Economics of Weed Control Methods for Tithonia Diversifolia in Water Yam (*Dioscorea Alata*) Plot

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***Abstract:-*Interest in developing most economical weed control method continues to increase because of the economic implications of repeated. Costs, including those of man power and yield due to weed infestation lower the profitability of crop production in the tropics especially those of highly cherished but slow growing crops like water yam. *Tithonia diversifolia*, an aggressive weed has become a major economic problem to arable crop production in Nigeria in general but water yam in particular. Thus, this study assessed the economics of weed control methods with a view to identifying the most profitable for water yam production.**

The experiment was conducted at Ogunba village near Baaya-Oje in Surulere Local Government Area, Ogbomoso, Oyo State. The treatments; Weed control with Black plastic mulch, Grass mulch, 2 hoe weeding, 3 hoe weeding, Atrazine, Diuron, IWM (Atrazine + Diuron + Plastic mulch) and unweeded plot, were evaluated in a Randomized Complete Block experiment with three replicates. Yam setts were planted at a spacing of 1m x 1m. Black plastic mulch was applied at the rate of 10,000m^2/ha, Grass mulch was applied at the rate of 5 tons/ha. Two (2) hoe weeding were done at 3 and 6 weeks after planting (WAP), while 3 hoe weeding was done at 3, 6 and 9 WAP. Atrazine and Diuron were applied at the rate of 2.5kg a.i/ha while they were applied each at half recommended rate (1.25kg/ha) before applying plastic mulch. The weedy plot was the control. Partial budgeting was used to evaluate the economics of each method. Results showed that weed control methods significantly (P = 0.05) affected water yam yield and net profit. The mean costs of water yam production under the weed control methods were: ₦786,000.00 (plastic mulch), ₦362,000.00 (Grass mulch), ₦312,800.00 (2 hoe weeding), ₦324,800.00 (3 hoe weeding), ₦256,800.00 (Atrazine), ₦286,800.00 (Diuron), ₦617,600.00 (IWM) and ₦283,500.00 (unweeded). The profitability of the weed control methods measured by the change in profit were: 3 hoe weeding (₦625200.00) > 2 hoe weeding (₦53000.00) >Diuron (– ₦161,200.00) > grass mulch (– ₦187,200.00) > Atrazine (– ₦211,200.00)> IWM (– ₦277,700.00) > Plastic mulch (– ₦361,200.00) >Unweeded (– ₦761200.00).

From the result it is concluded that 3 hoe weeding is the most economical for water yam production in the study area.

Key words: **Economics, Weed Control Methods, *Tithonia Diversifolia*, Water Yam**

I. INTRODUCTION

The significance of yam production in developing countries of the tropics cannot be over emphasized due to its role in human nutrition and diets. Yam is eaten in various forms in various communities. However, increasing yam production had remained difficult as its cultivation is limited by high costs of planting material, labour, decreasing soil fertility, inadequate yield potential of varieties as well as increasing weed competition on the field (Kathryn et al., 2012). Of these, the problem of weeds had remained intractable. Weeds must be controlled to prevent economic yield loss. In most cases different control methods are required for different weeds and locality. In some cases, a combination of a number of preventive practices may be required to effectively deal with weed problems due to the fact that the success of weed control is a function of the timing, the weed problem, methods and weed type as well as the season of the year (Akobundu, 1987)).

For a profitable water yam production, the bulk of labour requirement goes into weed control. The frequency and the total cost of weeding has been linked to weed type and the crop concerned (Akobundu, 1987).Similarly, the cost of weed control is directly related to weed control methods adopted and the frequency of weeding required. Higher frequency and total cost of weeding is required for aggressive weeds such as *Tithonia diversifolia* (Olabode *et al*., 1999) which easily out-competes accompanying plants.

As a tuber crop with slow initial growth rate, water yam is a poor weed competitor, which makes it susceptible to severe weed competition at the early stage of its growth. The weeds take the advantage of the wide spacing and slow canopy formation to grow faster and become well established before the slow growing water yam is established. Onochie (1975) stated that weeds which emerge during the first three months after planting are known to endanger yields more than those appearing later. Thus, frequent and effective weeding is one of the most essentials for successful water yam production (Coursey, 1967;Anon, 1973). Similarly, Oerke *et al*. (1994) had indicated that losses due to weeds were substantial in root and tuber crops in Nigeria.

Although, due to the slow development of water yam, early and repeated hoe weeding is usually adopted to reduce the competitive effects of *Tithonia diversifolia* (Olabode, 2004), however, the attendant implication on labour cost coupled with the dearth of Man-labour had continued to impinge on farmers' net profit due to delayed weeding which results in reduced yield. Therefore, it is in the light of this that this experiment was designed to assess the economics of alternative weed control methods on *Tithonia diversifolia*

infested field with a view to determining the most profitable for water yam production in the study area.

