Greener Journal of Agricultural Sciences
Vol. 11(4), pp. 268-276, 2021
ISSN: 2276-7770

https://gjournals.org/GJAS

Cost-Benefit Analysis of the Selected Weed Control Options in Cassava Production System

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ARTICLE INFO

Article No.: *112621134*
Type*: Research*
Full Text: PDF, HTML, PHP, EPUB

Accepted: *30/11/2021*
Published: *31/12/2021*

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Keywords: *Cassava, Weed, Investment cost, Integrated weed control option(s), Benefit cost ratio.*

ABSTRACT

Weeding activity is one of the major constraints in cassava production as it requires high capital and it takes 50 to 80 percent of the total production budget. Based on this fact, there is a need to determine the most economical integrated weed control option(s) that will effectively control weeds and minimize cost of production. The effect of different weed control treatment combinations was studied and the most economical one(s) were determined during 2019/2020 planting season at Ilonga village, Kilosa and Kiimbwanindi village, Mkuranga, Tanzania. Till only and till + Ridge, pre-emergence herbicides (Primagram Gold a.i 290 g L^{-1} S-metolachlor + 370 g L^{-1} atrazine and Oxfen a.i Oxyfluorfen 24% EC), post emergence herbicides (Force up a.i 480 g/L of Glyphosate-Isopropylamine salt and back pack weeder were tested on Cassava variety Kiroba in a (2 × 2 × 2) factorial experiment arranged in a randomized complete block design (RCBD) with three replications. Data collected were all variable costs for the inputs applied on each weed control treatment combination, costs of cassava harvest and the price of cassava per one kilogram. Data were subjected to benefit-cost ratio analysis. Results revealed that, at Mkuranga site, till × Oxfen × Force up and till × Primagram × Force up treatment combinations had high benefit cost ratio of 2.39 and 2.04 respectively while at Kilosa site, only Till and Rigde **×** Oxfen **×** Force up treatment combination had high benefit cost ratio of 2.31. These high benefit cost ratios indicate feasibility of using respective weed control combinations in cassava production. Therefore, good farm preparation, the use of *Oxyfluorfen 24% EC herbicides as pre-emergence herbicide and 480 g L^{-1} of Glyphosate-Isopropylamine salt* as post emergence weed control treatments are recommended in cassava production systems.

INTRODUCTION

Weed control has been identified as one of the major constraints in cassava production systems as it requires high capital, and found to be about 50-80% of the total budget while its return on investment (ROI) ranging from 32% to 37% (Ekeleme et al., 2016; Rana and Rana, 2016; Ojiako et al., 2018; Ekeleme et al., 2019). Ekeleme et al. (2019) reported that weed infestation can lead to 50-90% cassava yield loss if not properly managed. Therefore, in order to maximize profit through reducing the cost of weeding operation, weeding should be done by the least expensive technology that will effectively control weeds without affecting other phases of cassava production (Rana and Rana, 2016).

There is a need to determine the most cost-effective integrated weed control options by considering all the required input operational costs under different tested weed control options while observing the fundamental economic principles for weed management (Wiles, 2004; De Rus, 2010). According to Wiles (2004) and Ekeleme et al. (2019) who reported the economic threshold for weed management is calculated by comparing the value of prevented yield loss from weed competition in the current season with the cost of an input's application. Thus, any weed control procedures should be used only when its results are expected to be more economical than without using any control measure (Rana and Rana, 2016). The cost of weed control can be defined as the value of the resource used in producing the materials used for weed control in their best alternative aiming at either maximizing output, maximizing profit, maximizing utility, minimizing cost or a combination of all these (Ettah and Angba, 2016).

For the determination of good integrated weed control option, the choice of weed control measures to use depends not only on its efficacy but also its cost. Thus, in order to get the most economical treatment, the economics of each treatment should be worked out on the basis of current market prices of the inputs and output obtained (Rana and Rana, 2016; Itam et al., 2018). This can be done by conducting the cost-benefit analysis (CBA) which is according to Rana and Rana (2016) a systematic approach to estimate the short- and long-term significances by measuring all costs incurred and all possible revenue and benefits from an investment project proposal (Rana and Rana, 2016). Cost benefit analysis can be done by calculating the benefit cost ratio (BCR), by which if the ratio obtained is above one meaning that the farmer would get more additional returns from investment.

