On Farm Performance Evaluation of Back Pack Weeder for Weed Control in Cassava: A Case of Busia County, Kenya

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Authors' contributions

Original Research Article

ABSTRACT

This research work involved performance evaluation of back pack weeder in four representative cassava planted farms in Busia County. The main objective of the research study was to test the performance of the mechanical back pack weeder in cassava crop and comparing it with manual weeding. This was done in four test plots which 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. 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 were weeding efficiency, fuel consumption, operation time, plant damage, effective field capacity and field efficiency. The results show that efficiencies for test plots

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1, 2 and 4 were high ranging from 97.1%, 98%, 97% with bit lower fuel consumption of 0.4l/hr and operational cost of 1360kes/ha, 1366kes/ha and 1361kes/ha respectively due to the nature of soils texture which was equally sandy loam. The plant damage for all plots were found to be the same for both machine and manual weeding. The operational cost of manual was equally the same since the same number of casuals were used but the machine was a bit higher for the case of test plot 3 since it consumed a high amount of fuel. The weeding efficiency was depicted as 97.1 %, 98%, 86% and 97% for machine weeding for the four test plots respectively and 78%, 78%, 72% and 77% for hand weeding, since the human labour removes the weeds hence the efficiency of weeding was highest.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of the main cereal crop produced and consumed all around the world. It is an important staple food for subsistence 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 [1]. In Kenya, cassava is grown in Western, Eastern, Central and Coastal regions. It is a calorie-rich vegetable that contains a lot of carbohydrates and key vitamins and minerals. It is also a good source of vitamin C, thiamine, riboflavin, and niacin. The leaves, which are also edible when cooked and dried in the sun, can contain up to 25% protein [2]. Despite its importance, production and productivity of the crop has continued to decline due to low mechanization coupled with infestation by weeds and diseases. Cassava mechanization in Busia is very low especially in weeding and harvesting and this calls for great need for intervention with suitable technologies which must always match the characteristics of the land in terms of soil type and terrain among other factors. 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% [3,4]. Weeds waste excessive proportions of farmers' time, thereby acting as a setback on development. Weeding is one of the most important farm operations and equally labour intensive agricultural unit operation. Several methods to eradicate weeds have been studied including hand weeding using a hoe or jembe, chemical means, by using herbicides or by mechanical weeders [5]. 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 [6]. Chemical method, show promising results in weed eradications because of its simplicity and fast way of weed removal but restricted due to its ill-effect on both the environment and human beings [7].

To overcome these limitations, mechanical weeding can be adopted as appropriate weed control measure since it promotes the plant growth as a result of increased soil aeration, root length and better tiller production. Mechanical weeding also benefits the crop by breaking up the surface crust, aeration of soil, stimulating the activity of soil micro flora, reducing the evaporation of soil moisture and facilitating the infiltration of rainwater [8]. This may be done by traditional hand aided weeding tool; manual operated mechanical weeder and power weeders [9]. The weeding machine, Back Pack Weeder (Fig. 1, Table 1) was in the experiment. It is a 4 stroke air cooled single cylinder petrol engine with a rated power of 1.5kW/6500rpm and a fuel tank capacity of 900mls. The engine is mounted on the back side of the machine with sets of vertical blades on the front side to provide stability and easy handling by the operator. The weeder moves due to the thrust provided by the soil engaged vertical blades. The major parts of the power weeder are engine, blades assembly and transmission system. It is multi-Purpose in that the weeding blade is replaceable with the harvester blade for harvesting crops such as rice, simsim and millet. The harvesting blade can also be replaced with a brush cutter blade for slashing purposes [10]. The overall objective of the study was to evaluate field performance of the mechanical weeder as compared to manual weeding for validation of appropriate mechanical weed control practice. The specific objectives were;

✓ Evaluate the technical efficiency of the back pack weeder
✓ Undertake a comparison of the back pack weeder with manual weeding using a hoe or jembe based on the costs

Fig. 1. Back pack weeder

Table 1. Technical specification of the back pack weeder

s/no	Particulars	Specifications
1	Brand	Honda
2	Model	GX50CC
3	Type	Backpack
4	Power	1.5 KW/2 Hp
5	Power Source	Petrol
6	Weight	10 Kg
7	Engine Displacement	50 CC
8	Engine Type	4 Stroke
9	Starting System	Recoil Starter
10	Ignition System	Spark Plug
11	Cooling System	Air Cooled

