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Evaluation of Post Emergence Herbicides on Weed Control, Performance and Profitability of Rice (*Oryza sativa*) at Lafiagi, Kwara State of Nigeria

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Abstract: Field experiments were conducted in 2009 and 2010 wet seasons at Lafiagi, Kwara state in the Northern Guinea Savannah of Nigeria to evaluate the effect of some post emergence herbicides on weed control, performance and profitability of rice. The treatments consisted of four post emergence herbicides (450g pretilachlor + 30g pyribenzoxim, 3600g propanil + 2000g 2, 4-Dichlorophenoxy acetic acid, 40g bisbyribac sodium and 1020g pretilachlor + 1980g propanil), two hoe weeding at 6 and 9 WAS and the unweeded plot. The application rates were based on the manufacturers' recommendations. The treatments were laid out in a randomized complete block design replicated three times. Data on weed cover score, weed dry matter, crop injury, crop vigour, crop stand and grain yields were collected. Gross margin and cost benefit analysis were employed to determine the profitability of each of the control methods. From the results all the herbicides were similar in their effect on weed control and crop growth. The effect of herbicide treatments on rice yield were comparable to hoe weeding and significantly higher than unweeded treatments. The application of 40g/lha^{-1} of bisbyribac sodium and application of 450g pretilachlor + 30g pyribenzoxim as post emergence herbicides applied at 6 WAS gave the highest gross margin and Cost- benefit ratio over hand weeding respectively and are therefore considered as the best post emergence herbicides in rice among the evaluated herbicides in the study area. There is however the need for continuous evaluation of the herbicides in other to check herbicide resistant.

Key words: Herbicides · Rice production · Weed control · Profitability · Cost- benefit

INTRODUCTION

Rice (*Oryza sativa)* is the staple food for more than a half of the world population [1]. The global rice production is estimated at 454.6 million tonnes annually which has an average yield of 4.25 tonnes per hectare [2]. In Nigeria Rice is cultivated virtually in the entire Northern Guinea Savannah agro ecological zone. Land under rice cultivation in Nigeria has increased from 1,609,890 ha in 2005/2006 to 2,012,740 ha in 2009/2010, while production has also moved from 3,286,500kg ha^{-1} in 2005/2006 to 4,080,940kg ha^{-1} in 2009/2010. Average Nigeria consumes about 24.8kg of rice per year. Rice importation in Nigeria has grown from less than 500,000 metric tonnes in 1994 to 2.1 million metric tonnes in 2011. Between 2008 and 2011, Nigeria spent an average of US$ 2.5 Billion on rice importation. [3] This high level of rice importation may not be sustainable. Therefore, the Nigeria government at the federal level is refocusing attention on stimulating domestic rice production through a number of strategies, parts of which is the establishment of rice processing factories in Kano, Kwara, Ogun and Benue State with a combined installed capacity of 730,000 mt per annum [3]. It is very important to take advantage of the substantial processing capacity available in the country by boosting paddy rice production. Efficient rice production will create employment, increases incomes and reduce poverty.

Successful weed control is essential for economic rice production [4]. Weed can reduce rice yield by competing for moisture, nutrients and light during the growing season. Weed infestation can also interfere with combine operations at harvest and significantly increase harvesting and drying costs. Weed seeds contamination of rice grain lower grain quality and may lower the cash value of the crop. Weed infestation is one the causes of serious yield reduction in rice production worldwide. Losses caused by weeds vary from one country to another, depending on the predominant weed flora and on

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the control methods practiced by farmers. Weed competition do not occur during the entire cropping period. Control of weeds during the critical period of competition is important, usually it commence around 2 weeks after seeding and may continue up to 5-8 weeks. Hence early weeding is important to reduce yield losses [5]. Yield loss between 40-100% in upland rice has been reported [5-7]. Rice has been found to perform better under good weed management practices [4]. Weeds are one of the primary factors limiting rice yield in Nigeria. Hoe weeding is the commonest method adopted in controlling weeds in the study area. The practice is however expensive, labour intensive and the availability of labour is often not reliable particularly at the peak of the season. Rice being a closely spaced crop, yield losses could even be caused by hoe weeding through crop injury and stand losses, while some grass weeds which have close resemblance to the rice crop may escape hand weeding. This necessitates the evaluation of an alternative weed control method that may be more effective with less labour requirements. Herbicides, when used at recommended rate, offers good weed suppression and increased yield in rice production [8]. The use of pre-emergence herbicides has been reported to show some promising results in rice.10 reported that application of pre-emergence herbicides produced grain yield of rice that are significantly comparable to two hoe weeding. Herbicides resistance and crop injury is a major problem in the use of post emergence herbicides, there is need to identify selective herbicides for rice so as to increase rice production and save foreign exchange spent on importation of rice. Major herbicides available for weed control in rice in Nigeria include. propanil, oxadizon, butachlor, oxadiargyl, 2, 4-Dichlorophenoxy acetic acid, bisbyribac sodium, pretilachlor+ pyribenzoxim, propanil + 2, 4-Dichlorophenoxy acetic acid and pretilachlor + propanil, [3], but their use by farmers has been limited because of lack of information on crop injury, efficacy and cost benefit analysis of the herbicides. Therefore the focus of this study is to look at the efficacy and profitability of each of the herbicides available for rice farmers and compare it with the farmer's practice of two hoe weeding in the study area.

