ECONOMICS OF CASSAVA PRODUCTION WITH DIFFERENT TILLAGE AND CHEMICAL WEED CONTROL

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ABSTRACT

Herbicide use, which has now become an integral part of the chemical inputs required for weed control in modern agricultural production, have not only contributed to healthy crop growth but also improved farm work efficiency .The experiment was conducted to determine the economy of tillage and herbicide weed control in cassava production during 2021 and 2022 growing seasons at theTeaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, (Longitude $8^0 15^{"}$N and Latitude 4^0 25"" E) Oyo State Nigeria. The experiment was a randomized complete blockdesign, replicated three times with split plots arrangement, the treatments were Lagon (1 kg ai/ha), Primextra Gold (3 kg ai/ha), Xtravest (3 kg ai/ha), Atrazine (4 kg ai/kg), Pendimethalin (2 kg ai/ha) and Metolachlor (1 kg ai/ha) herbicide weed control. Hoe weeding at 4, 8 and 12 week after planting and unweeded checks were included to serve as control. Data were collected on sprouting and survival of cassava plants, weed population and biomass, and cassava tuber yields. Partial budgeting was used to evaluate economics of production. Data were subjected to analysis of variance and means compared with least significant difference (LSD 0.05).

Results showed that the herbicide treatments significantly affected both the sprouting and survival of cassava plants, hoe weeding had the least weed density (34.50 m^{-2}), Highest cassava fresh tuber yield(63.67 t/ha) was also obtained from hoe weeding. 3 hoe-weeding was the most profitable (₦1634000) followed by Primexra Gold (₦1511500), Metolachlor (₦ 1456500), Atrazine (₦1262000), Xtravest (₦ 1196500), Lagon (₦ 1160000) and Pendimethalin (₦1131000) in that order.

Keywords; Tillage, herbicides, weed control, economics.

INTRODUCTION

The agronomic problems change from one country to another, while the proliferation of weeds remains a constant problem, thereby becoming more and more problem in the tropical agriculture. Despite different types of advancement in crop and weed management systems, weeds have continued to be and will be a pest control required for agricultural production due to their remarkable ability to adapt to all varieties environments and weed management technologies. Fonteyne *et al.* (2020) reported that weeds have been a persistent problem since the beginning of agriculture. The use of herbicide has provided an alternative weed control to hand weeding in cassava cultivation. Herbicides can be applied before the emergence of the crops and weeds from the ground and can remain active for a long period till the crop will overcome the competitive effect of the weed. Owing to the reduction in labor requirement from the use of herbicides, additional resources could be invested in other food crops to the benefit of food security of the farmer. According to Adomako and Akyeampong (2016) herbicides are cheaper, faster and give a satisfactory and effective weed control than most other weed control methods. Arthi *et al.* (2015) posited that if farmers use herbicides, their labor bottleneck could be alleviated during the peak period of labor demand as human

labor could be released for operation on other crops. Although there has been some concern that herbicides are too costly to be used by the majority of farmers in Sub-Saharan Africa, however, increasing labor costs and the unavailability of labor at critical times are rapidly causing the use of herbicides to become more economical than hand-weeding. Benson (1982) compared the economics of different weed control technologies and reported that herbicides reduce labor requirement for weed control to between one-tenth and two-thirds of the requirement for manual weeding. Furthermore, Olabode *et al.* (2019) posited that repeated hoeing with the accumulation of labor cost will reduce farmers' net income when using hand weeding. The monetary savings resulting from the weed control with herbicides varies between crops and the price of herbicide used. In the light of this, this experiment was designed to assess the economics of weed control with tillage and herbicide with a view to determining the most profitable for cassava production in the study area.

