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Efficacy of Selected Herbicides on Weed Control, Cowpea (Vigna Uniguiculata L. Walp) Performance and Economic Returns in Akamkpa, Southeastern Nigeria

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ABSTRACT

A two year (2007 and 2008) field trial was conducted in Akamkpa Local Government Area of Cross River State, Nigeria to evaluate the effects of selected herbicides on weed control, cowpea (Vigna uniguiculata (L.) Walp) performance and economic returns to management. A randomized complete block design with a split plot arrangement was used and replicated three times. The main treatments were three cowpea varieties: Sampea 7(IAR-48), Sampea 4(IAR-176) and IT.4532-1, while the sub treatments were five herbicides: atrazine, diuron, galex, glyphosate, primextra, and all applied pre – emergence (a day after sowing) at 2.0kg.ai/ha and control ((manually weeded and no herbicide application). Results showed that cowpea establishment did not differ significantly among cowpea varieties whereas herbicide type significantly ($P<0.5$) affected cowpea establishment. High plant establishment was recorded in plots treated with Galex followed by Glyphosate compared to the high mortality rate in plots Atrazine and Primextra treated plots. Significant differences were also observed in the injury (mortality) rate of the cowpea. Atrazine was most lethal to cowpea followed by Primextra compared to other herbicides irrespective of the variety. Weed control efficiency rating differed significantly among the herbicides with Diuron being the most efficient in controlling the weeds followed by Primextra. The grain yield did not differ significantly among the cowpea varieties. However, on the basis of average for both years, the trend was in the order: Sampea7 (2.58 tha^{-1}) > IT.4532-1(2.55 tha^{-1}) > Sampea 4 (2.28 tha^{-1}). In contrast, grain yield differed significantly ($P<0.05$) among herbicide types irrespective of the cowpea varieties though no clear trend was exhibited. Averaged across both years indicated that Galex (3.42 tha^{-1}) promoted grain production in Sampea 7 variety plot followed by Glyphosate (3.13 tha^{-1}) and control (2.56 tha^{-1}).In IT.4532-1 plot, glyphosate recorded the highest grain yield (3.20 tha^{-1}) followed by Galex (3.11 tha^{-1}) and the control (2.35 tha^{-1}). The interaction effects between the cowpea varieties and the herbicide types on grain yield was significant ($P<0.05$) with Glyphosate, Galex and control highly favoured.The highest economic return (₦999,051.80) to management was obtained from Sampea 7(IAR-48) and was followed by IT.4532-1. This implies that Galex would be more effective in controlling weeds in cowpea plot followed by glyphosate particularly if Sampea 7(IAR-48) and IT.4532-1 varieties are planted.

Keywords: *Herbicides, weed control, cowpea performance, economic returns, Nigeria*

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is the most economically important indigenous African legume crop. Globally, an estimated 3.7 million metric tonnes of cowpea is produced annually on about 8.7 million hectares (Langyintuo *et al*., 2003). About 87% of annual cowpea production is undertaken in Africa, 10% in the Americas, and the rest in Europe and Asia. This grain is used throughout Nigeria and other parts of the semi-arid sub-Saharan Africa as a food source. Cowpeas can provide a relatively inexpensive source of high quality protein for both humans and animals, and its leaves and stems are fed to cattle. The grains contain 25% protein, and several vitamins and minerals (Mbata *et al*., 2000; Moussa *et al*., 2011). All parts of the crop are rich in nutrients and fibre and are used in Africa, where humans consume the young leaves, immature pods and seeds, and the mature dried seeds. The stems, leaves, and vines serve as animal feed and are often stored during the dry

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season. In addition, although local varieties often have low yields (200-350 kg/ha) cowpeas offer important benefits to its producers who are often resource poor farmers. As a legume, cowpeas fix nitrogen into the soil and, in doing so; reduce the need to buy inorganic fertilizers which are costly in most cases. Cowpea also plays an important role in providing soil nitrogen to cereal crops such as maize (*Zea mays* L.), Pearl millet (*Pennisetum glaucum* (L.) R. Br,) and sorghum (*Sorghum bicolor* (L.) Moench) when grown in rotation, especially in areas where soil fertility is a problem. In Nigeria, farmers who cut and store cowpea fodder for sale at the peak of the dry season can increase their annual income by 25% (Inaizumi *et al*., 1999). Cowpeas are relatively drought tolerant and thus offer farmers a means to reduce their exposure to weather risk. In Nigeria, cowpeas contribute to the food security of farmers in several ways as it, for instance, constitutes part of daily menu in many households.

