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Profitability of selected weed control methods in maize (*Zea mays* L.) in Nigeria

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1 SUMMARY

A study on the profitability of selected weed control methods of maize (*Zea mays* L.) was carried out during the 2004 and 2005 cropping seasons at the Teaching and Research Farm of Ambrose Alli University, Ekpoma, Nigeria. Ekpoma is located in a forest - savanna transition zone (Lat. 6° 45'N and long. 6° 8'E, attitude 314 metres above sea level) Seven treatments were used for the experiment, viz no weeding (control), Primextra® (2 – chloro – 4 (ethylamino)-6- (Isopropyl amino)-s- triazine + 2-chloro – N (2-ethyl-6-methyl phenyl)-N-(2 methoxy-1-methyl ethyl/acetamide (3.0kg a.i./ha), mulching (wood shavings), one-hoe weeding at 3 weeks after planting (WAP), two hoe- weedings at 3 and 7 WAP, cover-cropping with melon minus hoe-weeding, cover-cropping with melon plus one hoe-weeding at 3WAP. The seven treatments were laid out in a randomized complete block design with four replicates. Economic analysis of data were carried out by partial farm budgeting. The highest financial net return was obtained in mulched plots while the lowest was in cover cropping with melon plus hoe- weeding in both years. The net return (N35,475.00 or USD 373.42) Cost Benefit Ratio(CBR) (1:28.38) in 2004 and (N37,310.48 or USD 373.1) CBR (1:25.73) in 2005 implies that it is profitable to control weeds by wood shaving mulch in the area of study.

2 INTRODUCTION

Maize (*Zea mays* L.) is a very important crop consumed by over 200 million people in sub-Saharan Africa (Gana *et al.*, 1998). Although maize varieties and hybrids with high grain yield potential (> 5 tha^{-1}) are available, the average grain yield on farmers' fields is still very low in Africa (≤ 1 tha^{-1}) (Remison, 1979).Over the years weeds have remained one of the greatest production constraints for maize farmers especially in the tropics. Weeds are a major constraint in the production of maize at the subsistence farmers' level in Nigeria. Lack of efficient weed control methods is a key factor in the overall decline in the yield of maize. Currently, most researchers are particularly concerned with identifying management techniques that could suppress weed without paying attention to economic efficiency of these techniques. Weed control is a very important cultural operation for optimum growth and yield of maize. In monocrop maize, weeds are generally controlled using cultural (hand – or – hoe – weeding), mechanical (slashing), chemical (pre – plant, pre or post – emergence herbicides and integrated management practices. Mulching which is one of the cultural weed control methods is not so popular among maize grower, this could probably be due to lack of awareness on the part of the farmers. Swennen (1983) found