MATERIALS AND METHODS

Field experiments were conducted in 2009 and 2010 wet seasons at Demonstration Plot of Kwara State Agricultural Development projects located in Lafiagi Kwara state, (latitude 7° 45^{1} and longitude 2°30^{1}). Located in the Northern Guinea Savannah of Nigeria. Glyphosate was applied at the rate of 4 liters per hectare (1.440 kg a.i). After which the plot was left for two weeks before the land was ploughed and then harrowed to obtain a fine tilth, it was then marked out into 18 plots with 1.0m spacing between blocks and 0.5.0m spacing between plots. The gross and net plot sizes were was 16.0 m^2 (4 x 4) m and 12.0 m^2 (4 x 3) m respectively. Common weed species at the site were identified, classified and recorded. The treatments consisted of 4 post emergence herbicides; hand weeding at 6 and 9 WAS and unwedded check. The treatments were laid out in a randomized complete block design replicated three times. Pre-emergence herbicides used was 320g/l Oxadiargyl applied a day after planting with knapsack sprayer in a spray volume of about 200 liters per ha using a deflector nozzle at a pressure *of 2.1kg/m.*^{2}. At six weeks after planting different post emergent herbicides were applied which were, 450g Pretilachlor + 30g pyribenzoxim per ha, 3600g Propanil + 2000g 2,4-D per ha. 40g Bisbyribac sodium per ha and 1020g pretilachlor + 1980g propanil per ha. These rates are based on the manufacturer's recommendations. Hoe weeding was done at 6 and 9 WAS. The variety used was NERICA –1 which is early maturing. The seed were drilled at the rate 80 kg /ha with inter row spacing of 25 cm. Fertilizer was applied at the rate of 300 kg ha^{-1} of NPK at 3WAS and 150kg ha^{-1} of urea at 6 WAS. Visual observation was used to assess the crop injury score using percentage as the scale Where 1% = normal plant growth and 100% = leaf scorching and obvious stunted or dead plant. Weed weight sample was taken from 0.75m^2quadrant. The sample was cleared free of soil and weight fresh and oven dried at 70°c to constant weight for dry matter determination Weed cover score was assessed visually and expressed in percentage where 0% represent no weed cover and 100 % represent complete weed cover. Data collected were subjected to analysis of variance, where significant differences existed, the Duncan multiple range test was use for mean separation.

To examine the profitability of the different herbicides, the gross margin analysis and cost benefit analysis was done. The gross margin analysis is the difference between the total revenue and the total variable cost i.e. GM= TR-TVC Where GM= Gross margin; TR= Total revenue and TVC= Total variable cost

The profitability index, also known as cost- benefits analysis which measures the rate of return on investment was calculated. It gives the amount of profit on any Naira invested in each of the herbicides It is expressed as Cost-benefit ratio = GM/ VC where GM= Gross margin Where V.C. = variable cost of each of the weed control methods

The cost of the inputs and price of the products were obtained from market survey. The variable cost were that of weeding, chemicals and cost of application, the revenue was the farm gate price of rice at 50/kg (During the study US$=160 Naira).

RESULT

Table 2 shows the effect of post emergence herbicides on weed weight in 2009 and 2010 rainy seasons. The weight of grasses, broad leaves and sedges in all the herbicides treatments were statistically at par and are comparable to 2 hoe weeding but significantly lower to the no weeding treatment in both years of experimentation. All the herbicide had the same effect on grasses, broadleaves and sedges however, their control on sedges was not very effective. *Sida acuta* and *Cyperus species* were partially controlled.

Crop vigour score in percentage; where 0 represents dead plants and 100 vigorously growing plants.