However, the sustainable production of cowpea in Nigeria is limited by several biotic and abiotic factors including weed infestation, insect attack (Ukeh *et al*., 2011), and low soil fertility. Weeds constitute the most important constraints that influence cowpea production in the tropics (Keramati *et al*., 2008) as it compete with crops, reduce their growth rate, quantity and quality of grain yield as well as increase the cost of production (Akobundu, 1980; Zadeh *et al*., 2011). They also serve as alternate and alternative hosts of various insect pests and pathogens of cultivated cowpeas. Broad leaf weeds also reduces the availability of photosynthetic area radiation (PAR) to the lower layer leaves of the crop canopy (Lindquist, 2001), and decrease the longevity and expansion rate of lower leaves due to a reduction in available soil nitrogen and moisture levels (Wolfe *et al*., 1988). Resource poor farmers in Nigeria employ hand and hoe weeding for weed control, but this cultural method is time consuming, energy sapping and costly (Akobundu, 1980). Adequate chemical weed control using recommended dosages has been used in plantations and large scale sole cropping in Nigeria. The use of herbicides gives rapid result, more convenient to the farmers, increase yield of crops and reduce labour costs (Melifonwu, 1992).

The use of herbicides is therefore often considered an effective alternative to hand weeding (Akobundu, 1982). This alternative as observed by Adigun and Lagoke (1994) is often applicable to large hectares of farm land where hand weeding may not be feasible due to labour and other logistic constraints. The increasing scarcity and high cost of labour for manual weeding necessary to achieve adequate yields of cowpea in Nigeria have led to growing interest in herbicides (Akobundu, 1982).

Chemical weed control has also become popular among other crop farmers despite its attendant effects on the environment. IITA (1998) reported that within the past six decades, chemical weed control has become the most widely used method and in most developed countries of the world. Kearney and Kaufmann (1975) and Fadayomi (1979) reported that herbicides were commonly used in the humid and sub – humid tropical regions of the world in controlling weeds in farmlands. However, Shetty (1982) stated that the method was still being limited to a few plantation crops and other large scale sole cropping. Melifonwu (1992) reported that the advantage of herbicides in increasing yield of crops and reducing labour cost has been of great importance to farmers in Nigeria. The advantages gained from the use of herbicides must however pay for their use as they costly, particularly in the tropical countries. Therefore, Amakiri (1978) stated that it will be sensible, to compare its cost with that of mechanical weeding either by hand or animal – drain implements before choosing chemical weed control option.

Nonetheless, cowpea is believed to be more sensitive to herbicides than other leguminuos species. Borget (1992) reported that a mixture of *trifluralin* with *Diphenamid*e or *Linuron* in weaker doses or 0.5kg/ha to 1.0kg/ha of *trifluralin* instead of the 3.0kg/ha recommended when the product is used on its own gives satisfactory results, (Borget, 1992). IITA, (1995) reported that in a field experiment conducted at Ibadan, pre – emergence application of *fluorodifen* at 3.5kg/ha, *sulfallate* at 8.0kg/ha, *metolachlor* at 2 to 3.0kg/ha and *metolachlor plus metribuzine* at 0.25kg/ha gave an excellent weed control in cowpea plot and increased yields comparable to those from weed – free controls. Akobundu (1980) stated that *Alachlor* at 2 or 3.0kg/ha applied as pre – emergence caused injury to crops which was more severe when applications were made to moist rather than to dry soil. Similarly, results obtained with these same herbicides showed that tolerance by cowpea, but was toxic to soybean although it controlled *Rottboellia exaltata* effectively.