MATERIALS AND METHOD

The study was carried out in Ogbomoso agricultural zone, Oyo State, Nigeria in 2021 and 2022 rainy seasons. Ogbomoso(Latitude 8^{o} 15' N and Longitude 4^{o} 25' E.) in the southern Guinea Savanna with elevation of 366 meters above sea level. The soil in the experimental site consists properties of 6.14 pH. Total organic carbon and nitrogen are 1.21% and 0.12% respectively, available P (7.42) at mg/kg and K (0.90) at Cmol/kg; Ca (4.23), Mg (3.52), Fe (12.79); Na (0.53), heavy metals: Mn (2.80), Cu (0.22), Zn (0.37) and Pb (0.08) at mg/kg. The physical properties include: sand 86 %, silt 9% and clay 5% which typifies the soil as loamy-sand. The average annual temperature is 26.1^{o}C with highest on average in March (28.3^{o}C) while the lowest average temperature of 23.8^{o}C is recorded in August. The mean annual rainfall is 1080 mm per annum (Ogunbode and Ifabiyi, 2019). Cassava cuttings, (TME 419 variety), was planted at a spacing of 1 x 1 m giving 10,000 stands per hectare. Each plot measured 4 x 4 m while the whole plot measured 40 x 50 m. Each stem cutting of about 25cm length with at least four nodes was inserted at roughly 45^{o} into the soil and buried to 2/3 of their length. Non-sprouted cuttings were replaced at 3 weeks after planting (WAP). Harvesting was conducted at52 weeks after planting. First, all border plants were removed, then the net plants were harvested. The net plot size was 2 m x 2 m. Data were collected on sprouting, survival, weed population and biomass, and cassava fresh tuber yield. Data were subjected to analysis of variance; the means were compared using LSD at 5% probability level.

RESULTS

Conventional tilled plots had the highest value (85.69%), this value is comparable to value (82.26%) recorded on minimally tilled plots. On the other hand, the sprouting of cassava plants at 3 WAP was significantly affected by the herbicides (Table 1). The highest value (96.88%) was recorded under xtravest herbicide while the least (68.77%) was recorded on Pendimethalin treated plot. The interaction between tillage and herbicides showed that there was no significant effect of tillage and herbicide on the sprouting of cassava stems. There was significant effect of tillage on the % survival of cassava plant (P=0.05). Conventionally tilled plots were superior in terms of survival of cassava plants than minimally tilled plots. Furthermore, results in Table 1 showed that there was significant effect of herbicides on the percentage survival of cassava plants (P=0.05). The highest value (96.05%) was recorded on control plot with Hoe weeding while the least (66.67%) was noted on Pendimethalin treated plots. However, the interaction of herbicide with tillage showed no significant effect on the survival of cassava plants (P=0.05)

Table 1: Effect of tillage and herbicides on % sprouting and survival of cassava

	ATR	HOE	LAG	MET	PEN	PRM	UND	XTR	T $\bar{x}$
Sprouting									
CON	93.77	77.10	87.53	85.43	72.93	81.27	91.67	95.83	85.69
MIN	81.27	81.27	82.97	79.20	64.60	85.43	85.43	97.93	82.26
HBD$\bar{x}$	87.52	79.18	85.25	82.32	68.77	83.35	88.55	96.88	
LSDH	16.3								
LSDT	ns								
LSDHxT	ns								
Survival									
CON	97.37	97.37	90.57	88.50	70.87	93.20	79.20	90.57	88.45
MIN	98.57	94.73	89.03	90.57	66.67	84.90	70.87	86.97	84.29
HBD$\bar{x}$	93.97	96.05	89.80	89.53	68.77	89.05	75.03	88.77	
LSDH	6.61								
LSDT	3.30								
LSDHxT	ns								

HBD$\bar{x}$-herbicide mean,CON-conventional tillage,MIN-minimum tillage,ATR-atrazine,HOE-hoeweeding,LAG-lagon,MET-metolachlor,PEN-pendimethalin,PRM-primextra gold,UND-unweeded,XTR-xtravest,LSDH-least significant difference herbicide,LSDT-least significant difference tillage,LSDHXT-least significant difference interaction between herbicide and tillage, T $\bar{x}$-tillage mean

