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Assessment of Weed Management Strategies on Growth and Yield of Cassava (Manihot esculenta Crantz) in Ghana.

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Abstract

A 6 X 2 factorial experiment arranged in a randomized complete block design replicated four times was conducted in the Kwame Nkrumah University of Science and Technology Kumasi, Ghana, to assess the effect of various weed management strategies on cassava (Manihot esculenta Crantz) growth and yield.

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The treatments were two varieties of cassava:- Ampong (Early branching) and Dokuduade (late branching) and six weed control methods which were two pre-emergence herbicides (Butachlor and Terbulor at 4l/ha + 2 hoe-weedings), three-times manual hoe-weeding, three-times manual cutlass-weeding, weed-free (weeding every forth night using hand hoe) and weedy check treatments. The predominant weed species were Tridax procumbens, Mimosa pudica, Euphorbia heterophylla, Croton hirtus, Spigellia anthelmia, Digitaria ciliaris, Centrocema pubescens, Brachiaria deflexa and Panicum maximum. The early branching habit of Ampong variety had significant effect on weed control and consequently produced significantly more growth and tuber yield than the late branching Dokuduade variety. Among the weed control treatments, Terbulor (4l/ha) + 2 hoe-weeding treatment had significantly higher effect on weed control which resulted in over 91% of root tuber yield than other weed management strategies evaluated. Thus, the application of Terbulor (4l/ha) + 2 hoe-weeding is recommended as the most effective strategy for weed control in cassava fields.

Keywords: Cassava; herbicides; growth; weed management; yield.

1. Introduction

Agricultural weeds are plants that are undesirable, competitive, persistent and damaging, interfering with the activities or welfare of human beings [1]. According to [2], agricultural impact of weeds differs for various locations and crops. Cassava (Manihot esculenta) is highly susceptible to weed competition due to its initial slow growth after planting and weeds could outcompete it for nutrients, water and sunlight. In Ghana, weeds are a serious problem to cassava farmers, because weeds grow abundantly, vigorously, rapidly and completely cover the ground surface and reduce crop yield and quality [3, 4]. Yield losses may be as high as 90%, depending on the duration of competition [5]. Weed management in cassava production is the most labour intensive and expensive operation, and it is a key challenge to increasing cassava productivity and improving livelihood of smallholder farmers in Ghana. The use of weed management practice that can reduce this labour requirement thereby reducing the cost of food production has been emphasized [6]. The control of weeds is one of the most important operations in cassava production that should be effectively and efficiently carried out to ensure desired production and productivity. Resource poor peasant farmers employ various weed management practices with various degrees of success. It is therefore important to evaluate the efficiencies of the different weed management strategies and recommend the ones that are effective and economical to cassava production. Therefore, the objective of this research was to assess efficient and profitable weed management strategies to improve cassava productivity.

2. Materials and Methods

The experiment was carried out at Department of Crop and Soil Sciences crop field, Kwame Nkrumah University of Science and Technology Kumasi, Ghana. The field lies within latitude 06^{0} $43^{'}$ North and 01^{0} $36^{'}$ West. The study area has a mean annual temperature of 28.9^{0} C, rainfall 1,450 mm and relative humidity 84.4%. The soil chemical characteristics at 0-30 cm depth observed before commencement of the experimental trial were: % Organic carbon = 1.06; % Organic matter = 1.82; Total % of Nitrogen = 0.08; K (cm ol/kg) = 0.10; available P (mg/kg) = 5.10 and pH = 6.2.

The field was slashed, disc-ploughed to the depth of about 10-15 cm and harrowed using tractor driven plough. Planting materials were obtained from the Crops Research Institute (CRI), Kumasi. Stem cuttings of 20 cm long with at least four-five nodes were used as planting materials. Stakes were planted one per hill at an angle of about 45^0, depth of about 5-10 cm and at a spacing of 1m x 1m.