In Eastern zone of Tanzania, adoption of the best integrated weed control option(s) on cassava production which lead to the maximum return while having the lowest cost as possible thus producing highest profit has not been clearly done, thus farmers still face challenges in terms of efficiency, timeliness and effectiveness in weed control as they mostly relay on a single weed control option (Kayeke et al., 2018). Due to that, cassava fresh root yield in Tanzania was estimated by FAOSTAT (2017), to be 6.2 t ha^{-1} which is far most below the production potential of about 50.8-80 t ha^{-1} (Senkoro et al., 2018; URT, 2020). Other researchers reported the benefit cost analysis of a single agricultural input like fertilizer only as its used in cassava production (Senkoro et al., 2018). Therefore, this study aimed at establishing the cost of inputs used at each stage of production and to determining the most economical integrated weed control option(s) tested in cassava production in the selected sites of Eastern zone of Tanzania.

MATERIAL AND METHOD

Description of the study site

The study was conducted at Ilonga, Kilosa, Morogoro region located at 6°46' 27" S, 37°2'14" E, and 479.95 m ASL (Zakayo, 2015) and Mkuranga, Coastal region, Tanzania located at 7°12'19" S, 39°20'38" E, 93.87 m ASL (Mkuranga, 2009). At Mkuranga, average monthly temperature ranges from 18.8 °C during the coolest months of July and August to the highest monthly means of 31.9 °C to 32.6 °C during the hot season from December to March (Mkuranga, 2009). Relative humidity ranges from 67-70 % from August to October and increasing to 82 % during the wettest month of April, and the site is experiencing bi-modal rainfall pattern; form March to May (the main wet season) with averaged 550 mm of rain and November to December (short rains) with averaged 235 mm of rain (Mkuranga, 2009; RCO, 2011).

At Kilosa, the district experiences the mean annual temperature of about 25°C with an average of eight months of rainfall starting from October to May (Kajembe et al., 2013; Zakayo, 2015). According to Zakayo (2015) stated that the rainfall distribution at Kilosa site is bimodal, with short rains begins from October to January, followed by long rains starting from mid-February to May.

Treatments and experimental design

Experimental design used was factorial experiment (2 × 2 × 2) arranged in randomized complete block design, whereby eight plots were established to make one replication. Plot size was 4 m by 5 m and plots were separated by 1 m and replication was separated by 2 m. Treatments were replicated three times in each site. Treatments were two tillage practices (Till only and till + Ridge), two pre-emergence weed control options (herbicide) (Primagram Gold a.i 290 g L^{-1} S-metolachlor and 370 g L^{-1} atrazine and Oxfen a.i Oxyfluorfen 24% EC) and two post emergence weed control options (herbicide; Force up a.i 480 g/L of Glyphosate-Isopropylamine salt and mechanized weeder tool; back pack weeder with modified tines). Pre emergence weed control treatment was applied during a day of planting. Post emergence weed control treatments were applied when weed population reached 30% (three to four leaves stage) within a plot as per IITA (ACAI project) protocol. Cassava (Kiroba variety) planted at a population of 10,000 plants/ha was used.

Data collection

Data on inputs and its costs per tested weed management option/treatment were collected, which included the costs of acquiring herbicides and planting materials, labor costs on land preparation, tillage and ridging, herbicide application, physical weeding, and cassava harvesting. Also, data on the market price of cassava per one kilogram were recorded per each site. The market price (September 2020) was obtained from farmers who sell cassava in local markets and district extension workers.

Data analysis

Data on costs of acquiring herbicides, planting materials, labor costs on land preparation, tillage and ridging, herbicide application, mechanical weeding, cassava harvesting were recorded and used to compute benefit cost ratio.

Definition of terms

Production costs: This refers to the value of inputs used in producing a product or output. Thus, due to that, there are two types of costs; fixed cost which is the cost that does not change over a period of time as output changes and variable costs which are the costs that keep on changing as the output changes (Igben and Eyo, 2002; Itam et al., 2018).

Marginal return (MR): Is the difference between the total revenue obtained from the production activity and total variable cost incurred (Daramola et al., 2019). It is expressed as;

MR = Total Revenue from cassava production – Total Variable Cost incurred

Where; The total revenue is obtained by multiplying the quantity of cassava yield harvested per hectare by the price of one kilogram of the cassava product and the total variable cost is the summation of all variable cost incurred (Itam et al., 2018; Daramola et al., 2019).