mulching most efficient in weed control because a layer impedes or prevent weed growth. Anderson (1996) noted that mulched materials that can be efficient for weed control are hay, manure, grass clippings, straw, sawdust, wood chips, rice hulls, paper and plastic films. Wood shavings used as mulch had reduced cost of production due to no or low cost of purchase (Olabode *et al*., 2009).They also noted that the lowest profit was recorded under wood shaving mulch in okra production. Information on the profitability of wood shaving mulch in maize has not been documented. Whereas, chemical control was judged to be expensive and noxious, manual weeding was reported as damaging maize root systems. Manual weeding is the predominant method of weed control used by small holder farmers in Africa (Chikoye *et al.,* 2002). However, this method is time consuming, laborious and very expensive. For example, hand weeding one hectare of land cropped to maize may require as much as 25-40 person – days, depending on the weed density and cropping system adopted. This represents approximately 50%-80% of the total labor budget (Darkwa *et al*.,2001Chikoye *et al*.,2002;*et al*). Labor is often in short supply during the early stages of crop growth when weeds must be controlled. Weeds that are allowed to grow to adult stages demand more time and labor for effective control. Untimely weeding causes significant crop losses (Chikoye *et al*., 2004). Chemical control is better alternative to manual weeding because it is cheaper, faster, and gives better control (Chikoye *et al*., 2002; 2004). Akinyemi and Alimi (1989) noted that it is more profitable to use atrazine herbicide for controlling weeds in maize than manual hoe-weeding. Herbicides use has reported to be more profitable than hoe- weeding in the production of various crops in Nigeria (Adigun *et al* 1993). Judicious use of herbicides has been reported to reduce labor requirement for and cost of weed control, increased crop yields by reducing weed competition and consequently increased profitability (Ogunghile *et al*., 1982). Nazear *et al*., (2004) recommended Buctril – m-herbicide over hoe weeding for the management of broad leaf weeds in wheat as a result of the ability of the herbicide to produce higher grain yield compared to hoe-weeding and the attractive cost – benefit ratio of the use of this herbicide. Also Kehinde (2002) had noted that although controlling weeds, with pre and post emergence herbicide in upland rice was more expensive than two hoe- weedings, it gives the best weed control and had the highest net return. Korieocha *et al.* (2011) also noted that atrazine + metolachlor gave higher marginal return per naira in sweet potato (*Ipomoea batatas*) production over hand weeding, showing that weeding manually is expensive when compared to chemical weed control. In order to make up for upright growth characteristics of maize and reduce weed problem, cover crops especially 'egusi' melon (*Colocynthis vulgaris* L.) are planted locally as undergrowths. The incorporation of 'egusi' melon into maize cropping system at the right time has been more profitable and more environmentally friendly (Oguremi, 2005). Chikoye *et al.* (2000) has reported that simultaneous cropping of cover crops with food crops has a good potential for reducing cost of weed control and production. Maize production as a business like every other enterprise is aimed at profit maximization by the farmer. There is therefore the need to have a comparative understanding of the economic return on production investment on this crop. The aim of this study was to assess the most profitable method of weed control, involving selected, biological, chemical and cultural methods.

3 MATERIALS AND METHODS

3.1 Study Area: A field experiment was conducted at the Teaching and Research Farm of Ambrose Alli University (Latitude 6° 45'; 6° 8' E; 313m above sea level) in the forest – savanna transition zone of Nigeria, during 2004 and 2005 early rainy season. Soil samples were randomly collected from 10 spots (0-15 cm depth) over the entire field using auger before the commencement of the experiment. The samples were bulked and mixed thoroughly for analysis. The soil analysis result is presented in Table 1. Number of rainy days and total rainfall during the trials are presented in Figure 1.

Table 1: Physico-chemical properties of the experimental site before commencement of the study

Soil Properties	Values
Sand (g/kg)	963
Silt(g/kg)	17
Clay (g/kg)	20
pH (H20,1:1)	5.55
Organic matter (g/kg)	27.335
Organic Carbon (g/kg)	15.85
Total N (g/kg)	1.065
Available P (mg/kg)	15.21
Exchangeable cations (cmol/kg)	
Ca	5.045
Mg	2.575
K	0.275
Na	0.285
ECEC (cmol/kg)	8.58