2.1 Treatments and Design

The treatments were cassava varieties (Ampong, an early branching and Dokuduade, a late branching) and weed control methods, which were 3 hoe-weedings, 3 cutlass-weedings, Terbulor 500 EC (4l/ha) plus two supplementary hoe-weedings (2 and 4 months after planting), Butachlor 50% EC (4l/ha) plus two supplementary hoe-weedings (2 and 4 months after planting), weed-free(weeding every forth night) and weedy check (no weed control). The experiment was set up as a 6 x 2 factorial arranged in randomized complete block design (RCBD) with four replications. Each plot measured 4 m x 6 m with a space of 0.5 m between plots and 1 m between replicates. The two pre-emergence herbicides (Terbulor and Butachlor) were applied in sixteen plots at a rate of 9.6 ml/plot in a spray volume of 480 ml of water a day after planting and two supplementary hoe-weeding was done at 2 and 4 months after planting. The manual weedings (hoeing and cutlassing) were done at 1, 2 and 4 months after planting, while weed-free treatment was applied every forth night till harvest.

2.2 Data Collection

Weeds were assessed using a 0.25 m^2 quadrate thrown thrice in each plot. Weeds enclosed within the quadrate area were counted and identified according to family, species, life cycle and morphological group, oven dried and weighed. Canopy spread of five plants in the middle rows of each plot were measured from the longest length across each plant using a graduated pole. Branch number was recorded by counting the first primary branching and division of subsequent branches from the top of the plant. Fresh root yield, percent root dry matter and harvest index were measured according to [7].

Yield: $$\frac{\text{Root weight (kg)} \times 10{,}000\ m^2}{\text{Area harvested } (m^2)} \quad (1)$$

Dry matter: $$\frac{\text{Dry root weight} \times 100}{\text{Initial wet weight}} \quad (2)$$

Harvest index: $$\frac{\text{Fresh root weight}}{\text{Above-ground biomass + fresh root weight}} \quad (3)$$

Economic parameters of the various weed management strategies were evaluated according to [8].

- Gross revenue (GR) = Root yield (t/ha) x Current market price of root (GH¢/ha). (4)

- Net revenue or profit (NR) = Gross revenue (GH¢/ha) – Total cost of production. (5)
- Marginal rates of return (MRR) = Change in net revenue x 100 (6)

Change in total cost of production

2.3 Data Analysis

The data was subjected to analysis of variance (ANOVA) using the Genstat 12th edition and Least Significant Difference (LSD) test was used to compare treatment means at 5% level of probability. Also, weed assessment data was analyzed after transformation using log base 10 (Log_{10}).

3. Limitations of the study

Despite the significant role weed control plays in this study, its development was faced by a number of constraints, amongst which were high cost of herbicides and clean planting materials, less access to funds, limited and expensive farm labour to harvest.

4. Results and discussion

4.1 Canopy spread and number of branches

Analysis of variance showed varietal differences with Ampong recording significantly ($P < 0.05$) greater canopy spread and number of branches than Dokuduade, which could be attributed to structural morphological growth differences, which influences light transmission to the ground, and so, the efficacy of weed control(Table 1).The effects of canopy spread and number of branches in the weed-free treatment was greater and significantly ($P < 0.05$) higher than the other weed control measures, followed by Terbulor + 2 hoe-weeding treatment. In addition, canopy spread and branch number in the weedy control effect was significantly ($P < 0.05$) lower than all other treatment effects at each sampling occasion. The effects of pre-emergence herbicides + 2 hoe-weeding treatments were not significantly different for number of branches. Also, treatment differences between hoeing and cutlass weeding were not significant at all sampling periods for both canopy spread and number of branches.

4.2 Weed Species

A total of 24 weed species were identified in the study area of which 15 were annuals 5 perennials and 4 annuals/perennials, comprising of 18 braodleaves, 5 grasses and 1 sedge (Table 2). These weed species represented 12 families, including Asteraceae with 5 species, Euphorbiaceae 4, Poaceae 5, Fabaceae 2, Commelinaceae, Molluginaceae, Convolvulaceae, Cyperaceae, Longaniaceae, Malvaceae, Rubiaceae and Portulacaceae each had only one species. The most abundant weed species found during weed assessment were Tridaxprocumbens, Panicum maximum, Mimosa pudica, Euphorbia heterophylla, Croton hirtus, Spigeliaanthelmia, Digitariaciliaris, Centrosemaprobescens and Brachiariadeflexa. Those with moderate abundance were Ageratum conyzoides, Bidenspilosa, Commelinabenghalensis, Phylanthusamarus, Cyperusrotundus and Eleusineindica. This result agrees with the report of various weed flora found in the same area by [9].