Cost benefit analysis (CBA): Is an approach used to estimate the short- and long-term significances of the tested treatments by measuring all costs and all possible revenue and benefits from treatments applied at a period of production (Rana and Rana. 2016). According to De Rus (2021) stated the cost benefit analysis can be done using the benefit cost ratio. Thus, for this study, the benefit cost ratio (B:C) for each treatment applied was calculated by dividing gross profit obtained by the total cost incurred from integrated weed control combinations.

$$Benefit\ Cost\ Ratio\ = Marginal\ returns\ (MR)/\ Total\ variable\ cost\ (TVC)$$

From the formular above, if the benefit cost ratio is < 1 then the costs exceed the benefit, therefore the tested weed control package was rejected. However, if the benefit cost ratio is ≥ 1 then the benefits exceed the costs, therefore the tested weed control package was accepted.

RESULTS

The influence of tillage practice, pre-emergence weed control and post emergence weed control treatments on cassava fresh root weight (t/ha) at Mkuranga and Kilosa sites

The results on the influence of tillage practices on cassava fresh root weight (t ha^{-1}) are shown in Table 1. At Mkuranga site, tillage practice did not significantly (P>0.05) influence the cassava fresh root weight. Till treatment showed the highest cassava fresh root weight of 38.56 t ha^{-1} as compared to the till and ridge treatment which was used as standard. Pre emergence treatments and post emergence treatments did not significantly (P>0.05) affect the cassava fresh root weight. Oxfen herbicide which was as a pre-emergence weed control treatment exhibited the highest cassava fresh root weight (38 t ha^{-1}) while mechanical weeding which was the post emergence weed control treatment led to highest cassava fresh root weight (40.64 t ha^{-1}) followed by force up herbicide which exhibited the lowest cassava fresh root weight (34.53 t ha^{-1}).

At Kilosa site, tillage practice significantly (P<0.05) affected the cassava fresh root weight. Till and ridge treatment resulted into the highest cassava fresh root weight of 21.14 t ha^{-1}. Pre emergence treatments and post emergence treatments did not significantly (P>0.05) affect the cassava fresh root weight. Oxfen treatment showed the highest cassava fresh root weight (14.8 t ha^{-1}) when used as a pre-emergence treatment while mechanical weeding which was used as a post emergence treatment led to lowest cassava fresh root weight (14.5 t ha^{-1}) as compared to force up herbicide which exhibited the highest cassava fresh root weight (14.85 t ha^{-1}).

Table 1: The influence of tillage practice, pre-emergence weeds control and post emergence weed control treatments on cassava yield, biomass and dry matter content

Treatment factors		Fresh root weight (t ha^{-1})
	Mkuranga	
Factor A (Tillage practice)	Till	38.56a
	Till and Ridge	36.61a
	Mean	*37.59*
	p value	*0.6705*
Factor B (Pre emergence treatment)	Oxfen	38.00a
	Primagram	37.17a
	Mean	*37.59*
	p value	*0.8558*
Factor C (Post emergence treatment)	Force up	34.53a
	Mechanical weeding	40.64a
	Mean	*37.59*
	p value	*0.1944*
	Kilosa	
Factor A (Tillage practice)	Till	8.2b
	Till and Ridge	21.14a
	Mean	*14.67*
	p value	*0.0109*
Factor B (Pre emergence treatment)	Oxfen	14.8a
	Primagram	14.55a
	Mean	*14.68*
	p value	*0.9561*
Factor C (Post emergence treatment)	Force up	14.85a
	Mechanical weeding	14.5a
	Mean	*14.68*
	p value	*0.9391*

Values in the same column, respectively, followed by the same letter(s) do not differ significantly (P≤0.05) according to Tukey's honestly significance test.
Source: Authors

The influence of weed control treatment interactions on cassava fresh root weight

The results presented on Table 2 show the influence of weed control treatment interactions on cassava fresh root weight for both Mkuranga and Kilosa sites. At both sites, the combinations of tillage practices and pre-emergence weed control treatments did not significantly (P>0.05) affect the cassava fresh weight. At Mkuranga site, Till × Primagram treatment combinations showed the highest cassava fresh weight of 41.25 t ha^{-1} while Till and Ridge × Primagram herbicide treatment combinations showed the lowest cassava fresh weight of 33.08 t ha^{-1}. At Kilosa site, Till and Ridge × Oxfen treatment combinations showed the highest cassava fresh weight of 23.68 t ha^{-1} while till × Oxfen herbicide treatment combinations showed the lowest cassava fresh weight of 05.91 t ha^{-1}.