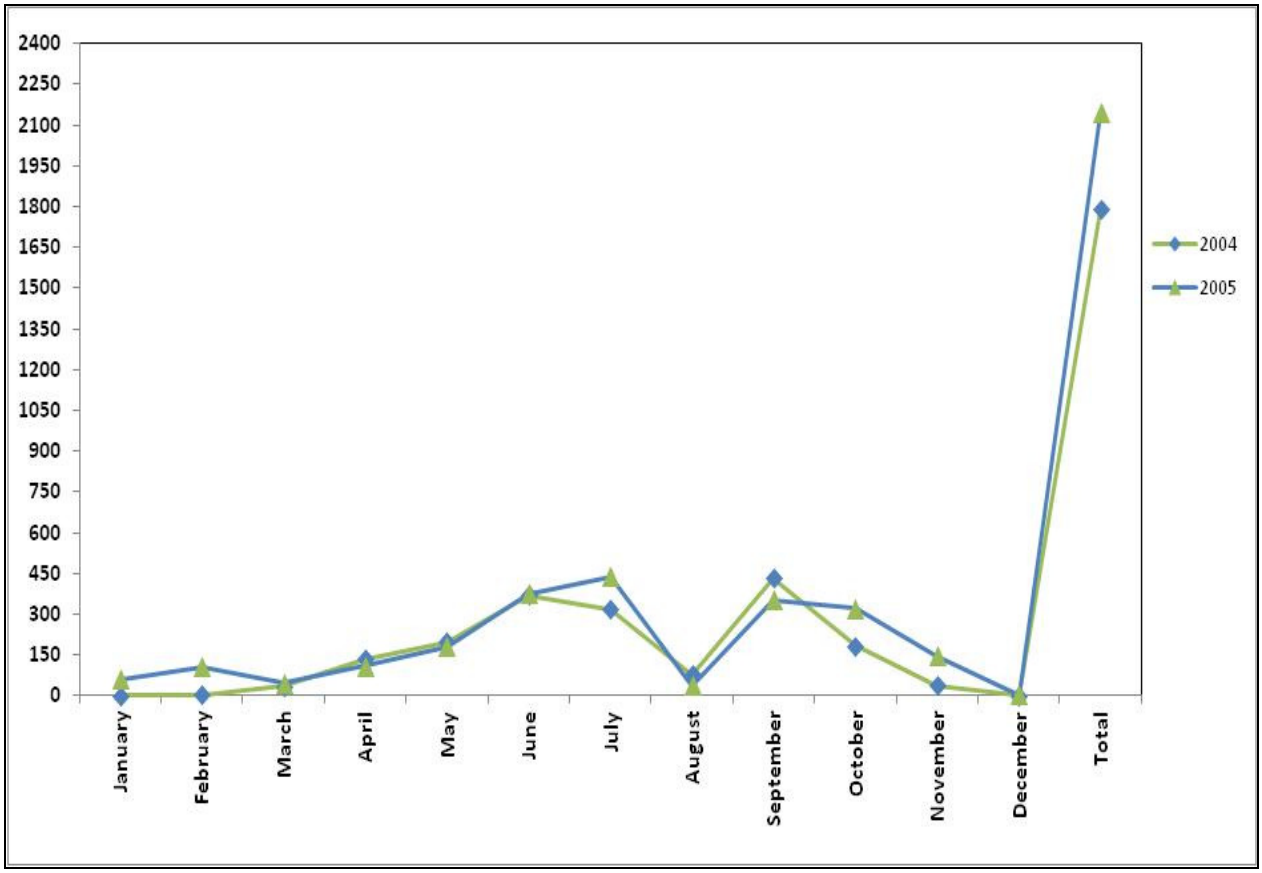

Figure 1: Monthly and total rainfall during the trial 2004-2005 –(Source: Edo State Agricultural Development Project (EADP),Irrua, Edo State).