Crop injury in percentage; where o represents normal crop plants growth and 100 leaf scorching and obvious stunted or dead plant

Table 3 shows the effect of post emergence herbicides on crop stand, crop injury and crop vigour in 2009 and 2010 rainy seasons. The effect of herbicides treatment on crop establishment as evident by data on crop stand was not significant in both years. All the treatments including the control did not have any significant effect on crop stand. The effect of post emergence weed control on Crop growth as evident by the data on Crop vigour and crop injury was not affected by the application of herbicides. There were no significance differences among all the treatments on crop vigour and Crop injury as indicated in Table 3 There was initial yellowing of the whole field few days after application but by the 8th weeks after sowing the yellowish colour had disappeared.

Table 4 shows the effect of post emergence herbicides on the yield of rice in 2009 and 2010. The yields of rice obtained by application of the various herbicides were statistically comparable with that of hoe weeding. The unweeded plots however, produced significantly lower yield as compared to both herbicides and hoe weeding.

Table 5 shows the profitability of post emergence herbicides in rice in the study area. The application of 40g/ l/ha of bisbyribac sodium and 450g pretilachlor +30g pyribenzoxim gave the highest gross margin and cost-benefit ratio which were statistically similar and significantly higher than the use of 1020g pretilachlor +1980g Propanil. The use 3600g propanil +2000g 2, 4-D and 2 hoe weeding at 6 and 9 WAS however gave the lowest gross margin and cost-benefit ratio among the herbicides. The unweeded plot resulted in a loss of 7,975 Naira/ ha.

Table 1: Effect of post emergence herbicides on weed control at Harvest

Treatments	2009	Weed cover score (%)		Total weed cover in %	2010	Weed cover score (%)		Total weed cover in%
Herbicides rate	Grasses	Broad leaf	Sedges		Grasses	Broad leaf	Sedges	
450g pretilachlor +30g pyribenzoxim	20 c	10c	10	40b	20 b	10 b	10	40c
3600g propanil +2000g 2,4-D	20 c	10 c	10	40 b	20 b	10 b	10	40 c
40g Bisbyribac sodium	20c	10 c	10	40 b	20 b	10 b	10	40 c
1020g pretilachlor +1980g Propanil	20 c	10 c	10	40 b	20 b	10 b	10	40 c
Hoe weeding	25b	15 b	10	50b	25 b	15 b	10	50 b
No weeding	50a	40 a	10	100 a	50a	40a	10	100a
S.E±	0.89	0.76	0.021	1.45	1.74	0.65	0.02	0.34

Means in the same column followed by unlike letter (s) are significantly different (p=0.05), DMTR. Weed cover score in percentage; where 0 represents no weed and 100 complete weed cover

Table 2: Effect of post emergence herbicides on weed weight at harvest in 2009 and 2010

Treatments	2009 Grasses	Weed weight(g) Broad leaf	Sedges	2010 Grasses	Weed weight (g) Broad leaf	Sedges
450g pretilachlor +30g pyribenzoxim	1.07 b	2.22 b	1.14b	1.37 b	1.72 b	0.55 b
3600g propanil +2000g 2,4-D	1.03 b	2.27 b	1.10 b	1.33 b	1.77 b	0.11 b
40 gBisbyribac sodium	1.33 b	2.74 b	1.13 b	1.35 b	2.24 b	0.41 b
1020g pretilachlor +1980g Propanil	1.37 b	1.19b	1.15 b	1.67b	1.69 b	0.41 b
Hand weeding	1.5b	2.02 b	1.14 b	1.80b	1.5 b	0.41 b
No weeding	7a	17.9 a	7.84 a	7.3 a	17.4 a	6.85 a
S.E±	0.69	2.37	0.64	0.99	2.87	1.35

Means in the same column followed by unlike letter (s) are significantly different (p=0.05), DMTR.

Table 3: Effect of post emergent herbicides on crop stand, crop injury and crop vigour in (%) at 9 WAS in 2009 and 2010

	2009			2010		
Treatments a.i./ha	Crop stand	Crop injury	Crop vigour	Crop stand	Crop injury	Crop vigour
450g pretilachlor +30g pyribenzoxim	100	5	95	100	5	95
3600g propanil +2000g 2,4-D	100	9	91	100	9	91
40g Bisbyribac sodium	100	3	97	100	3	97
10200g pretilachlor +1980g Propanil	100	5	95	100	5	95
Hand weeding	100	10	90	100	10	90
No weeding	100	3	100	100	2	100
S.E±	2.456	1.890	2.0980	2.51	1.790	2.100

Means in the same column followed by unlike letter (s) are significantly different (p=0.05), DMTR.