II. MATERIALS AND METHODS

Field experiment was carried out to access and compare the economics of different weed control methods for *Tithonia diversifolia* on infested Water yam (*Dioscorea alata*) plot at Ogunba village near Baaya-Oje in Surulere Local Government Area, Ogbomoso, Oyo State in the Southern guinea savanna zone of Nigeria. The soil of the area is deep and permeable with the following nutrient concentrations; N; 0.27 %, P; 5.57 % and K; 0.44. The organic carbon content was 1.83 %. The temperature ranges from 25^{o}C – 33^{o}C with humidity above 76% all the year round except in January when the dry wind blow from the North (NIMET, 2016).

Ridges were made manually on each 4m x 3m plot. There were four ridges per plot in three replicates each measuring 31m x 4m. The experiment was laid out in a Randomized Complete Block design with eight (8) treatments namely; Atrazine, at 2.5kg a.i/ha, Diuron at 2.5kg a.i/ha, 2 hoe weeding at 3 and 6 week after planting (WAP), 3 hoe weeding at 3,6 and 9 WAP**,** Black plastic mulch, Grass mulch at 5 tons per hectare, Atrazine + Diuron (each at 50% of dosage) + Plastic mulch (IWM) and unweeded check. Yam was planted at a spacing of 1m x 1m. Bamboo sticks of 3m length were used for staking at two weeks after emergence. Harvesting of tuber was done at eight months after planting. Data were collected on the yield parameters of water yam as follows: Number of tubers per plant by physical counting, weight of tubers per plant by using Weighing Balance, tubers weight per plot and tuber yield per hectare. *Tithonia diversifolia* weed density was estimated from 3 randomly placed quadrat of 0.25m x 0.25m at a spacing of 30cm interval, while the dry weight of the weed was measured using Weighing Balance. The economy of the control methods was assessed using partial budgeting as described by Ronald (1986). Data collected were subjected to Analysis of Variance (ANOVA) and the means were compared using Duncan Multiple Range Test (DMRT) at 5% probability level.

III. RESULTS

Water yam tuber yield as affected by weed control methods

Table 1 shows the effects of weed control methods on the tuber yield of water yam. The number of water yam tuber per plant at harvesting did not vary significantly with the weed control methods (p=0.05). Average number of tubers per plot at harvesting was 3.67 tubers, highest number of tubers was obtained from Diuron treated plot (4.00) while the least number was obtained from weedy plot (3.00). The weight of tuber per plant varied significantly with the weed control methods (p=0.05). Plastic mulch (2.10 kg) and IWM (2.07 kg) had tuber yields which were significantly better than other treatments. The tuber yield of water yam plant with 3 hoe weeding (1.90 kg) was also comparable to that obtained from plastic mulch and IWM. The tuber yields from other treatments are in the order 2hoe weeding (1.77 kg) > Grass mulch (1.60 kg) >Diuron (1.53 kg) > atrazine (1.40 kg).

The tuber yield of water yam as affected by the weed control method is also presented in Table 1. There was significant difference in the tuber yields among the treatments. Plastic mulch produced the highest yield (21.0 t/ha) which was followed by IWM (20.0 t/ha). The weedy plot had the least yield per plot (3.0 t/ha). Yield from 3 hoe weeding (19.0 t/ha) was comparable to IWM (P =0.05) and was also not significantly superior to 2 hoe weeding (18,0t/ha). Yields from grass mulch (16.0 t/ha), Diuron(15.0 t/ha) and atrazine (14.0 t/ha) were significantly (P = 0.05) lower than that of plastic mulch but similar to one another.

Table 1: Effects of weed control methods on the yield and yield parameters of water yam

	Average number oftuber per plant	Average weight of tuber per plant (kg)	Average yield per plot (kg)	Estimated yield per hectare (Tons)
Plastic mulch	3.67a	2.10a	24.50a	21 a
Grass mulch	3.67a	1.60cd	18.60d	16 d
2 hoe weeding	3.67a	1.77bc	21.53c	18 c
3 hoe weeding	3.67a	1.90ab	22.8bc	19 bc
Atrazine	3.67a	1.40d	17.87d	14 d
Diuron	4.00a	1.53cd	18.90d	15 d
IWM	3.67a	2.07a	23.30ab	20 ab
Weedy	3.00a	0.33e	5.27e	3 e

Means with the same letter in each column are not significantly different at p = 0.05 (DMRT).