3.2 Field Procedures: The land was manually slashed, stumped before leveling the soil surface with spades. Each plot size was 3m x 4m with an alley way of 1m among plots and 1m between replicates. There were thus, a total of 28 plots occupying an experimental area of 27m x 19m (514m^2) approximately 0.05ha. There were seven treatments involved in the experiment, namely, no-weeding (control), Primextra® (3.0kg a.i./ha) mulching (wood shavings), one hoe-weeding (3WAP), Two hoe-weedings (3 and 7WAP), Melon cover – crop minus hoe- weeding and melon cover-crop plus one hoe weeding at 3WAP. The treatments were arranged in a randomized complete block design (RCBD) with four replicates. A plant spacing of 75cm x 25cm was used in each cropping season. Two seeds of maize (cultivar DMRESR – W, obtained from the International Institute of Tropical Agriculture (IITA) were planted per hole and thinned to one seedling per stand at 2WAP, giving a population density of 53, 333 plants/ha. One day after planting, four plots were sprayed with primextra® at 3.0kg a.iha^{-1} using a hand operated CP3 knapsack sprayer calibrated to deliver approximately 250lha^{-1} spray volume ata pressure of 210kpa with red poliject nozzle (swath width ½m). A local variety of melon (*Colocynthus vulgaris* L.) was planted within the alleys of maize, planting the same day in each of the cropping seasons. Three seeds of melon were planted per hole at a spacing of 50cm x 30cm giving population density of 66667 plantsha^{-1} and the seedlings were thinned to one per stand at 3WAP. Eight (8) tha^{-1} of wood shavings, in each of the cropping seasons, were weighed with a spring balance fixed to a horizontal bar supported on three 1.5m fork – sticks, were uniformly spread over the appropriate treatments the same day maize was sown. The first hoe-weeding for sole maize/melon inter-crop was carried out at 3WAP in each season. Three days after the first weeding

urea fertilizer containing 46% Nitrogen was applied at the rate of 39.56 kg N ha^{-1} and 40.48 kg N ha^{-1} in 2004 and 2005 respectively to make up the critical level of nitrogen. These were carried out because the level of nitrogen in the soil was inadequate compared to the critical level of 1.5gkg^{-1} (Adepetu *et al.*, 1986; Sobulo and Osiname, 1981). The second weeding was carried out at 7WAP in sole maize plots only.

3.3 Data collection and analysis: Data taken were cost of weed control, yield of maize and total returns to different weed control methods. Maize was harvested from a net plot of $3m^2$ at maturity in both years. Maize grain yields were adjusted to the standard 12.5% moisture (Ighalo *et al.*, 2008).

3.4 Economic Assessment: Economic evaluation of the different weed control methods was carried out using partial farm budget (Okoruwa *et al.*,.2005). Prevailing labor and market costs of materials were used to obtain the revenue from grain yield of each treatment. Sale revenue was obtained by multiplying the final grain yield ($kgha^{-1}$) by the International market price ($Nairakg^{-1}$). This is represented below in the following formula:

i. Revenue=Ym * Pm (where, Ym=maize yield in kilogram/ha; Pm=Price of maize grain

The profit was calculated by subtracting the costs of production from the sale revenue represented as follows

ii. Profit (net revenue)=Revenue-Total cost of production

iii. Simple proportion of total cost of weed control (cost of production) and net revenue (profit) were used to determine the cost/benefit ratio (CBR) of each of the weed control method as follows: Cost benefit ratio (CBR)= Profit(net revenue)/Total cost of production

4 RESULTS AND DISCUSSION

Costs and benefits analysis of selected weed control treatments of maize production in 2004 and 2005 cropping seasons are presented in Tables 3 and 4. The value of the total output per hectare or total revenue from the selected weed control methods varied from N7,565.00 to N36,725.00(USD 76.32 to 386.58) in 2004. The highest revenue was recorded under wood shaving mulch N36,725.00 (USD 386.58) followed by Primextra® at 3.0kg a.i./ha (N34,447.60 USD) while the weedy check and melon cover-crop without hoe-weeding (N7,565.00) and (N8,275.00(USD 87.11) respectively recorded the lowest revenue compared to the rest of the treatment. Similar trend was observed in 2005 with wood shaving mulch recording the highest revenue (N38,760.48 (USD 387.60) followed by Primextra® at 3.0kg a.i./ha (N33,670.56 or (USD336.71) while the weedy check and melon cover crop without hoe-weeding (N7,524.00 (USD 75.24) and (N7,843.44(USD 78.43) respectively compared to the rest of the treatment. The above results were due to differences in yield/ha recorded by the different treatments with wood shaving mulch resulting in the highest yield.