At both sites, the treatment combination of tillage practices and post emergence weed control did not significantly (P>0.05) affect the cassava fresh weight. At Mkuranga site, Till and Ridge × Mechanical weeding treatment combinations showed the highest cassava fresh weight of 42.21 t ha^{-1} while Till and Ridge × Force up herbicide treatment combinations showed the lowest cassava fresh weight of 31.00 t ha^{-1}. At Kilosa site, Till and Ridge × Force up herbicide treatment combinations showed the highest cassava fresh weight of 21.83 t ha^{-1}, while till × Force up herbicide treatment combinations showed the lowest cassava fresh weight of 07.86 t ha^{-1}.

The treatment combinations of pre-emergence and post emergence weed control treatments did not significantly (P>0.05) affect the cassava fresh weight at both sites. At Mkuranga site, Oxfen × Mechanical weeding treatment combinations showed the highest cassava fresh weight of 42.27 t ha^{-1} while Oxfen × Force up treatment combinations showed the lowest cassava fresh weight of 33.73 t ha^{-1}.

The application of tillage practice, pre-emergence herbicides and post emergence weed control treatment combinations significantly (P<0.05) affected cassava fresh root weight at Mkuranga while did not at Kilosa site. At Mkuranga site, Till and Ridge × Oxfen × Mechanical weeding treatment combinations gave the highest fresh root weight (52.9 t ha^{-1}) while Till and Rigde × Oxfen × Force up treatment combination recorded the lowest fresh root weight (27.36 t ha^{-1}). At Kilosa site, Till and Rigde × Oxfen × Force up treatment combinations produced the highest fresh root weight (25.58 t ha^{-1}) while till × Oxfen × Mechanical weeding treatment combinations had the lowest fresh root weight (2.66 t ha^{-1}).

Table 2: The influence of weed control treatment combinations (interaction) on cassava fresh root weight, biomass and dry weight at Mkuranga and Kilosa

Treatment interactions		**Fresh root weight (tha-1)**	
		Mkuranga	**Kilosa**
A × B	Till × Oxfen	35.87a	5.91a
	Till × Primagram	41.25a	10.49a
	Till and Ridge × Oxfen	40.12a	23.68a
	Till and Ridge × Primagram	33.08a	18.6a
	p value	*0.1876*	*0.2983*
A × C	Till × Force up	38.06a	7.86a
	Till × Mechanical weeding	39.07a	8.54a
	Till and Ridge × Force up	31.00a	21.83a
	Till and Ridge × Mechanical weeding	42.21a	20.45a
	p value	*0.275*	*0.8209*
B × C	Oxfen × Force up	33.73a	17.37a
	Oxfen × Mechanical weeding	42.27a	12.22a
	Primagram × Force up	35.33a	12.32a
	Primagram × Mechanical weeding	39.01a	16.77a
	p value	*0.5971*	*0.3013*
A×B×C	Till × Oxfen × Force up	40.10a	9.17a
	Till × Oxfen × Mechanical weeding	31.64a	2.66a
	Till × Primagram × Force up	36.01a	6.55a
	Till × Primagram × Mechanical weeding	46.49a	14.43a
	Till and Ridge × Oxfen × Force up	27.36a	25.58a
	Till and Ridge × Oxfen × Mechanical weeding	52.90a	21.79a
	Till and Ridge × Primagram × Force up	34.64a	18.09a
	Till and Ridge × Primagram × Mechanical weeding	31.52a	19.11a
	Mean	37.58	14.67
	CV%	29.4	59.8
	p value	*0.0179*	*0.6014*

Values in the same column, respectively, followed by the same letter(s) do not differ significantly (P≤0.05) according to Tukey's honestly significance test, CV = coefficient of variation, A = Tillage practice, B = Pre emergence weed control treatment, C = Post emergence weed control treatment.
Source: Authors

Cost benefit assessment of weed control treatment combinations on cassava yield in Mkuranga and Kilosa