Currently, there is a growing interest among Akamkpa farmers to expand the list of crops grown in the area and as such have added cowpea to their cropping system. However, the major constraint remains weed infestation due to ignorance, fear of herbicide toxicity to crops and the high cost of the herbicides. Against this background therefore, a study was carried out to evaluate the efficacy of selected herbicides on weed control, cowpea performance and economic returns to management in Akamkpa, southeastern Nigeria.

MATERIALS AND METHODS

The experiment was conducted at Nsan Community in Akamkpa Local Government Area of Cross River State from September – December in 2007 and 2008. Akamkpa, (situated between latitude 5°00′ and 5°15′ North and longitude 8°04′ and 8°25′ East and located in the low land humid tropics about 65 to 75 metres above sea level) in Cross River State. The climate of the area is characterised by wet season and relatively short dry season. The rainfall pattern is bimodal, with long (March - July) and short (September – November) rainy seasons separated by a short dry spell of uncertain length usually during the month of August and usually referred to as "August break". The mean relative humidity is 78% and the atmospheric temperature range is 28^0C- 30^0C. The mean sunshine hours is 12.

The experimental design used was the randomized complete block design with a split plot arrangement and replicated three times. The entire experimental plot measured 46 m x 13 m. Each main plot measured 14.4 m x 10.8 m while each subplot measured 2.4 m x 1.8 m. Main and subplots were separated from each other by 1m path, whereas replicates were separated from each other by a 2 m path. The fields were prepared manually and common weeds found at the experimental site included, *Calopogonium mucunoides, Pennisetum violaceae, Acalypha ciliate, Euphorbia heterophylla, Pueraria phaseoloides, Urena lobata, Centrosema pubescence, Aspilia africana* and *Panicum rapens*. The main treatments were the three cowpea varieties – Sampea 7 (IAR-48), Sampea 4 (IAR-176) and IT 4532-1, while the sub treatments were the herbicides used namely: Atrazine, Galex, Diuron, Glyphosate and Primextra as well as the control (manually weeded and no herbicide application). Three seeds were planted per hole at a planting distance of 60 cm between rows and 30 cm within rows. Seedlings were thinned to two plants per stand at 2 weeks after planting. Application of herbicides was done one day after planting at an equal rate of 2 kg ai/ha for all the herbicides. Spraying was done with a knapsack sprayer at a spray volume of 250 litres/ha using a deflector nozzle at a pressure of 2.1 kg/cm^2, and walking speed of 1 metre second.

Clearing of bush from the 3 year fallowed land was done manually between 3rd and 7th of September in both years, followed by demarcation of the experimental plots. Insect pests were controlled by spraying Cymbush (*Cypermethrin*) at 2.0kg ai/ha, starting from six weeks after planting (WAP) and continued at two weekly intervals until pods matured.

DATA COLLECTION AND ANALYSIS

Percentage establishment of cowpea varieties was determined before thinning by counting the number of emerged stands and expressed as a percentage of the total number of seeds planted per sub – plot at 2 WAP. Visual ratings were taken for herbicide toxicity (injury) levels on the crop plants and their control using the method of Smith and Khodayari (1985). Ratings were done as follows: (i) Toxicity (injury) in which less than 10% of the crop was killed (mortality rate) was insignificant. (ii) Toxicity (injury) was slight where 10 – 29% of the crop was killed. (iii) Toxicity (injury) level of 30 – 70% was regarded as moderate, while (iv) Toxicity (injury) level from 70 – 100% was considered as severe. In assessing herbicide weed control efficiency, a scale was used thus: (i) If less than 10% of weeds emerged after spray, then the rating was regarded as very good. (ii) If 10 to 49% of weeds emerged, the rating was regarded as good. (iii) If 50 – 79% of weeds emerged, it was fair while of 80 – 100% of weeds emerged, the rating was considered poor. Both toxicity (injury) levels of the herbicides on the crop and control level were determined at 6 weeks after application in both years.

Grain yield was obtained from each plot by weighing in Kg and later expressed in tonnes per hectare (t/ha). Data collected were subjected to analysis of variance using GenStat Statistical Software (Version 13), and significant means were compared using least significant difference (LSD) at 5% probability. Grain yields were determined and the means for the two seasons pooled for the determination of economic returns to management using benefit- cost analysis which involved

subtracting the total cost of production (TC) for each cowpea variety, per hectare, from the gross revenue (GR) accruing from the production (i.e GR - TC) of that cowpea variety based on the prevailing market price of a tonne of cowpea (Ndaeyo and Aiyelari, 2010).