Table 3: Costs and benefits of selected weed control treatment of maize production during the cropping season of 2004

Treatment	Primextra®(5L) (₦/ha)	Wood Shavings (₦/ha)	Planting material Melon (₦/ha)	Time of Treatment Application (man-hr/ha)	Cost of Treatment application (₦/ha)	Total Cost (₦/ha)	Grain yield (kg/ha)	Revenue (₦/ha)	Net revenue (profit) (₦/ha)	Cost/ benefit Ratio (CBR)
No weeding (control)	0.00	0.00	0.00	-	-	-	756.50	7,565.00	0.00	-
Primextra® (3.0kg a.l:/ha)	4,500.00			5	300.00*	4,800 .00	3,444.76	34,447.60	29,647.60	1:6.18
Mulching(wood shavings)	0.00	50.00		20	1,200.00**	1,250. 00	3,672.50	36,725.00	35,475.00	1:28.38
One hoe-weeding(3WAP)	0.00			145	14,500.00***	14,500.00	2,023.33	20,233.30	5,733. 30	1:0.40
Two hoe-weeding(3 & 7 WAP)	0.00			245	24,500.00***	24,500.00	2,705.00	27,050.00	2,550 .00	1:0.10
Melon cover-crop (-Hoe-weeding)	0.00		2092.50	25	1,750.00	3,842.50	827.50	8,275.00	4,432.50	1:1.15
Melon cover-crop + Hoe weeding(3WAP)	0.00		2092.50	25	18,342.50	18,342.50	2,307.50	23,075.00	4,732.50	1:0.30

1kg of maize = ₦10.00 (Maize International Market price = US $ 104.48/ton; 1US $ = ₦95) ; 1 litre of Primextra® = ₦900
*Cost of application of Primextra® = ₦50/hr. knapsack (hired) = ₦50/hr (₦100- ₦150)(N250 average) between 7.00am-12noon = 5 hours approx.
**Cost of application of wood shavings = ₦60/hr (₦140 – ₦160)=(₦300 average) between 7.00am-12noon = 5 hours approx)
***Cost of hand weeding = ₦100/hr (₦400-₦600) = (₦500 average) between 7.00am-12noon = 5 hours approx.)
****Seed rate of melon = 22.5kg/ha, cost of 1kg of melon = ₦93
Cost of planting melon seeds = ₦70/hr (₦150-₦200) (₦300 average) between 7.00am – 12noon= 5 hours approx

Table 4: Costs and benefits of selected weed control treatment of maize production during the cropping season of 2005

	Material cost									
Treatment	**Primextra® (5L)(₦/ha)**	**Wood Shavings (₦/ha)**	**Planting material Melon (₦/ha)**	**Time of Treatment application (man-hr/ha)**	**Cost of Treatment application (₦/ha)**	**Total Cost (₦/ha)**	**Grain yield (kg/ha)**	**Revenue ₦/ha**	**Net revenue (profit) (₦/ha)**	**Cost/ benefit Ratio (CBR)**
No weeding	0.00	0.00	0.00	-	-	-	712.50	7,524.00	0.00	-
Primextra® (3.0kg a.l:/ha)	4,750.00			5	350.00*	5,100	3,188.50	33,670.56	28,570.56	1:5.60
Mulching(wood shavings)	0.00	50.00		20	1,400.00**	1,450	3,670.50	38,760.48	37,310.48	1:25.73
One hoe-weeding(3WAP)	0.00			145	17,400.00***	17,400	2,005.00	21,172.80	3,772.80	1:0.22
Two hoe-weeding(3 & 7 WAP)	0.00			245	29,400.00***	29,400	2,675.00	28,248.00	-1,152	1:-0.04
Melon cover-crop (-Hoe-weeding)	0.00		2,137.50	25	2,000.00****	4,137.50	742.75	7,843.44	3,705.94	1:0.90
Melon cover-crop + Hoe weeding(3WAP)	0.00		2,137.50	25	21,537.50	21,537.50	2,082.50	21,991.20	453.7	1:0.02