The cost of inputs incurred in the production of cassava, total variable cost, gross return, and net income for cassava production at Mkuranga and Kilosa sites are shown in Table 3 and Table 4, respectively. In this study, the same market prices of cassava were used (the market estimate for the cassava in September 2020 was Tanzania shillings 80 000 per tonne of fresh cassava and Tanzania shillings 100 000 per tonne of fresh cassava at Mkuranga and Kilosa, respectively) for the budget estimation for all treatments applied in the studied sites. It was observed that, total variable cost per hectare varied from 947 000 Tanzania shillings for the inputs used on the treatments till × primagram × force up and treatments till × oxfen × force up to 2 072 900 Tanzania shillings for the inputs used under the treatments till and ridge × oxfen × mechanical weeding Tanzania shillings at Mkuranga site, while at Kilosa site, total variable cost ranged from Tanzania shillings 522 000 for the inputs used on the treatments combination till × primagram × force up to 1 636 900 Tanzania shillings for the inputs used under the treatments Till and ridge × oxfen × mechanical weeding and treatments combination till and Ridge × primagram × mechanical weeding.

The gross revenue per hectare obtained differed from one treatment to the other at both sites. At Mkuranga site, the highest gross revenue was 4 232 000 and the lowest was 2 188 480 while at Kilosa site, the highest gross revenue was 2 558 00 and the lowest was 266 000. Thus, at Mkuranga site the treatment combinations of till × Oxfen × Force up and till × Primagram × Force up treatment combinations had high benefit cost ratio of 2.39 and 2.04 respectively regardless of the lower cassava root yield obtained from those treatment combinations while at Kilosa site, the only treatment combination Till and Ridge × Oxfen × Force up had high benefit cost ratio of 2.31.

Table 3: The partial budget analysis showing the cost, gross revenue, marginal revenue* and benefit-cost ratio of different weed management options in Mkuranga site

	ACTIVITY	PRICE PER Ps	VARIABLE COSTS/Ha		TREATMENTS							
					1. Till + Primagram + Force up	2. Till + Primagram + Mechanical weeding	3. Till + Oxfen + Force up	4. Till + Oxfen + Mechanical weeding	5. Till and Ridge + Primagram + Force up	6. Till and Ridge + Primagram + Mechanical weeding	7. Till and Ridge + Oxfen + Force up	8. Till and Ridge + Oxfen + Mechanical weeding
Input Cost	Primagram purchase	12000	36000		36000	36000			36000	36000		
	Oxfen purchase	12000	36000				36000	36000			36000	360
	Force up purchase	12000	36000		36000		36000	36000	36000		36000	360
	Mechanical weeder purcchase	450000	450000			450000		450000		450000		4500
Labor cost of operation	Tillage	100000	250000		250000	250000	250000	250000	250000	250000	250000	2500
	Ridging	150000	375000						375000	375000	375000	3750
	Planting	50000	125000		125000	125000	125000	125000	125000	125000	125000	1250
	Pre emergence weed control	25000	62500		62500	62500	62500	62500	62500	62500	62500	625
	1st Post emergence weed control using mechanical weeder	50000	125000			125000		125000		125000		1250
	Fuel costs/Ha (Avg 21 lts/Ha)	1800	37800			37800		37800		37800		378
	1st Post emergence weed control using herbicide	25000	62500		62500		62500		62500		62500	
	2nd Post emergence weed control using mechanical weeder	50000	125000			125000		125000		125000		1250
	Fuel costs/Ha (Avg 21 lts/Ha)	1800	37800			37800		37800		37800		378
	2nd Post emergence weed control using herbicide	25000	62500		62500		62500		62500		62500	
	3rd Post emergence weed control using mechanical weeder	50000	125000			125000		125000		125000		1250
	Fuel costs/Ha (Avg 21 lts/Ha)	1800	37800			37800		37800		37800		378
	3rd Post emergence weed control using herbicide	25000	62500		62500		62500		62500		62500	
	4th Post emergence weed control				125000	125000	125000	125000	125000	125000	125000	1250
Harvest cost		50000	125000		125000	125000	125000	125000	125000	125000	125000	1250
TOTAL VARIABLE COST (TVC)					**947000**	**1661900**	**947000**	**1697900**	**1322000**	**2036900**	**1322000**	**20729**
REVENUE	**A. Cassava price/t**	**80000**			**80000**	**80000**	**80000**	**80000**	**80000**	**80000**	**80000**	**800**
	B. Tonnes of Cassava harvested per Ha				36.011	46.489	40.1	31.644	34.644	31.522	27.356	5
GROSS REVENUE (GR)					**2880880**	**3719120**	**3208000**	**2531520**	**2771520**	**2521760**	**2188480**	**42320**
MARGINAL REVENUE (MR) = GR - TVC					**1933880**	**2057220**	**2261000**	**833620**	**1449520**	**484860**	**866480**	**21591**
BENEFIT-COST RATIO (BCR) = (MARGINAL REVENUE/TOTAL VARIABLE COST)					**2.04**	**1.24**	**2.39**	**0.49**	**1.10**	**0.24**	**0.66**	**1**