2. MATERIALS AND METHODS

2.1 Study Area

The study was undertaken at four farmers' fields in Busia County where in each of the four fields a back pack weeder was evaluated against manual weeding. Cassava crop was 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 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. Fig. 2 shows the location of the test plots. 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 Sampling Methods and Data Collection

Data was collected from sub-plots within the main demo plot so as to achieve the parameters for the two methods of weeding. This was achieved by equal sampling of sub-plots of 10m length by 10m width within each demo-plot and applying both the mechanical and manual weeding.The data was collected using timers, measuring tapes and calibrated fuel containers where 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 15% -20%. The data collected was the number of plants per sub-plot damaged and undamaged, numbers of weeds before and after per unit area before weeding operation, area covered based on time consumed and distance travelled per unit time. This 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.

2.3 Methods of Data Analysis

Data was analyzed for the two methods of weeding based on field tests of the performance parameters for the two methods in the four subplots using descriptive statistics.

2.3.1 Evaluation of performance parameters

The following field tests were carried out in the research fields to evaluate the performance of the back pack weeders for weeding operation. The field tests were carried out to ascertain the following performance parameters.

2.3.1.1 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 [11]. The weeders was tested on the same field to determine weeding efficiency. It is calculated by using equation 2.1

$$W = \frac{W_1 - W_2}{W_1} \times 100$$

(2.1)

Where,

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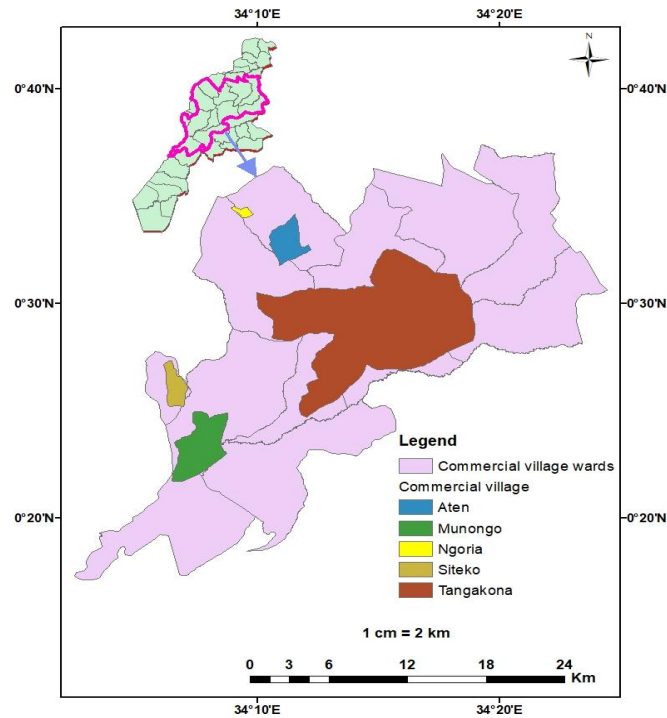W_2 = Number of weeds counted in same unit area after weeding operation.

Fig. 2. Map of the study area showing the test plots

2.3.1.2 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 [1].

$$R = \frac{A}{B} * 100 \qquad (2.2)$$

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.

2.3.1.3 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;

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

2.3.1.4 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 [12]

$$Effective\ field\ capacity = \frac{Actual\ field\ capacity}{Theoretical\ field\ capacity} \qquad (2.5)$$

2.3.1.5 Performance index of weeder

Performance of the weeder was assessed through performance index (PI) by using the following relation [13]

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

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

2.3.1.6 Speed of operation

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

$$S = \frac{L}{t} \qquad (2.7)$$

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

2.3.1.7 Fuel consumption

It was measured by top fill 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.

2.3.1.8 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

3.1 Technical Efficiency of Backpack Weeder

The performance of back pack weeder for the cassava crop was evaluated under field conditions against manual weeding under cassava crop in all the test plots named as Tangakona, Aten, Siteko and Munongo. Both machine and manual parameters including field capacity, weeding efficiency, plant damage, and performance index and fuel consumption for weeder were discussed. The results of the analysis are presented in Table 2.