RESULTS

Physico-Chemical Properties of Soil at the Experimental Site

The soil is a well-drained sandy loam (Table 1), acidic and with good organic matter content.... The cation exchange capacity, total nitrogen, available P and exchangeable K, Ca and Mg were generally within acceptable ranges for sustainable crop production.

Table1. *Some Physico-Chemical Properties of Soil at the Experimental Site before planting*

Soil properties	2007		2008	
	……. Soil depth (cm)…….			
	0-15	5-30	0-15	15-30
Soil pH (H_2O)	5.65	5.32	5.63	5.30
Organic matter (%)	2.70	2.35	2.65	2.30
Total Nitrogen (%)	0.22	0.20	0.20	0.18
Available P(mg/kg)	158.32	142.21	168.70	152.21
Exchangeable cations				
Ca (meg/100g)	4.80	3.20	6.70	6.10
Mg (meg/100g)	2.20	2.10	2.56	2.40
Na (meg/100g)	0.06	0.06	0.04	0.04
K (meg/100g)	0.21	0.20	1.06	0.05
Exchangeable acidity				
Al (cmol/kg)	0.62	0.50	0.58	0.40
H (cmol/kg)	0.41	0.40	0.43	0.10
ECEC (cmol/kg)	8.30	6.46	10.35	9.45
Particle size distribution (%)				
Sand	89.60	89.60	89.60	89.69
Silt	5.50	5.68	5.50	6.28
Clay	4.90	4.72	4.90	4.96
Soil texture:	Sandy loam			

Plant Establishment, Crop Mortality Rating and Weed Control Efficiency

Cowpea percentage establishment at 2 weeks after planting (WAP) did not differ significantly among cowpea varieties (Table 2). However, herbicide type significantly affected ($p<0.5$) cowpea establishment. The type of herbicide applied affected the percentage establishment and the mortality rate of crop. This was confirmed by the high percentage establishment of crop in plots treated with Galex and Glyphosate as compared to the high mortality rate in plots treated with Atrazine and Primextra. The interaction effects between the herbicide type and the cowpea varieties was also significant ($P<0.5$) with the trend showing that galex and glyphosate favoured cowpea establishment.

Table2. *Effects of selected herbicides on percentage establishment of some cowpea varieties at 2 weeks after planting*

Cowpea	Herbicides	2007	2008	**Mean**
variety				
Sampea 7	Control	90.63	91.40	91.02
(IAR-48)	Atrazine	46.90	45.81	46.36
	Galex	93.77	95.79	94.78
	Diuron	82.30	85.32	83.81
	Glyphosate	90.63	91.52	91.08
	Primextra	50.00	48.26	49.13
	Mean	**75.71**	**76.35**	**76.03**
Sampea 4	Control	87.50	87.60	87.55
(IAR-176)	Atrazine	38.57	42.25	40.41
	Galex	91.67	92.30	91.98
	Diuron	84.40	80.25	82.33
	Glyphosate	89.60	90.50	90.05
	Primextra	64.53	60.40	62.47

	Mean	**76.05**	**75.55**	**75.80**
IT. 4532-1	Control	90.63	95.50	93.07
	Atrazine	41.67	45.60	43.64
	Galex	97.80	92.52	95.16
	Diuron	82.30	81.32	81.81
	Glyphosate	91.67	94.60	93.14
	Primextra	62.43	65.50	63.97
	Mean	**77.75**	**79.17**	**78.47**
LSD (P=0.05)		*NS	NS	
Variety		5.70	4.62	
Herbicide		25.40	18.20	
Variety x Herbicide				

**NS = Not Significant*

Galex was more effective in controlling weeds irrespective of cowpea variety compared to other herbicides applied. Percentage crop establishment for Galex treated plots was highest in all the plots irrespective of cowpea variety. Galex was closely followed by glyphosate treated plots. Significant differences were observed in the injury (mortality) rate (Table 3) of the cowpea Atrazine was most lethal to cowpea followed Primextra compared to other herbicides irrespective of the variety Atrazine and Primextra herbicides recorded severe and moderate plant mortality rating, respectively. Weed control efficiency rating differed significantly among the herbicides. It revealed that Diuron was the most efficient in controlling the weeds followed by Primextra (Table 4) whereas Galex was the least effective herbicide in controlling the weeds. There were no significant differences in mortality rate among the cowpea varieties as well as for weed control efficiency rating and interaction effects.