Table 4: Effect of post emergence herbicides on yield in kg ha^{-1} of rice in 2009 and 2010

Treatments	Yield in 2009	Yield in 2010	Yield in combined analysis
450g pretilachlor +30g pyribenzoxim	4131[a]	3718[a]	3925[a]
3600g propanil +2000g 2,4-D	4126[a]	3713[a]	3920[a]
40g Bisbyribac sodium	4212[a]	3791[a]	4001[a]
1020g pretilachlor +1980g Propanil	4129[a]	3716[a]	3923[a]
Hoe weeding	4231[a]	3807[a]	4019[a]
No weeding (control)	869[b]	912[b]	890.5[b]
S.E±	14.96	12.96	13.96

Means in the same column followed by unlike letter (s) are significantly different (p=0.05), DMTR.

Table 5: Profitability of rice production under post emergence herbicides

Treatment a.i/ha	Rate in L/Ha	Variable cost	Other cost Naira	Total Variable cost	Revenue (Yield x price)	Gross Margin Naira R-TVC	Benefit-cost ratio
450g pretilachlor +30g pyribenzoxim	1.5	22,460	52,500	74,960	196250	121,290	5.4
3600g propanil +2000g 2,4-D	10	31,460	52,500	83,960	196000	112,040	3.6
40 gBisbyribac sodium	0.4	21,800	52,500	74,300	200050	125,750	5.8
1020g pretilachlor +1980g Propanil	6	25,460	52,500	77,960	196150	118,190	4.6
Hoe weeding at 6 and 9 WAS	0	32,460	52,500	84,960	200950	115,990	3.6
No weeding	0	0	52,500	52,500	44525	-7,975	0

DISCUSSION

The major weeds in the study area includes grasses such as *Cynodon dactylon* (L) pers*, Digiteria cilliaris* willd, *Elusine indica* Garten *and Dactyloctenium spp* (L) Beave. Broad leaves such as *Solanum nigrum* L. *S. americanum* Mill. *Ageratum conyziods* L. *Amaranthums spinosus* L. *and*

Acanthospermum hispidum DC. Sedges were few and included *Sida acuta* and *Cyperus* s*pp*. The use of the different herbicides at 6WAS to supplement the pre planting and pre emergence herbicides resulted in effective control of weed and yield that are comparable to hoe weeding at 6 and 9 WAS in both years of experimentation. This shows that these herbicides when used at the recommended rate have the ability to control weeds in rice. It was also found that the herbicides had partial control on sedges; they were not very effective on *Sida acuta* and *Cyperus species*. Weeds that emerged after application were not controlled. The herbicides were selective on rice thus, they did not affect crop stand, crop vigour and did not cause any injury on rice. Crop establishment and growth of rice were not affected and their performance were comparable to the conventional farmers practice of two hoe weeding at 6 and 9 WAS. The yield of rice produced by the use of herbicides were comparable with the farmer's practices of 2 hoe weeding and all the herbicides performed similar, which resulted in almost the same yield. This agrees with the work of (1;2;3;4 and 5) which shows that herbicides, when use in rice suppresses weed and increase the yield of rice.Gross margin for the uncontrolled plot resulted in a lost and the cost- benefit ratio cannot be calculated since there was no cost incurred. The application of 40g/ l/ha of bisbyribac sodium and of 450g pretilachlor +30g pyribenzoxim were more profitable than the use of 1020g pretilachlor +1980g Propanil. The use of 3600g propanil +2000g 2, 4-D and 2 hoe weeding at 6 and 9 WAS, however gave the lowest gross margin and cost-benefit ratio as compared to the other herbicides. The low profitability recorded in the use

3600g propanil +2000g 2, 4-D and 2 hoe weeding at 6 and 9 WAS were due to the cost associated with the two control methods. Uncontrolled weed in rice resulted in a loss of about N7, 975when compared with the farmer's practices of 2 hoe weeding

CONCLUSION

From the results from these trials it can be concluded that the application of 40g/l/ha of Bisbyribac sodium or 450g pretilachlor +30g pyribenzoxim as post emergence herbicides applied at 6 WAS to supplement the application of 4l/ha of glyphosate applied as pre planting and the 320g/l/ha Oxadiargyl applied as pre emergence enhanced rice yield and profitability over hand weeding. Their application gave higher gross margin and cost – benefit ratio and are therefore considered as the best post emergence herbicides in rice among the evaluated herbicides in the study area. There is however the need for continuous evaluation to prevent herbicide resistant over time

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