***** The cost, gross revenue, marginal revenue was in Tanzanian shillings. The market cassava market price was estimated in September 2020. Herbicide spraying costs involves the cost of knapsack sprayer used and water. Source: Authers

Table 4: The partial budget analysis showing the cost, gross revenue, marginal revenue* and benefit-cost ratio of different weed management options in Kilosa site

	ACTIVITY	PRICE PER Ps	VARIABLE COSTS/Ha	TREATMENTS 1. Till + Primagram + Force up	2. Till + Primagram + Mechanical weeding	3. Till + Oxfen + Force up	4. Till + Oxfen + Mechanical weeding	5. Till and Ridge + Primagram + Force up	6. Till and Ridge + Primagram + Mechanical weeding	7. Till and Ridge + Oxfen + Force up	8. Till and Ridge + Oxfen + Mechanical weeding
Input Cost	Primagram purchase	12000	36000	36000	36000			36000	36000		
	Oxfen purchase	12000	36000			36000	36000			36000	36
	Force up purchase	12000	36000	36000		36000		36000		36000	
	Mechanical weeder purcchase	450000	450000		450000		450000		450000		450
Labor cost of operation	Tillage	50000	125000	125000	125000	125000	125000	125000	125000	125000	125
	Ridging	100000	250000					250000	250000	250000	250
	Planting	10000	25000	25000	25000	25000	25000	25000	25000	25000	25
	Pre emergence weed control	5000	12500	12500	12500	12500	12500	12500	12500	12500	12
	1st Post emergence weed control using mechanical weeder	50000	125000		125000		125000		125000		125
	Fuel costs/Ha (Avg 21 lts/Ha)	1800	37800		37800		37800		37800		37
	1st Post emergence weed control using herbicide	5000	12500	12500		12500		12500		12500	
	2nd Post emergence weed control using mechanical weeder	50000	125000		125000		125000		125000		125
	Fuel costs/Ha (Avg 21 lts/Ha)	1800	37800		37800		37800		37800		37
	2nd Post emergence weed control using herbicide	5000	12500	12500		12500		12500		12500	
	3rd Post emergence weed control using mechanical weeder	50000	125000		125000		125000		125000		125
	Fuel costs/Ha (Avg 21 lts/Ha)	1800	37800		37800		37800		37800		37
	3rd Post emergence weed control using herbicide	5000	12500	12500		12500		12500		12500	
	4th Post emergence weed control	50000	125000	125000	125000	125000	125000	125000	125000	125000	125
Harvest cost		50000	125000	125000	125000	125000	125000	125000	125000	125000	125
TOTAL VARIABLE COST (TVC)				522000	1386900	522000	1386900	772000	1636900	772000	1636
REVENUE	A. Cassava price/t	100000		100000	100000	100000	100000	100000	100000	100000	100
	B. Tonnes of Cassava harvested per Ha			6.55	14.43	9.17	2.66	18.09	19.11	25.58	21
GROSS REVENUE (GR)				655000	1443000	917000	266000	1809000	1911000	2558000	2179
MARGINAL REVENUE (MR) = GR - TVC				133000	56100	395000	-1120900	1037000	274100	1786000	542
BENEFIT-COST RATIO (BCR) =				0.254789272	0.040449924	0.75670498	-0.80820535	1.343264249	0.167450669	2.313471503	0.331174

* The cost, gross revenue, marginal revenue was in Tanzanian shillings. The market cassava market price was estimated in September 2020. Herbicide spraying costs involves the cost of knapsack sprayer used and water. Source: Authers

DISCUSSION

The influence of tillage practice, pre-emergence and post emergence weed control treatments on cassava yield

The study findings revealed that, high cassava root yield observed in Till and ridged plots could be attributed by the fact that, ridges provide large surface area for cassava roots to expand and enlarge as compared to the plots with no ridges. Also, the use of oxfen herbicide (a.i Oxyfluorfen 24% EC) as pre-emergence herbicide reduces weed competition during the initial stages of cassava growth. These results are in accordance to that of Schwartz-Lazaro and Copes (2019) who observed, weed seedbank and weed population is highly reduced as tillage intensity increases as a result of exposure of weed seeds to the conditions that does not favor their growth. Also, Godwin et al. (2017), reported pre-emergence herbicide help in controlling weeds for up to four weeks after cassava planting.