Table3. *Injury rating (%) of selected herbicides on some cowpea varieties at two weeks after planting.*

	2007	2008	Mean
Control	1.06	0.71	0.89
Atrazine	73.98	66.22	70.10
Galex	5.81	5.21	5.51
Diuron	11.07	9.57	10.32
Glyphosate	13.91	12.31	13.11
Primextra	50.00	40.99	45.30
Mean	**25.89**	**22.50**	**24.21**
LSD(P<0.05)	6.21	5.92	

Table4. *Weed control efficacy ratings (%) of the selected herbicides at two weeks after planting*

Treatments	2007	2008	Mean
Control	80.22	78.36	79.29
Atrazine	76.21	70.54	73.38
Galex	100.00	98.68	99.34
Diuron	60.28	65.38	62.83
Glyphosate	85.63	85.25	85.44
Primextra	68.52	70.20	69.36
Mean	**78.48**	**78.07**	**78.27**
LSD(P<0.05)	7.11	6.94	

Grain Yield

The grain yield did not differ significantly among the cowpea varieties (Table 5.).However, on the basis of average for both years, the trend was in the order: Sampea7 (2.58tha^{-1}) > IT.4532-1(2.55 tha^{-1}) > Sampea 4 (2.28 tha^{-1}). In contrast, grain yield differed significantly (P<0.05) among herbicide types irrespective of the cowpea variety though no clear trend was exhibited. Averaged for both years indicated that Galex (3.42 tha^{-1}) promoted grain production in Sampea 7 variety plot followed by Glyphosate (3.13 tha^{-1}) and control (2.56 tha^{-1}).In IT.4532-1 plot, glyphosate recorded the highest grain yield (3.20 tha^{-1}) followed by Galex (3.11 tha^{-1}) and the control (2.35 tha^{-1}),. In Sampea 4 plot, control recorded the highest grain yield (2.98 tha^{-1}) followed by Glyphosate (2.33 tha^{-1}) and galex and primextra (2.20 tha^{-1}). The interaction effects between the cowpea varieties and the herbicide types on grain yield was significant (P<0.05) with Glyphosate, Galex and control highly favoured

Table5. *Effects of selected herbicides on the grain yield of cowpea varieties.*

Cowpea variety	Herbicide type	Grain yield (t/ha)		
		2007	2008	Mean
Sampea 7 (IAR-48)	Control	2.50	2.62	2.56
	Atrazine	1.94	2.20	2.07
	Galex	3.24.	3.60	3.42
	Diuron	2.51	2.40	2.50
	Glyphosate	3.25	3.00	3.13
	Primextra	1.75	1.86	1.81
	Mean	**2.53**	**2.61**	**2.58**
Sampea 4 (IAR-176)	Control	2.95	3.02	2.98
	Atrazine	1.92	1.85	1.88
	Galex	1.90	2.50	2.20
	Diuron	2.40	1.82	2.11
	Glyphosate	2.20	2.46	2.33
	Primextra	2.23	2.10	2.20
	Mean	**2.26**	**2.29**	**2.28**
IT.4532-1	Control	2.43	2.26	2.35
	Atrazine	1.94	2.23	2.10
	Galex	3.20	3.02	3.11
	Diuron	2.30	2.35	2.33
	Glyphosate	3.14	3.25	3.20
	Primextra	2.20	2.16	2.20
	Mean	**2.54**	**2.55**	**2.55**
LSD (P=0.05) Variety Herbicide Var. x Herb.		NS* 3.42 3.25	NS 3.62 3.48	

NS = Not significant*

Table6. *Cost of Production of Cowpea and Economic Returns to Management in Naira per Hectare (₦'000/ha) as Influenced by the Different Types of Herbicides*