Table 1: Effect of variety and weed management strategies on canopy spread and branch number of cassava, 2014-2015.

Treatment	**Canopy spread (m)**			**Number of branches**		
	2 months after planting	**4 months after planting**	**6 months after planting**	**2 months after planting**	**4 months after planting**	**6 months after planting**
Variety						
Dokuduade	1.00	1.66	1.99	1.98	8.50	18.81
Ampong	1.08	1.79	2.09	2.82	12.30	21.44
LSD (5%)	**0.03**	**0.04**	**0.06**	**0.23**	**0.88**	**1.08**
Weed control treatments						
Hoe weeding	1.03	1.67	2.03	2.27	10.05	18.93
Cutlass weeding	0.99	1.62	1.94	2.15	9.05	18.10
Weed-free	1.18	1.96	2.22	3.00	13.38	24.90
Butachlor + 2 hoe-weedings	1.06	1.76	2.11	2.60	10.75	21.45
Terbulor + 2 hoe-weedings	1.13	1.89	2.23	2.82	12.10	23.00
Weedy	0.86	1.46	1.71	1.57	7.07	14.38
LSD (5%)	**0.05**	**0.08**	**0.11**	**0.41**	**1.53**	**1.88**
CV (%)	**5.3**	**4.6**	**5.4**	**16.8**	**14.5**	**9.2**

4.3 Weed density

Analysis of variance showed that Ampong had significantly ($P < 0.05$) lower weed density than Dokuduade variety (Table 3), which was attributed to shading occasioned by the lesser quantity and quality of light reaching the soil surface, which negatively influenced weed growth. This result agrees with [10], who reported that high vegetative biomass of early branching crop is a good potential for physical obstruction of light and weed seedling emergence. Generally, late branching variety obtained taller plants, suggesting differential varietal growth potential. Plots treated with Terbulor + 2 hoe-weeding had significantly ($P < 0.05$) lower weed density and showed dominance over other weed control methods.This agrees with [11], who reported that chemical control appears to be an excellent alternative for the control of weeds in cassava.Significantly, lower weed density was observed in hoe weeded plots than cutlass weeding treatment (Table 3), which could be attributed to the fact that hoeing removed the roots of weedsthat reduced sprouting.

Table 2: Weed species composition of the experimental plots, 2014-2015.

Family	Weed species	Life cycle	Morphological group
Asteraceae	*Chromolaenaodorata*	Perennial	Broadleaf
	Tridaxprocumbens	Annual	Broadleaf
	Acanthospermum hispidum	Annual	Broadleaf
	Ageratum conyzoides	Annual	Broadleaf
	Bidenspilosa	Annual	Broadleaf
Commelinaceae	*Commelinabenghalensis*	Annual/Perennial	Broadleaf
Convolvulaceae	*Ipomoea spp*	Annual/ Perennial	Broadleaf
Cyperaceae	*Cyperusrotundus*	Perennial	Sedge
Euphorbiaceae	*Euphorbia heterophylla*	Annual	Broadleaf
	Euphorbia hirta	Annual	Broadleaf
	Phyllantus amarus	Annual	Broadleaf
	Croton hirtus	Annual	Broadleaf
Loganiaceae	*Spigelia anthelmia*	Annual	Broadleaf
Malvaceae	*Sidaacuta*	Perennial	Broadleaf
Poaceae	*Brachiaria deflexa*	Annual	Grass
	Eleusine indica Gaertn	Annual	Grass
	Rottboellia cochinchinensis	Annual	Grass
	Digitaria ciliaris	Annual	Grass
	Panicum maximum	Annual	Grass
Fabaceae	*Mimosa pudica*	Annual/Perennial	Broadleaf
	Centrosema pubescens	Perennial	Broadleaf
Molluginaceae	*Molugusp*	Annual	Broadleaf
Rubiaceae	Borreriasp	Annual/perennial	Broadleaf
Portulacaceae	*Talinum triangulare*	Perennial	Broadleaf\

The tendency of weeds to sprout under cutlass weed control method was high due to rapid growth of nodes on stems partly cut-off. Plots treated with weedy check treatment had significantly greater weed density than all other weed control methods applied in this study.