Cost benefit assessment of weed control treatment combinations on cassava yield in Mkuranga and Kilosa

In these findings, the variation in total variable costs between treatments inputs applied could be attributed by the difference in input applied and difference in method used for equipment operation. These results are in accordance to that of Kosemani and Bamgboye (2018) who observed the differences in expenditure per hectare during cassava production was a result of difference in amount of biological and chemical energy input and difference in method of equipment acquisitions in cassava production. Also, James et al. (2011) observed in cassava production, the amount spent on manual resources was the highest as compared to the amount spent on chemical resources as the amount spent in physical resources was more than 42% of the total cost of the inputs.

Also, the gross revenue per hectare obtained differed from one treatment to the other at both sites. This difference in revenue observed was largely attributed by the difference in cassava yield obtained per each treatment. Similar results were explained by Velmurugan et al. (2017), who reported during cassava production, the difference in cassava growth and the cassava yield may be attributed by the difference in weed management activities applied.

Thus, at Mkuranga site the treatment combinations of till × Oxfen × Force up and till × Primagram × Force up treatment combinations had high benefit cost ratio of 2.39 and 2.04 respectively regardless of the lower cassava root yield obtained from those treatment combinations while at Kilosa site, the only treatment combination Till and Ridge × Oxfen × Force up had high benefit cost ratio of 2.31. These results were due to the fact that, the use of herbicides in controlling weeds in cassava is cheaper than the use of mechanical weeding treatments. The results are in agreement with that of Udensi et al. (2012); Islami et al. (2017); Kosemani and Bamgboye (2018) and Ekeleme et al. (2019) who reported that the use of herbicides in controlling weeds in cassava production were very cheap as compared to the use of other means of weed control like the use of mechanized tools.

CONCLUSION

Benefit cost ratio of 2.31 at Kilosa site and 2.39 at Mkuranga site, respectively indicates practicability of cassava production from the economic point of view. Therefore, good farm preparation, the use of herbicides, the use of high yield cassava varieties (Kiroba) and optimum use of fertilizer increased the profitability of cassava production. Based on the findings of this study, tillage should be done initially before cassava planting, proper use of pre-emergence and post-emergence herbicides as the integrated weeding operations could lead to optimum cassava root production. Consequently, the treatment combinations of Till and Ridge × Oxfen herbicide × Force up herbicide and till × Oxfen herbicide × Force up herbicide are recommended for Kilosa and Mkuranga sites respectively in order to increase cassava productivity and income of the farmers in these areas.

CONFLICT OF INTEREST

I declare no potential conflict of interest.

ACKNOWLEDGMENT

This is part of MSc. Research Dissertation by Joseph Adonia Leonard funded by International Institute of Tropical Agriculture (IITA) under the African Cassava Agronomy Initiative (ACAI) project.

REFERENCES

Daramola, O. S., Adeyemi, O. R., Adigun, J. A. and Adejuyigbe, C. O. (2019). Economics of row spacing and integrated weed management in soybean (*Glycine max* L.). *Journal of Agricultural Sciences (Belgrade)* 64(3): 265-278.

De Rus, G. (2010). *Introduction to Cost-benefit Analysis: Looking for Reasonable Shortcuts*. Edward Elgar. University Carlos III de Madrid and research affiliate, FEDEA, Spain. 264pp.

Ekeleme, F., Atser, G., Dixon, A., Hauser, S., Chikoye, D., Olorunmaiye, P. M., Sokoya, G., Alfred, J., Moses C. O., Korieocha, D. S. and Olojede, A. O. (2019). Assessment of weeds of cassava and farmers management practices in Nigeria. *Tropical Agriculture* 37(2): 1-22.

Ekeleme, F., Hauser, S., Atser, G., Dixon, A., Weller, S., Olorunmaiye, P., Usman, H., Olojede, A. and Chikoye, D. (2016). Weed management in cassava in Africa: Challenges and opportunities. *Outlook Pest Management* 27(5): 208-212.

Ettah, O. I. and Angba, A. O. (2016). Analysis of cost and returns among cassava farmers in Cross River State, Nigeria. *International Journal of Science and Research (IJSR)* 5(11): 111-114.