	Sampea 7 (IAR-48)						**Sampea 4(IAR-176)**						**IT.4532-1**					
Operation/ Production variables	Con-trol	Atrazine	Galex	Diuron	Glyph-osate	Prime-tra	Con-trol	Atrazine	Galex	Diuron	Glyph-osate	Prime-tra	Con-trol	Atrazin	Galex	Diuron	Glyph-osate	Prime-tra
Land preparation	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400	33,400
Planting	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361	8,361
Cost planting	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4	2,508.4
Cost of herbicide application	__	2000	1000	2000	1000	2000	__	2000	1000	2000	1000	2000	__	2000	1000	2000	1000	2000
Cost of insecticide application	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Soil analysis	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Cost of herbicides	__	5200	3000	5200	2800	5600	__	5200	3000	5200	2800	5600	__	5200	3000	5200	2800	5600
Cost of insecticide	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600
Weeding	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2	8,361.2
Miscellaneous[a]	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total cost (TC)	**61,230.2**	**66,172.3**	**65230.6**	**68430.6**	**65030.6**	**68830.6**	**61230.6**	**68430.6**	**6523.66**	**6843.66**	**6503.66**	**6883.66**	**6072 2.9**	**6792 2.9**	**6472 2.9**	**677 22.9**	**6452 3.1**	**6832 2.88**
Yield (t/ha)	2.56	2.07	3.42	2.50	3.13	1.81	2.98	1.88	2.20	2.11	2.33	2.20	2.35	2.10	3.11	2.33	3.20	2.20

Gross Revenue (GR)[b]	235424	183955	260536	238293	309401	166363	280326	182386	180778	225576	301706	211755	244511	184464	299297	216401	298224	205930
Return to management (GR – TC)	**174193.8**	**117782.4**	**195305.4**	**169865.4**	**244370.4**	**97532.4**	**272495.4**	**113955.4**	**115547.4**	**157145.4**	**236675.4**	**142924.4**	**183788.1**	**116541.0**	**234574.1**	**148678.1**	**233700.9**	**137607.12**
Benefit/cost ratio $^{GR}/_{TC}$	**3.84**	**2.77**	**3.99**	**3.48**	**4.75**	**2.42**	**4.57**	**2.66**	**2.77**	**3.29**	**4.64**	**3.07**	**4.03**	**2.72**	**4.62**	**3.19**	**4.62**	**3.01**

(a) Miscellaneous costs are expenses on feeding, harvesting and transportation.

(b) Gross revenue = yield x unit price of ninety five thousand naira per tonne (₦ 95000.00/tonne), (the prevailing market price of cowpea)

© ₦ 156 = US Dollar,

Economic Returns to Management

Table 5 shows the cost of production of three cowpea varieties and their economic returns to management as influenced by the different herbicides. The cost of production was highest when primextra was used (₦ 68830.6) followed by the application of Diuron (₦ 68430. 6) irrespective of cowpea variety while the least was the control (no herbicide application). Economic returns to management (profit) for Sampea 7 (IAR- 48) cowpea variety was highest when glyphosate was applied (₦ 24437.4) followed by galex variety (₦ 195305.0) and with corresponding benefit/ ratio of 4.75 and 3.99, respectively. Economic returns to management for Sampea 4(IAR-176) was highest when glyphosate was used (₦ 236675.4) followed by the control(₦ 2724095.4) and with corresponding benefit/ ratio of 4.64 and 4.57, respectively while for IT.4532-1, it was highest when galex and glyphosate were used (₦ 233700.9) followed by the control (₦ 183788.1 and with corresponding benefit/ ratio of 4.62 and 4.03, respectively

DISCUSSION

The significant difference in the percentage establishment and mortality rate among herbicide types indicated that some herbicides were toxic to the plants at this stage of growth of the cowpea although Akobundu (1982) reported that most pre – emergence herbicides are less toxic to plants at lower rates of 2.0kg or 3.0kg.ai/ha. Cowpea percentage establishment was lower in plots where atrazine and primextra were applied than in plots that received other herbicides. This was confirmed by the high mortality rate of the cowpea varieties that received atrazine and primextra treatments. Primextra is a combination of atrazine and S – metalachlor, Therefore, the toxicity of primextra might have been the action of atrazine present in it. Akobundu (1982) reported that proper timing of herbicides application and adequate knowledge of which herbicides to use in a given weed situation are very essential in crop production. Therefore, this atrazine toxicity effect is likely to be reduced if planting of cowpea is done not earlier than 48 hours after application as pre – emergence as to reduce high mortality rate of crops due to herbicide toxicity (injury).