1kg of maize = ₦10.56 (Maize International Market price = US $ 105.60/ton; 1US $ = ₦100)
1 litre of Primextra® = ₦950
*Cost of application of Primextra® = ₦60/hr. knapsack (hired) = ₦50/hr (₦100- ₦150)(N250 average) between 7.00am-12noon = 5 hours approx.
**Cost of application of wood shavings = ₦70/hr (₦150 – ₦200) = (₦350 average) between 7.00am-12noon = 5 hours approx)
***Cost of hand weeding = ₦120/hr (₦500-₦700) = (₦600 average) between 7.00am-12noon = 5 hours approx.)
****Seed rate of melon = 22.5kg/ha, cost of 1kg of melon = ₦95
Cost of planting melon seeds = ₦80/hr (₦150-₦250) (₦400 average) between 7.00am – 12noon= 5 hours approx

Plots hoe weeded twice at 3 & 7 WAP recorded the highest cost of production (N24,500.00(USD 257.89)) followed by melon cover crop plus one hoe weeding at 3WAP (N18,342.50 (USD 193.08)) compared to the other treatments while wood shaving mulch recorded the lowest total cost of production (N1,250.00(USD13.16)) in 2004. In 2005,the same trend was observed with the highest cost of production incurred by weeding at 3 and 7 WAP compared to all the other treatments while wood shaving mulch resulted in the lowest total cost of production. This confirms the report of Adigun and Lagoke (2003) that hoe weeding is expensive. It also shows the advantage of herbicide application over hoe-weeding in the reduction of cost of production of maize.

In 2004, the highest net revenue (profit) (N35, 475.00 (USD 373.42)) was obtained under wood shaving mulch followed by Primextra® (N29,647.60) or (USD 312.08) compared to the other treatments, while the lowest profit (N2,550.00) or (USD 26.89) was obtained in plots that were weeded at 3 and 7WAP. In 2005, the highest profit (N37, 310.48(USD 373.10)) was obtained under wood shaving mulch followed by Primextra® (N28, 570.56(USD 285.70)) compared to the other treatments, while negative profit (-N1,152)(USD 11.52) which signifies loss was obtained in plots that were hoe – weeded twice at 3 & 7 WAP. The observed negative returns from plots that were hoe-weeded twice were probably due to high cost of production. In 2004, wood shaving mulch had the highest CBR (1:28.38) followed by Primextra® (1:6.18) while the least was in plots that were hoe-weeded twice (1:0.10). Similar trend was observed in 2005 but plot hoe weeded twice had a negative CBR (1:-0.04). This result is in conformity with that of Chikoye *et al* (2005) who noted that chemical control is a better alternative to manual weeding because it is cheaper, faster and gives better weed control. Wood shaving mulch was the most profitable method of weed control in both years; judging from the values obtained from the cost benefit ratio (CBR). CBR of 1:28.38 and 1:25.73 were obtained in 2004 and 2005 respectively which imply that for every one naira used in the production of maize using wood shaving mulch option, there are profit of N28.38 and N25.73 in 2004 and 2005 respectively. However, the results obtained from wood shaving mulch is not in conformity with that of Olabode *et al* (2009) who noted that wood shaving mulch recorded the lowest profit among plastic mulch and grass mulch in the control of Mexican sun flower (*Tithonia diversifolia* Hemsl. A Gray) weed in Okra production in South Western Nigeria.

5 CONCLUSION

Wood shavings and Primextra® were the best options for weed control in the present study, and were better than hoe weeding twice. However, wood shaving mulch was slightly more economical than the herbicide option, probably because of its relatively low input nature. This option may appeal to small holder farmers , who may be ready to adopt it; since it does not involve any technical rigor besides signifying a non-chemical weed control option. However, it feasibility at a commercial farm level of weed control involving large hectares of land must be evaluated to further determine it relevance.

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