Effect of tillage andherbicide on weed biomass and population

Tillage affected the weed population significantly. The average value (60.46 m^{-2}) recorded in minimally tilled plots was significantly higher than (41.58 m^{-2}) value recorded on conventionally tilled plots. There was significant (p = 0.05) effect of herbicide on weed population. The highest (85.83m^{-2}) weed density was noted for unweeded check treatment while the lowest (34.50 m^{-2}) was recorded in Hoe weeding treatment. Weed population in Lagon (42.m^{-2}) and Primextra Gold (41.50 m^{-2}) were comparable to those of Hoe weeding.Result also revealed that both tillage andherbicide significantly affected the fresh weed biomass (kg m^{-2}). Higher fresh weed biomass (0.32 kg m^{-2}) was recorded in minimally tilled plots while the lower (0.28 kg m^{-2})was recorded in conventionally tilled plots. For the herbicides, the highest freshweed biomass (0.79 kg m^{-2}) was recorded in weedy, check plot while the least (0.16 kg m^{-2}) fresh weed biomass was in Hoe weeding. Values recorded in Lagon (0.20 kg m^{-2}), Metolachlor (0.22 kgm^{-2}) and Primextra Gold (0.22 kg m^{-2}) treated plots were comparable to those of Hoe weeding.Interaction between tillage and herbicides had no significant effect on the fresh weed biomass.

Table 2 Effect of tillageand herbicide on weed population

	ATR	HOE	LAG	MET	PEN	PRM	UND	XTR	T $\bar{x}$
Weed Population									
CON	39.33	29.33	36.00	35.33	40.33	35.67	79.00	37.67	41.58
MIN	65.33	39.67	48.00	61.67	68.33	47.33	92.67	60.67	60.46
HBD$\bar{x}$	52.33	34.50	42.00	48.50	54.33	41.50	85.83	49.17	
LSDH	5.63								
LSDT	2..81								
LSDHxT	7.51								
Weed Biomass									
CON	0.24	0.14	0.18	0.22	0.27	0.20	0.75	0.21	0.28
MIN	0.29	0.18	0.23	0.23	0.31	0.24	0.84	0.26	0.32
HBD$\bar{x}$	0.27	0.16	0.20	0.22	0.29	0.22	0.79	0.24	
LSDH	0.06								
LSDT	0.29								
LSDHxT	Ns								

HBD$\bar{x}$-herbicide mean,CON-conventional tillage,MIN-minimum tillage,ATR-atrazine,HOE-hoeweeding,LAG-Lagon,MET-metolachlor,PEN-pendimethalin,PRM-primextra gold,UND-unweeded,XTR-xtravest,LSDH-least

significant difference herbicide,LSDT-least significant difference tillage,LSDHXT-least significant difference interaction between herbicide and tillage, T $\bar{x}$-tillage mean

Effect of tillage and herbicide on cassava fresh tuber yield

There was significant effect of tillage on the fresh tuber yield of cassava. The highest (44.01 t/ha) fresh tuber yield was recorded in conventionallytilled plots which was highly significant compared to (27.69 t/ha) value recorded under minimally tilled plots. The highest (50.00 t/ha) fresh tuber yield recorded in Hoe weeding treatment was significantly higher than those across all other treatments. Value (43.33 t/ha) and (43.67 t/ha) recorded in Metolachlor and Primextra Gold treated plots respectively were however comparable to those of Hoe weeding treatment. The least (0.28 t/ha) fresh tuber yield was recorded in unweeded check plot. Furthermore, results also showed that the interaction between herbicide and tillage produced an effect which was highly significant on cassava fresh tuber yield.

Table 3 Effect of tillage and herbicide on cassava fresh tuber yield

	ATR	HOE	LAG	MET	PEN	PRM	UND	XTR	T $\bar{x}$
CON	47.00	63.67	44.00	53.67	42.33	56.00	0.42	45.00	44.01
MIN	31.4	36.33	30.67	33.00	28.67	31.33	0.14	30.00	27.69
HBD$\bar{x}$	39.2	50.00	37.33	43.33	35.50	43.67	0.28	37.5	
LSDH	2.35								
LSDT	1.17								
LSDHxT	3.32								

HBD$\bar{x}$-herbicide mean,CON-conventional tillage,MIN-minimum tillage,ATR-atrazine,HOE-hoeweeding,LAG-lagon,MET-metolachlor,PEN-pendimethalin,PRM-primextra gold,UND-unweeded,XTR-xtravest,LSDH-least significant difference herbicide,LSDT-least significant difference tillage,LSDHXT-least significant difference interaction between herbicide and tillage, T $\bar{x}$ -tillage mean.