Partial budget on weed control for water yam production

Table 2 shows the farm income statement per hectare of water yam production using 3 hoe weeding as the standard method of weed control for yam production. The total variable costs of water yam production was ₦320,800.00 while the overhead cost was ₦4,000.00. Therefore the total cost of production per hectare of water yam using 3-hoe weeding was ₦324,800.00. The tuber yield obtained was 19 tons (Table 1). At a market price of ₦50.00/kg, the total income was ₦950,000.00, at a gross margin of ₦629,200.00 and Net profit of ₦625,200.00.

Table 2: CONTROL PLOT: (3 HOE WEEDINGS)

			₦ : K
a.	Income		
	Yield: 19000kg at N50/kg		950,000.00
b.	Variable costs		
	Land preparation	18 MDL	
	Planting	5 MDL	
	Mulching	4 MDL	
	Staking	4 MDL	
	Weeding	18 MDL	
	Harvesting	8 MDL	
	Transportation	2 MDL	
	Total MDL = 59at ₦2,000/MDL		118,000.00
	Cost of Hoe: (8 hoes at N350)		2,800.00
	Yam setts at ₦20/sett.		200,000.00
c.	Over head cost		
	Rent		4,000.00
d.	Total cost of production		
	b + c		324,800.00
e.	Gross margin		
	a – b		629,200.00
f.	Net profit		
	a – (b + c) (950,000 – (320,800 + 4,000)		625,200.00
	MDL = MandayLabour		

The result from the cost / benefit analyses of the effect of the weed control methods on water yam yield as presented in tables 3-9 showed that the net profit for the weed control methods compared to the ₦625, 200 for the control treatment (3 hoe weeding) are: plastic mulch, ₦438,000; IWM, ₦393,500; Atrazine, ₦414,000; Grass mulch, ₦438,000; Diuron, ₦464,000 and 2 hoe weeding, ₦572,200. The weedy plot posted a loss of ₦136, 800.

Table 3: Partial budgeting for water yam production with plastic mulch
Proposed change: Plastic mulch.

Additional cost:		Additional income:	
	₦ : K		₦ : K
10000m^2 plastic Mulch at ₦50/m^2	500,000.00	Yield increase over control plot 21,000 – 19000 = 2000k at ₦50/kg	100000 00
Fixing of the plastic Mulch	8,000. 00	Reduced cost 18MDL of weeding at ₦2,000/MDL	36000.00
Subtotal	508,000.00	4MDL of mulching	8,000.00
Reduced income	Nil	8 hoes	2,800.00
Additional cost + reduced Income	508000.00	Subtotal	46800 .00
		Additional income + Reduced cost = 100000 + 46800	146800. 00
Net charge in profit = ₦(146800 – 508000) =	- ₦361,200.00		

MDL = MandayLabour.

Table 4: Partial budgeting for water yam production with grass mulch

Proposed change: grass mulch.

Additional cost:		Additional income:	
	₦ : K		₦ : K
Cutting of *panicum* Grass 20MDL		Reduced cost 18MDL of weeding	
Application of the mulch 5MDL		at ₦2000	36000.00
Tacking & Transportation 3MDL		cost of 8 hoes	2800.00
Total 38MDL at ₦2000	76000.00	Sub-total	38800.00
Reduced income Yield reduction below the control 19t – 16t = 3t 3t = 3000kg at ₦50/kg	150000.00		
Additional cost + reduced income	226000.00		
Net change in profit = (₦38800 – 226000) =	– ₦187,200.00		

MDL = MandayLabour

Table 5: Partial budgeting for water yam production with 2 hoe weeding

Proposed change: 2 Hoe weeding.

Additional cost:		Additional income:	
	₦ : K		₦ : K
Nil			
Reduced income Yield reduction below the control (19000 – 17700)kg = 1300kg at ₦50/kg	65000.00	Reduced cost Weeding 6 MDL at ₦2000/MDL	12000.00
Additional cost + Reduced income	65000.00		
Net change in profit = ₦(12000–65000) = – ₦53,000.00			

MDL = MandayLabour

Table 6: Partial budgeting for water yam production with Atrazine
Proposed change: Atrazine.

Additional cost:	₦ : K	Additional income:	₦ : K
Nil		Nil	
Reduced income		Reduced cost	
Yield reduction below		18MDL of weeding	36000 .00
Control		cost of 8 hoes	2800. 00
= (19000 – 14000)kg		Sub total	
at ₦50/kg – 5000kg			38800.00
	250000.00		
Additional cost +			
Reduced income	250000.00		
Net change in profit			
= ₦(38800–250000) = – ₦211200.00			

MDL = MandayLabour

Table 7: Partial budgeting for water yam production with Diuron
Proposed change: Diuron.