Grain yield of cowpea differed significantly among the herbicide types applied and also in the level of interaction between the cowpea varieties and the herbicide types. This shows a tremendous effect of the types of herbicide applied on the yield of cowpea. The highest yield was obtained in plots treated with glyphosate and galex. This confirms reports by Minjas (1978) and Akobundu (1982) that galex is very effective in controlling weeds in cowpea field. The reports were both supported by Moody (1981) and Shebaya *et al.* (1985) who reported that galex was very effective in controlling weeds in legumes.

Therefore, it is observed that the use of herbicides in controlling weeds in cowpea cultivation may not only increase the yield, but is also more economical. Herbicides such as galex and glyphosate, were less expensive in cost per hectare, yet effectively controlled weeds leading to high productivity and hence high economic returns. Economic returns for Sampea7 (IAR-48) were very high greatly because the demand for brown beans was the market was high and the unit price for it was also high. The price and demand for IT.4532-1 (small white beans) is low compared to Sampea 7(IAR-48) and Sampea 4(IAR-178).

However, it is obvious that the economic returns from the production of the cowpea varieties vary from one variety to the other. The overall cost of procuring herbicides for application was ₦ 65,000.00 per hectare. The highest cost of herbicide was in the procurement of atrazine and primextra

which cost ₦ 5200.00 and ₦ 5600.00 respectively. The lowest cost per hectare was in the procurement of glyphosate which cost ₦ 2800.00 per hectare.

CONCLUSIONS

Based on the findings, it is concluded that galex is the most effective herbicides in controlling weeds in cowpea under sole cropping. However, glyphosate could be used if galex is unavailable as they had 90% and 100% weed control,respectively. They also recorded very low injury levels to crops due to phyto-toxicity effect. Atrazine and products containing *atrazine* such as *primextra* are highly toxic to cowpea plants, if they are to be used in controlling weeds in cowpea sole cropping, then application should be done pre – planting, and planting should be done not less than two days after application so that the toxicity effect of *atrazine* can be reduced through evaporation. It is more economical to use herbicides in the production for large scale cowpea production. Although grain yields were similar, Sampea 7 (IAR-48) was superior to others on the average. The highest returns were obtained from Sampea 7(IAR-48) (₦ 999,051.80) based on unit price in the market. Therefore, farmers in Akamkpa can successfully cultivate cowpea using 7 (IAR-48) variety in particular with either Galex or glyphosate herbicide in controlling weeds.

REFERENCES

[1] Adigun, J. A. and Lagoke, S. T. (1994). Chemical weed control in Maize groundnut mixture in Northern Guinea savannah ecological zone of Nigeria. *Nigeria Agric Journal*, 27:100– 112.

[2] Akobundu, I.O. (1980). Weed control in cowpea in the humid tropics. *Weed Science Journal of Nigeria*, 4: 6-10.

[3] Akobundu, I. O. (1982). The status and effectiveness of no tillage cropping at the small holder farmer level in developing countries. Paper presented at the FAO/WSS Expert consultation on weeds management strategies for the 1980s for LDC's, Rome 6th – 10th September, 1982, 1 – 14.Amakiri, M. A. (1978). Weed control in legumes with phenl – urea herbicides in weeds and their control in humid and sub – humid tropics (Akobundu, I. O. ed). Proc. SeriesNo. 3 IITA, Ibadon, Nig. 300 – 302.

[4] Borget, M. (1992). *The tropical Agriculturist; food legumes*. Macmillan CTA London. pp 38 – 42.

[5] Brosnan, J.T.Breeden, G.K. and Mueller, T.C. (2012). A Glyphosate Resistant Biotype of Annual Bluegrass in Tennessee. *Weed Science*, 60: 97-100.