4.4 Weed Biomass

Weed biomass was significantly (P < 0.05) lower under Ampong than Dokuduade variety on all sampling occasions (Table 4). Besides weed-free treatment, analysis of variance showed that plots treated with Terbulor + 2 hoe-weeding had significantly (P < 0.05) lower weed biomass than other control measures,which attests the effectiveness of the herbicideenhanced weed control efficacythan cutlass and hoe-weeding treatments.Additionally, weed biomass under cutlass weeding method was significantly higher than hoe weeding treatment, this result similarly agrees with the report of [12] who reported lower weed biomass in hoe-weeded plots than cutlass weeding. Weedy check treatment had the greatest weed biomass.

Table 3: Effect of variety and weed management strategies on total weed density, 2014-2015.

Treatment	Weed population/m^2			
	1 month after planting	**2 months after planting**	**3 months after planting**	**4 months after planting**
Variety				
Dokuduade	1.50	1.68	1.69	1.88
Ampong	1.29	1.50	1.42	1.66
LSD (5%)	**0.08**	**0.05**	**0.14**	**0.12**
Weed control treatments				
Hoe-weeding	1.51	1.64	1.65	1.86
Cutlass weeding	1.72	1.88	2.03	2.13
Weed-free	-	-	-	-
Butachlor + 2 hoe-weeding	1.18	1.46	1.27	1.58
Terbulor + 2 hoe-weeding	1.15	1.28	1.09	1.47
Weedy	1.94	2.06	2.29	2.39
LSD (5%)	**0.14**	**0.10**	**0.24**	**0.20**
CV (%)	**9.8**	**6.2**	**15.2**	**11.6**

4.5 Yield and Yield Components of Cassava

The root yield, root number, dry matter content and harvest index of Ampong variety was significantly ($P < 0.05$) higher than Dokuduade (Table 5). Fresh root yield for Ampong variety was 57% greater than Dokuduade, although their harvest indices were similar. Between the chemical controls, root yield under Terbulor + 2 hoe-weeding was 27% greater than that under Butachlor + 2 hoe-weeding. The herbicides plus 2 supplementary hoe-weeding control treatments had root yields averaging 67% greater than the two physical controls of hoeing and cutlassing. Weed-free treatment had root yield of about 3.7 times greater than the weedy treatment.This result agrees with the report of [13], who reported crop failure grown in slashed plots and no weeding. Harvest index was greatest in the Terbulor + 2 hoe-weeding treatment and this was significantly higher than other treatment effects, except for the weed-free and Butachlor + 2 hoe-weeding treatments. Treatment effect of the weedy check for root yield, root number, dry matter content and harvest index per plot were significantly ($P < 0.05$) lower than the other treatment effects.

4.6 Partial Budget Analysis for Cassava Production

The budget analysis showed Terbulor + 2 hoe-weeding had higher gross revenue (7,176.09GH¢/ha) and net revenue (6,899.18 GH¢/ha) per hectare than other weed control methods, followed by weed-free treatment

(6566.16 GH¢/ha and 5735.97 GH¢/ha respectively). Weedy check treated plots had significantly lower gross revenue (2,015.53 GH¢/ha) and net revenue (1,807.85 GH¢/ha) than all other weed control methods. Weed-free treatment had the highest total cost of production (830.74 GH¢/ha) than the various weed management strategies evaluated in this study. The marginal rate of return (MRR) for applying 3 cutlass weeding over weedy plot = 279.8%. This means for any extra cost of GH¢ 100.00/ha incurred for adding 3 cutlass weedings over the weedy treatment, the farmer will recoup the GH¢ 100.00 and make an extra income of GH¢ 179.8/ha. Butachlor + 2 hoe-weedings has dominated the 3 hoe weedings because the 3 hoe weedings has less net revenue (NR) but higher total cost of production than adopting the Butachlor + 2 hoe weedings. In addition, Terbulor + 2 Hoe weedings has dominated the weed-free treatment because the weed-free has less net revenue (NR) but higher total cost of production (TCP) than adopting the Terbulor + 2 hoe weedings.