Farm Income Statement per Hectare of Cassava Production

Table 4 presents the farm income statement per hectare of cassava production using 3 hoe-weeding. The man day labour (MDL) was ₦3, 000.00. The total variable cost was ₦279000.00 while the overhead cost was ₦10, 000.00.Total cost (TC) of production per hectare of cassava production with 3 hoe-weeding was ₦289000.00. The average fresh tuber yield from the two experimental sites was 64.1 t/ha cassava root tuber at ₦30000.00.per tone (current market price at Local markets in Ogbomoso: Arada, Iresaapa and Iregba). Sales from cassava fresh tuber was ₦1, 923,000.00 (₦30000.00 x 64.1 t). The gross margin was determine by subtracting Total variable cost from the income (Income TVC)—₦ 1923000.00 – ₦279000.00 = ₦1644,000.00 while the Net profit was ₦1,634,000.00 (Income – total Cost of production).

Table 5 presents the partial budgeting for cassava production per hectare with minimum tillage in combination with 3 hoe-weeding. It was revealed from the table that there was no additional cost. However, the income was reduced due to reduction in the average yield below the control (64.1 – 36 t/ha = 28.1t) plot. At ₦30000.00 per tone, 28.1t = ₦843,000.00. On the other hand, there was no additional income while there was reduction in the cost of production. This was ₦45000.00. The Net change in profit from using minimum tillage in place of conventional tillage was (₦45000 – ₦843,000) {(Additional income + reduced cost) – (Additional cost + reduced income)} = –₦ 738000.00.

Table 4. Farm Income Statement per Hectare of Cassava Production
Control Plot: 3 Hoe Weeding

(a)	Income		₦	K
	Yield – ₦30000 x 64.1 t/ha		1,923,000.00	
(b)	Variable Costs			
	Land Preparation	18MDL		
	Planting	3 MDL		
	Weeding	50 MDL		
	Harvesting	5 MDL		
	Transportation	3 MDL		
	Total MDL 79 at N3000 MDL		237000.00	
	Cost of Hoes (8 hoes at 1500/hoe)		12000.00	
	Cassava stems		30000.00	
(c)	Overhead Cost			
	Rent		10000.00	
(d)	Total Cost of Production			
	b + c (279000 + 10000)		289000.00	
(e)	Gross Margin			
	a – b (1923000 – 279000)		1,644000.00	
(f)	Net Profit			
	a – (b + c) 1923000 – (279000 + 10000)		1,634,000.00	

Table 5: Partial Budgeting for Cassava production with minimum tillage + Hoe weeding
Proposed charge – minimum tillage

Additional Cost	₦	K	Additional Income	₦	K
			Nil		
			(Yield Increase over control)		
Reduced Income					
Yield reduction below control			Reduced Cost		
64.1 tonnes – 36 tonnes = 28.1t			10 MDL (Land preparation		
At ₦30000/t	=	843000.00	at ₦3000	30000.00	
Additional Cost + Reduced			3 MDL (Harvesting)	9000.00	
Income		843.000.00	2 MDL (transportation)	6000.00	
			Subtotal	45000	
Net charge in Profit					
B – A			B Additional Income + Reduced		
= 45000 – 843000	= –	₦738000	Cost	45000.00	

The partial budgeting for cassava production with conventional tillage without weeding (unweeded check) was shown in Table 6 Reduced income of using unweeding weed control at average across the two experimental sites was ₦1, 812,000.00. Result analysis from the Table indicated that there was no additional cost. The value of Additional cost in addition to reduced income was ₦1, 812,000.00. Table 4.26 also showed that there was no additional income, but, there was reduced income of ₦165000.00 resulted from elimination of weeding, reduction in MDL used for harvesting and reduction in the cost of transportation. Hence, Additional income plus reduced cost was ₦165000.00 Net change in profit (Additional income + reduced cost – Additional cost + reduced income) was – ₦1647000.00.

