time, plant damage, effective field capacity and field efficiency. The results show that weeding efficiency, fuel consumption, operation cost, theoretical efficiency, effective field capacity and efficiency on the first farm were; 97.1% for machine and 98% for manual, 0.4 ltr/hr, Kes.1361/ha, 0.02 ha/hr, 0.016 ha/hr and 80% effectively. The study showed that the back pack weeder is favorable for working in dry conditions and used in young weeds to avoid reduction in efficiency. It is considered more appropriate alternative than jembe or hoe implement. This knowledge will be of great help to farmers if adoption would be increased by mastering of use and maintenance by the operators and mechanics. The youth will benefit by hiring out services for weeding using the weeder. Additionally, frequent use of this weeder willlead to manufacture of spare parts locally and open up for employment opportunities for many youth Kenyans as obtainable in other part of the World.

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