FAOSTAT. (2017). Crop statistics. FAO, Rome. [http://www.fao.org/faostat/en/#data/QC] site visited on 25/10/2021.

Igben, S. M. and Eyo, E. O. (2002). *Agricultural Economics: An Introduction to Basic Concepts and Primary Principles*: Best print Business Press, Uyo, Nigeria. pp.82-88.

Islami, T., Wisnubroto, E. I. and Utomo, W. H. (2017). Effect of chemical and mechanical weed control on cassava yield, soil quality and erosion under cassava cropping system. *Journal of Advanced Agricultural Technologies Vol*, 4(1): 57-61.

Itam, K. O., Ajah, E. A. and Udoeyop, M. J. (2018). Comparative cost and return analysis of cassava production by adopters and non-adopters of improved cassava varieties among farmers in Ibesikpo Asutan LGA, Akwa Ibom State, Nigeria. *Global Journal of Agricultural Sciences* 17(1): 33-41.

James, A., Nandi, P. G., and Evans, N. Y. (2011). Economic Analysis of Cassava Production in Obubra Local Government Area of Cross River State, Nigeria. *Asian Journal of Agricultural Sciences* 3(3): 205-209.

Kajembe, G. C., Silayo, D. S. A., Mwakalobo, A. B. and Mutabasi, K. (2013). The Kilosa District REDD+ pilot project, Tanzania. A socioeconomic baseline study IIED. *Turkish Journal of Fisheries and Aquatic Sciences* 12(4): 743–749.

Kayeke, M. J., Nhamo, N. and Chikoye, D. (2018). Reducing Risk of Weed Infestation and Labor Burden of Weed Management in Cropping Systems. In: *Smart Technologies for Sustainable Smallholder Agriculture*. pp. 123-143.

Kosemani, B. S. and Bamgboye, A. I. (2018). Cost of Energy Input in the Production of Cassava (*Manihot Esculenta*). *Energy and Environment Research* 8(1): 10-17.

Mkuranga ICMAP. (2009). Mkuranga District Integrated Coastal Management Action Plan. Prime Minister's Office Regional administration and local government, Mkuranga District Council. 170pp.

Ojiako, I. A., Tarawali, G., Okechukwu, R. U., Chianu, J., Ezedinma, C. and Edet, M. (2018). Profitability of cassava production: comparing the actual and potential returns on investment among smallholders in southern Nigeria. *Journal of Biology, Agriculture and Healthcare 8*(16): 51-65.

Rana, S. S. and Rana, M. C. (2016). Principles and practices of weed management. *Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur*. 138pp.

RCO. (2011). Pwani Regional Website - Regional Commissioner's Office. [http://www. pwani.go.tz/bagamoyo/d_acl.php] site visited on 27/10/2021.

Senkoro, C. J., Tetteh, F. M., Kibunja, C. N., Ndungu-Magiroi, K. W., Quansah, G. W., Marandu, A. E., Ley, G. J., Mwangi, T. J. and Wortmann, C. S. (2018). Cassava yield and economic response to fertilizer in Tanzania, Kenya and Ghana. *Agronomy Journal* 110(4): 1600-1606.

The United Republic of Tanzania (URT). (2020). *National Cassava Development Strategy (NCDS) 2020 – 2030*. Ministry of agriculture, Tanzania. 96pp.

Udensi, E. U., Tarawali, G., Ilona, P., Okoye, B. C. and Dixon, A. (2012). Adoption of chemical weed control technology among cassava farmers in south eastern Nigeria. *Journal of Food, Agriculture and Environment* 10: 667-674.

Velmurugan, M., Manickam, S. and Pugalendhi, L. (2017). Effect of Weed Management Practices on The Growth and Yield of Cassava (*Manihot esculenta* Crantz). *Journal of Root Crops* 43(1): 34-38.

Wiles, L. J. (2004). Economics of Weed Management: Principles and Practices 1. *Weed Technology* 18(1): 1403-1407.

Zakayo, R. (2015). *Pastoral adaptive capacity in the changing climate in Kilosa district.* Doctoral Dissertation for Award Degree at Sokoine University of Agriculture. [www.weadapt.org › system› files_force › annotated_bibliography_ecosyst] site visited on 27/10/2021.

Cite this Article: Leonard, JA; Kudra, AB; Tryphone, GM (2021). Cost-Benefit Analysis of the Selected Weed Control Options in Cassava Production System. *Greener Journal of Agricultural Sciences* 11(4): 268-276.