Table 7 showed the partial budgeting for cassava production using minimum tillage without weeding. It was indicated in the table that there was no additional cost of using unweeded method of weed control. Reduced income which occurred from the reduction in yield below the control plot was ₦1, 917,600.00. Additional cost plus reduced income was ₦1917, 600.00. There was also no additional income; however, there was reduced cost (195000.00) from Land preparation, elimination of weeding, reduction in MDL for harvesting and reduction in transportation cost. Additional income plus reduced cost therefore was ₦195000.00 The Net change in profit was – ₦1, 722600.00.

Partial budgeting for cassava production per hectare using conventional tillage with herbicide (Primextra Gold) is presented in Table 8. The table showed that the additional cost was incurred from buying sprayer, herbicide and spraying. These were amounted to ₦44500 while the reduced income (8 tones at ₦30000.00) was ₦240000.00 Additional cost plus Reduced income was (₦44500.00 + 240000.00) ₦284500.00. It was also revealed in the table that there was no additional income except Reduced cost which was ₦162,000.00. Hence, Addition income plus Reduced Cost amount to ₦162,000.00. Net change in profit (₦162,000.00 – 284500.00) was - ₦122500.00.

Table 9 showed the partial budgeting for cassava production per hectare with minimum tillage and herbicide (Primextra Gold). ₦44500.00 was incurred as additional cost with the use of herbicide while the yield below the control was 31.5 tones at ₦30000 /t which amounted to ₦989500.00. There was no additional income, but the cost of production reduced as a result of minimum land preparation, avoidance of weeding and skipping of buying hoes. This amount was ₦192,000.00. Additional income plus reduced cost was ₦192,000.00. The proposed Net change in Profit was – ₦797500.00 (₦192000.00 – 989500.00).

Table 6: Partial Budgeting for cassava production with conventional tillage without weed control

Proposed charge – Unweeding

Additional Cost	₦	K	Additional Income	₦	K
Nil			Nil		
Reduced Income			Reduced Cost		
Yield below control			50 MDL (weeding)	150000.00	
64.1 – 0.37 tonnes/ha at			3MDL (Harvesting)	9000.00	
₦30000	=	1812000.00	2 MDL (transportation)	6000.00	
			Sub total	165000.00	
A. Additional Cost + Reduced Income		1812000.00	B. Additional Income + Reduced Cost	165000.00	
Net charge in Profit					
165000 – 1812000		-1647000.00			

Table 7: Partial budgeting for cassava production with minimum tillage without hoe weeding

Proposed charge – Minimum tillage + unweeding.

Additional Cost		Additional Income	
Nil		Nil	
Reduced Income		Reduced Cost	
Yield reduction below control		10 MDL (Land preparation)	– 30000.00
64.1 – 0.18 at ₦30000		50 MDL (weeding)	150000.00
= 1923000.00 – 5400		3MDL (Harvesting)	9000.00
= 1917600	1917600.00	2 MDL (transportation)	6000.00

A.	Additional Cost + Reduced Income	1917600.00	
			Sub total 195000.00
			B. Additional Income + Reduced Cost 195000.00
Net change in Profit B – A = 195000 – 1917600		1722600.00	

Table 8: Partial budgeting for cassava production with conventional tillage with herbicide **Proposed change – Herbicide (Primextral Gold)**

Additional Cost			Additional Income
Cost of sprayer		7000	Nil
Cost of herbicide 8500/1 (3)		25500	
Cost of spraying 4MDL		12000	
		44500	
Reduced Income			Reduced Cost
64.1 – 56.1 t/ha			Cost of Weeding 50 MDL 150000.00
= 8 tonnes at ₦30000		240000.00	Cost of Hoes 12000.00
(A)	Additional Cost + Reduced Income		Sub Total 162000.00
	= 44500 + 240000	284500.00	(B) Additional Income + Reduced Cost 162000.00
Net Change in Profit ₦162000 – 284500	=	-122500.00	

Table 9 Partial budgeting for cassava production with minimum tillage with herbicide **Proposed Change - Minimum tillage + herbicide (Primextra Gold)**