[6] Fadayomi, O. A. (1979). Weed competition and cost effectiveness of Different weed control alternative in cowpea (*Vigan unguiculata* (L.) Walp) CV. Ife brown In: *Proc. 9th Ann. Conf. Weed Sci. Soc. of Nig*. 43 – 48.

[7] Ghanizadeh, H., Lorzadeh, S. and Ariannia N. (2010). Critical period for weed control in corn in the South-West Iran. *Asian Journal of Agricultural Research*, 4: 80-86.

[8] Hutto, K. C., J. M. Taylor, and J. D. Byrd (2008). Soil temperature as an application indicator for perennial ryegrass control. *Weed Technology*, 22:245–248.

[9] IITA (International Institute for Tropical Agriculture) (1998).International Institute for Tropical Agriculture. Annual Reports for 1994. Pp. 10 – 15.

[10] Inaizumi, H., Singh, B.B., Sanginga, P.C., Manyong, V.M., Adesina, A.A. and Tarawali, S. (1999). *Adoption and impact of dry-season dual-purpose cowpea in the semi-arid zone of Nigeria*. International Institute of Tropical Agriculture, Ibadan, Nigeria, 16p.

[11] Kearney, P. C. and Kaufman, D. D. (1975). *Herbicide chemical degradation and mode of action*. Marce Dekkar Inc. N. Y: 22 – 48.

[12] Keramati, S., H. Pirdashti, M.A. Esmali, A. Abbassian and M. Habibi, (2008). The critical period of weed control in soybean (*Glycine max* L.Merr.) in North of Iran conditions. *Pakistani Journal of Biological Science*, 11: 463-467.

[13] Langyintuo, A.S., Lowenberg-DeBoer, J., Fayec, M., Lambert, D., Ibro, G., Lindquist, J.L. (2001). Mechanisms of crop loss due to weed competition. In: *Biotic Stress and Yield Loss*, Peterson, R.K.D. and L.G. Higley (Eds.), FL, CRC Publishers, Boca Raton, pp. 233-253.

[14] Lycan, D. W. and S. E. Hart. 2006. Seasonal effects on annual bluegrass (*Poa annua* L.) in creeping bent grass with bispyribac-sodium. *Weed Technology*, 20:722–727.

[15] Mbata, G.N., Shu, S. and Ramaswamy, S.B.(2000). Sex pheromones of *Callosobruchus subinnotatus* and *C. maculatus* (Coleoptera: Bruchidae): congeneric responses and role of air movement. *Bulletin of Entomological Research*, 90: 147-154.

[16] Melifonwu, A. A. (1992). Control of *Mimosa invisa* in maize with atrazine and its mixtures with alachlor and metalachlor. *Nig. Journal of Weed Sci.*, 7:9 – 14.

[17] Minjas. A. N. (1978). Weed problems and control practices in Tranzania. In: IITA Proc. Series 3 (Akobundu ed.), IITA. Nigeria. 207P.

[18] Moddy, K. (1981). Weed management in intercropping systems. *Proc. of the Int. Workshop on Intercropping*. Int. crop Res. Inst. for the semi-arid tropics, Hyderabad, India: 229 – 237.

[19] Moussa, B., Kergna, A. Kushwaha,S., Musa, S. and Ntoukam, G. (2003). Cowpea supply and demand in West and Central Africa. *Field Crops Research*, 82: 215-231.

[20] Ndaeyo, N. U**.** and Aiyelari, E. A. (2010). Yields, cost of production and economic return to management of maize/cassava intercrop as influenced by different tillage practices. *Researcher*, 2 (10): 68-74.

[21] Shebaya, J. A. and Lagoke, S. T. (1985). Report on weed control in soya bean. In: *Proc. of the 5th National weed control in soya bean.* IITA Ibadan. 4th – 5th February 1988:56 – 62.

[22] Shetty, S. V. (1982). Weed control in intercropping system. Paper presented the FAO/WSS expert consultation in weed management strategies for the 1980's for LDC's 6th–20thSeptember, 1989 FAO Rome Italy.

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