Table 4: Effect of variety and weed management strategies on weed biomass, 2014-2015.

Treatment	**Weed biomass (g)**			
	1 month after planting	**2 month after planting**	**3 month after planting**	**4 month after planting**
<u>Variety</u>				
Dokuduade	0.83	1.25	0.66	0.95
Ampong	0.56	0.94	0.43	0.71
LSD (5%)	**0.06**	**0.08**	**0.15**	**0.06**
<u>Weed control treatments</u>				
Hoe-weeding	0.73	0.98	0.23	0.73
Cutlass weeding	0.92	1.40	1.02	1.25
Weed-free	-	-	-	-
Butachlor + 2 hoe-weeding	0.56	1.18	0.08	0.51
Terbulor + 2 hoe-weeding	0.38	0.63	0.05	0.20
Weedy	1.08	1.57	1.85	1.93
LSD (5%)	**0.10**	**0.14**	**0.27**	**0.11**
CV (%)	**15.5**	**13.0**	**48.8**	**27.1**

5. Conclusions

The results indicated variable effectiveness of the various weed control measures studied. Among these, Terbulor + 2 hoe-weeding treatment was most effective and economically a better weed control measure than the other weed control methods evaluated in this study. The results also showed that the application of the two pre-emergence herbicides (Terbulor and Butachlor) supplemented with two hoe-weeding resulted in better weed control, higher yield and net revenues comparable to or better than those other control measures.In addition, the structural morphological growth of Ampong variety had significant effect on weed control and management than Dokuduade variety.

Table 5: Effect of variety and weed management strategies on yield components of cassava at 12 months after planting, 2014-2015.

Treatment	**Total root number/plot**	**Fresh root yield (t/ha)**	**Dry matter %**	**Harvest index %**
Variety				
Dokuduade	48.71	14.92	0.43	0.22
Ampong	58.42	23.41	0.50	0.23
LSD (5%)	**2.35**	**2.69**	**0.01**	**0.01**
Weed control treatments				
Hoe-weeding	52.25	18.12	0.46	0.23
Cutlass weeding	50.38	12.44	0.45	0.19
Weed-free	58.38	26.16	0.49	0.25
Butachlor + 2 Hoe-weeding	55.38	22.50	0.47	0.24
Terbulor + 2 Hoe-weeding	63.25	28.59	0.53	0.27
Weedy	41.75	7.16	0.39	0.18
LSD (5%)	**4.07**	**4.65**	**0.02**	**0.03**
CV	**7.5**	**23.9**	**4.9**	**14.7**

Table 6: Budgetary analysis in cassava production under different weed management strategies in Ghana, 2014-2015.

Treatment	**Fresh root Yield t/ha**	**Gross revenue GH¢/ha**	**Total cost of production GH¢/ha**	**Net revenue GH¢/ha**	**Marginal rate of return**
Weedy	8.03	2,015.53	207.68	1,807.85	-
Cutlass weeding	12.22	3,067.22	484.60	2,582.62	279.78
Hoe-weeding	18.12	4,548.12	553.82	3,994.30	2,039.41
Butachlor + 2 hoe-weeeding	22.50	5,647.5	311.53	5,335.97	-553.75

Weed-free	26.16	6,566.16	830.74	5,735.97	77.04
Terbulor + 2 hoe-weeding	28.59	7,176.09	276.91	6,899.18	-210.04

*Selling price of cassava was GH¢ 251 per ton

6. Recommendation

- Based on the findings in this study, it was recommended that Terbulor with two supplementary hoe-weedings was an effective and economic weed management strategy which can be adopted by farmers.
- In view of the above, cassava farmers must be educated on the potentials of using herbicide to control weeds.
- It was also recommended that farmers should plant cassava varieties that branch early for maximum yield and better weed suppression.

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