From the analysis, the results (Table 2) revealed variations in the test parameters while still using the same mechanical weeder. The differences were brought about by the differences in soil textures and moisture contents of the soils in the different plots. The weeding machine efficiency was depicted as 97.1 %, 98%, 86% and 97% for the four test plots, respectively and 78%, 78%, 72% and 77% for hand weeding with means of

94.525 and 76.25 for machine and manual respectively which still indicated a high efficiency for machine than hand weeding. The efficiencies for test plots 1, 2 and 4 were high ranging from 97.1%, 98%, 97% with bit lower fuel consumption of 0.4l/hr and operational cost of 1360kes/ha, 1366kes/ha and 1361kes/ha, respectively due to the nature of soils texture which was equally sandy loam. The plant damage for all plots were found to be similar for both machine and manual weeding. The test plot 3 had somehow a hard pan which needed more time for both methods of weeding. The operational cost of manual was equally the same since the same number of casuals were used but the machine was a bit higher for the case of test plot 3 since it consumed a high amount of fuel. Soil moisture content is a great influence of the weeding efficiency and field 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 was affected.

3.2 Observed Effects of Weeder Performance on Test Parameters

3.2.1 Effect of weeder performance 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 weeder performance on weeding efficiency in cassava

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

3.2.3 Effect of weeder Performance 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.

Table 2. Results for tested parameters for the four test plots

s/no	Parameter	Test plot 1 (Tangakona)		Test plot 2 (Aten)		Test plot 3(Siteko)		Test plot 4(Munongo)		MEAN	
		Mechanical	Manual	Mechanical	Manual	Mechanical	Manual	Mechanical	Manual	Mechanical	Manual
1	Weeding Efficiency (%)	97.1	78	98	78	86	72	97	77	94.525	76.25
2	Plant Damage (%)	20	10	20	10	20	10	20	10	20	10
3	Effective Field Capacity (ha/hr)	0.016	0.0094	0.017	0.0104	0.013	0.0078	0.016	0.0094.	0.00325	0.00195
4	Field efficiency (%)	80	60	80	62	78	60	80	60	79.5	60.5
5	Fuel Consumption (Litres/hr)	0.4	0	0.4	0	0.5	0	0.4	0	0.425	0
6	Operation Cost (Ksh/ha)	1361	3846	1360	3846	1540	4200	1366	3846	1406.75	3934.5
7	Performance Index of Weeder	0.26	0	0.26	0	0.26	0	0.26	0	0.26	0

3.2.4 Effect of weeder performance 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 AND RECOMMENDATIONS

Power weeder was evaluated for its performance in cassava crop. This test was conducted at different soil textures and different speeds of weeder. The evaluated parameters were weeding 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 with a cost attached either per acre or per hour of operation. Additionally, frequent use and adoption of this weeder will lead to manufacture of spare parts locally and open up for employment opportunities for many youth Kenyans as obtainable in other part of the World.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kumar T, Nagesh V, Sujay. Performance evaluation of weeders. 2014;3:2160 – 2165.
2. Balagopalan C. Cassava in food, feed, and industry; 2018.
3. Sastry KS, Zitter TA. Plant virus and viroid diseases in the tropics. 2014;2.
4. Legg, Jame, Fauquet, Claude. Cassava mosaic geminiviruses in Africa. Plant Molecular Biology. 2004; 56:585-99. 10.1007/s11103-004-1651-7.
5. In Jabran, K., In Chauhan, BS. Non-chemical weed control; 2018.
6. Ragesh KT, Jogdand SV, Victor VM. Field performance evaluation of power weeder for paddy crop. Curr Agri Res. 2018;6(3). DOI:http://dx.doi.org/10.12944/CARJ.6.3.24
7. In Radhakrishnan, R. Biological approaches for controlling weeds; 2018.
8. Corsi S, Muminjanov H. Food and agriculture organization of the United Nations. Conservation agriculture: Training guide for extension agents and farmers in Eastern Europe and Central Asia; 2019.
9. Diao X, Takeshima H, Zhang X. An evolving paradigm of agricultural mechanization development: How much can Africa learn from Asia?; 2020.
10. Bello SR. Farm tractor systems: Maintenance & operation; 2013.
11. Devasenapathy P, Ramesh T, Gangwar B. Efficiency indices for agriculture management research. New Delhi: New India Pub. Agency; 2008.
12. Olaoye, Joshua, Adekanye, Timothy. Development and evaluation of a rotary power weeder; 2012.
13. Devojee, Bhookya, Meena, SS Sharma, AK, Agarwal, Chitranjan. Performance evaluation of weeder by number of blades per flange in chilli crop. 2020. International Journal of Chemical Studies. 8. 727-731. 10.22271/chemi.2020.v8.i2k.8855.