Additional Cost			Additional Income
Cost of sprayer		7000.00	Nil
Cost of herbicide 8500/l (3)		25500.00	
Cost of spraying 4MDL		12000.00	
		44500.00	
Reduced Income			Reduced Cost
64.1 – 32.6 t/ha			10 MDL (Land preparation) 30000.00
= 31.5 at ₦30000			50 MDL (Weeding) 150000.00
1923000 – 978000		945000.00	Cost of Hoes 12000.00
			Subtotal 192000.00
(A)	Additional Cost + Reduced Income (44500 + 945000)	989500.00	(B) Additional Income + Reduced Cost = 192000.00
Net Change in Profit B – A (192000 – 989500)		- 797500.00	

DISCUSSION

Sprouting and survival of cassava stem were significantly affected by herbicide treatments. The lowest survival percentage was found in Pendimethalin treated plots. By implication, Pendimethalin negatively affected the survival of cassava plant. Reddy *etal*. (2012) and Mohamed *etal*., (2013) had reported the toxicity of pendimethalin on cassava especially when application of the herbicide was done about the time of planting as was done in this experiment. But the survival of cassava plants was not significantly affected by tillage, this could be attributed to the adequate rainfall distribution at the time of planting which ensured adequate soil moisture and reduced influence of soil bulk density.

The weed population per plot was expectedly highest on weedy plots but higher in the minimally tilled weedy plot than conventionally tilled weedy plot. This may be attributed to better soil preparation. Using weed population as an indicator of the effectiveness of the weeding approaches, it was obvious that the manual hoe weeding was the most effective. Weed biomass was lower in conventionally tilled plots than minimally tilled plots. This may be due to the burial of plant residue with implement that kill the weeds. Tillage significantly affected the fresh tuber yield of cassava as higher yield was recorded in conventional tillage than minimum tillage treatment. This finding is a confirmation of Omenihu *et al.,* (2014) submission that the best soil preparation method for tuber crops is that which allows deeper growth by virtue of absence of stones, hard pan and reduction of soil bulk density. Among the herbicides, Metolachlor and Primextra Gold were superior to others in term of yield. This may be due to reduced persistence of these herbicides as stated by Olabode *et al. (*2021). The estimated costs and return from this study showed that the highest cost of production (₦289000.00) was recorded under conventional tillage treatment with hoe weeding while the least (₦82000.00) cost of cassava production was recorded under minimum tillage treatments with unweeded. 3 hoe weeding in conventionally tilled plots also produced the highest Net profit (₦1,634 000.00) which was comparable to ₦1,511,500.00 recorded in conventional tillage with Primextral Gold herbicide. However, amongst the problems of conventional tillage with 3 hoe-weeding is the cost of operation, availability of labour at affordable cost and as at when needed. To solve these problems, Odjugo,(2020) and Reyes-Sanches *et al.,* (2022)had advocated for the use of herbicides in weed control owing to ease, reduced labour, timleiness and effectiveness, as manual weeding has also been identified as a major catalyst for soil erosion due to enahance erodibiity of the soil arising from eroded soil particles.

Conclusion

The conventional tillage + Hoe weeding used in this study gave a satisfactory weed control up to 12 week after planting (WAP) as well as good yield at harvesting period. This was reflected in the low weed density and biomass, including the high fresh root tuber yield. However, the scarcity of labour at the right time and the concurrent rise in the cost of hoe weeding can make timely removal of weeds by direct labour difficult and expensive. Arthi *etal*., (2015) had observed that there is usually an acute shortage of labour at the beginning of the wet season for land preparation, planting and first weeding. The preemergence herbicides (Lagon, Primextral Gold, Metolachlor and Xtravest) had better weed control up to 10 week after planting without injuring the cassava plants except Pendimethalin which caused stunted growth in the early stage of the plant. Therefore, herbicide weed control method has the potentials to reduce labour requirements by reducing cost of production. From economic point of view, the herbicides are very adequate for weed control in cassava production. The use of herbicides tends to ensure a reduced erodibility, thereby protecting the soil.

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