Additional cost:	₦ : K	Additional income:	₦ : K
Nil			
Reduced income		Reduced cost	
Yield reduction below		18MDL of weeding	36000. 00
the control		cost of 8 hoes	2800 .00
= 19000 – 15000kg			
= 4000kg at ₦50/kg		Subtotal	38800. 00
200000.00			
Additional cost + Reduce			
income	200000.00		
Net change in profit			
= ₦(38800–200000) – ₦161,200.00			

MDL = MandayLabour

Table 8: Partial budgeting for water yam production with Integrated Weed Management
Proposed change: Integrated Weed Management.

Additional cost:	₦ : K	Additional income:	₦ : K
6600m^2 plastic		Yield increase over	
Mulch at ₦50/m^2	330000.00	Control plot	
Fixing of the plastic		20300 – 19000kg	
Mulch	10000.00	- 1300kg at ₦50/kg	65000.00
Cost of herbicide	1500.00		
Cost of application	2000.00	Reduced cost	
Sub total	343,500.00	18MDL of weeding	
		at ₦2000/MDL	36,000.00
Reduced income	Nil	4MDL of mulching	8,000.00
		8 hoes	2,800.00
		Subtotal	46,800.00
Additional cost +			
reduced income	343,500.00	Additional income +	
		Reduced cost	111,800.00
Net change in profit			
= ₦(111800 – 343500) = – ₦231,700.00			

MDL = MandayLabour

Table 9: Partial budgeting for water yam production without weed control

Proposed change: Weedy.

Additional cost:		Additional income:	
	₦ : K		₦ : K
Nil		Nil	
Reduced income =		Reduced cost	
(Yield reduction below			
the control)		18MDL of weeding	36000.00
19000kg – 3000kg =		cost of hoes	2800.00
16000kg at ₦50/kg			
	800,000.00	Subtotal	38800.00
Additional cost +			
reduced income	800,000.00		
Net change in profit			
= ₦(38800 – 800000) = – ₦761,200.00			

MDL = MandayLabour

The summary of the yield, cost, revenue, gross margin and change in revenue compared to the control is presented in Table 10. The highest revenue (₦1, 050,000) was obtained from treatment with plastic mulch which was followed by IWM (₦1, 000,000) and 3 hoe weeding (₦950, 000). The least revenue (₦150,000) was obtained from the weedy plot. Similarly the highest cost (₦786,000) was from obtained using plastic mulch which was followed by IWM (₦617, 500) and grass mulch (₦362,000). The least cost was obtained under zero weeding (₦286, 800). The percentage change in revenue following adoption of alternative methods compared to the control in ascending order follows the trend 2 hoe weeding (0.09% reduction) <Diuron (26% reduction) < grass mulch (30% reduction) < Atrazine (34% reduction) < IWM (36% reduction) < plastic mulch (58% reduction) <unweeded (>100% reduction).

Table 10: Summary Table of water yam production under different weed control methods

Treatment	Tuber Yield (t/ha)	Total Variable Cost (₦)	Total Cost (₦)	Total Revenue (₦)	Gross Margin	Change in Revenue Relative to Control	% loss in Revenue
Plastic mulch	21 tons	782000	786000	1050000	268000	– 361200	58
Grass mulch	16 tons	358000	362000	800000	442000	– 187200	30
2 hoe weeding	18 tons	308800	312800	885000	576200	– 53000	0.09
3 hoe weeding (control)	19 tons	320800	324800	950000	629200	625200	
Atrazine	14 tons	282800	286800	700000	417200	– 211200	34
Diuron	15 tons	282800	286800	750000	467200	– 161200	26
IWM	20 tons	613500	617500	1000000	382500	– 227700	36
Unweeded	3 tons	282800	286800	150000	– 132800	– 761200	– 1.22

NB: Market price of yam ₦50.00/kg.

IV. DISCUSSION

Observed higher yield under plastic mulch compared to other treatments may be due to benefits ranging from absence of weed competition, reduced water loss and better nutrition due to solarization effect on soil (Olabode *et al*, 2009). Yield performance of yam grown under IWM was also comparable to those of plastic mulch which is also attributable to the benefits of plastic mulch. However, in spite of the better yield, the net income from plastic mulch is significantly lower than those of other control methods except the weedy plot due to the higher cost of the plastic materials. Hoe weeding, an age long practice, gave the highest net returns of all the control methods. This may be due to ready labour availability as well as cheap and readily available equipment (hoe). However, with the increasing awareness of Westerneducation, there is the great expectation of dearth of human labour which may make hoe weeding both costlier and unpracticeable on a large scale. At such a period, the use of grass mulch with the attendant enhancement of soil fertility becomes a better option.

From the present study however, it could be concluded that 3 hoe weeding, a common practice by the local farmers in the tropics, remains the most economical and is recommended for profitable water yam production in the study area.

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