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Growth and yield response of upland rice to nitrogen levels and weed control methods

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Abstract

Field trials were conducted to evaluate the effect of nitrogen levels and weed control methods on growth and yield of rice at the Federal University of Agriculture, Abeokuta (07°15'N, 03°25'E) in the forest-savannah transition zone of South west Nigeria during the rainy seasons of 2014 and 2015. Three nitrogen levels (0, 60 and 90)kg ha^{-1} constituted the main plot treatments. The sub-plot treatments were seven weed control methods: Propanil +2, 4-D (*Orizoplus*) at 2.0kg a.i. ha^{-1}; *Orizoplus* at 2.0kg a.i. ha^{-1} followed by supplementary hoe-weeding (fb SHW) at 6 weeks after sowing (WAS); Butachlor (*Buster*) at 1.0kg a.i. ha^{-1}; *Buster* at 1.0kg a.i. ha^{-1} fb SHW at 6 WAS; two hoe-weedings at 3 and 6 WAS; three hoe-weedings at 3, 6 and 9 WAS (season-long weed control); and weedy check. Nitrogen level had no significant effect on weed growth. Rice growth and grain yield increased with increase in nitrogen level from 0 to 90kg ha^{-1}. All weed control methods significantly reduced weeds with subsequent improved rice growth and yield compared with weedy-check. Pre-emergence application of *Orizoplus* at 2.0 or *Buster* at 1.0kg a.i. ha^{-1} fb SHW at 6 WAS provided weed control, and rice growth and yield similar to season-long weed control. Practical applications of this study are that increased nitrogen level and early weed control with a pre-emergence herbicide followed by supplementary weed removal at 6 WAS could help to improve growth and yield of upland rice.

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Introduction

Rice (*Oryza sativa* L.) is considered the most important staple food in the world as it supplies the major food requirement for more than half of the world's population. It is the predominant staple food in at least 33 developing countries including Guinea, Guinea- Bissau, Gambia, Liberia, Nigeria, Senegal and Cote d'voire where it provides about 27% of dietary energy supply, 20% dietary protein and 3% of dietary fat. Rice contributes nutritionally significant amount of thiamine, riboflavin, niacin and zinc to the diet (Food and Agriculture Organization [FAO], 2001). The total world production of paddy rice (paddy) is around 592 million tonnes. Ninety percent of this total is grown in developing countries, mostly in Asia, while Latin America and Africa produce 3.8 and 2.8 percent, respectively (FAO, 2001). In Nigeria, rice has become an increasingly important staple in the diet of about 170 million people as a result of increasing urbanization (FAO, 2004). Rice is widely cultivated in most agro-ecological zones of Nigeria. The country is the largest producer of the crop in West Africa, where it occupies 1.7 million hectares with a production of 3.2 million tonnes of paddy (FAO, 1996).

Inspite of its great popularity, acceptability and high economic importance as the most important staple food crop in the world, the productivity of rice is constrained by a number of factors. These include low soil nitrogen status (Padhan *et al.*, 2016), the use of low yielding local varieties (Kumar *et al.*, 2014) pest and diseases (Gupta *et al.*, 2014), poor knowledge of agronomic practices and weed management problems (Adigun *et al.*, 2005). Of all the factors limiting the production of rice in Nigeria, low soil nitrogen status and weed management problems appear to be the most deleterious causing between 75 and 100% reduction in potential paddy rice yield (Akobundu, 1987; Imeokparia and Okunsanya, 1997) reports indicated that only an average of 1.5 tons per hectare is realized in the country. This is far below the potential yield compared with 6.5 tons/ha in Egypt and 7.0 tons ha^{-1} in Japan (FAO, 1996). According to (Alagesan and Raja Babu, 2011), insufficient and inappropriate nitrogen fertilizer application accounts for two third of the gap between actual and potential rice yields. Nitrogen is the main nutrient associated with crop yield (Bouman *et al.*, 2007) and the most limiting nutrient in tropical crop. Nitrogen, often taken up in large amount by plants, plays an important role in chlorophyll, protein, nucleic acid, hormone and vitamin synthesis as well as helps in cell division and cell elongation. It affects overall weed abundance and influences the competitive balance between crops and weeds (Good *et al.*, 2004).

Weed infestation on the other hand also poses a recurrent and ubiquitous threat to rice production causing between 48 and 100% yield losses in direct seeded upland rice (Rodenburg and Johnson, 2009). In Sub-Sahara Africa, weed may account for annual rice yield loses of at least 2.2 million tonnes equating to 1.45 billion US dollars (Rodenburg and Johnson, 2009). This is because rice is a weak competitor against weeds, with direct seeding; the germination of rice seeds and the emergence of weeds take place almost at the same time. Therefore, weed control at the early stages of the crop growth is important. Improved weed control has been estimated to raise rice yield by 15-23% (Rodenburg and Johnson, 2009). However, majority of Nigeria farmers have few options and resources available for effective weed control. Traditional manual weeding which is the most popular method of weed control is time consuming, labor-intensive and generally expensive. Rice being a closely sown crop also makes mechanical weeding difficult and some degree of crop damage is unavoidably involved in frequent manual weeding.

In addition, hand weeding allows weeds with similar morphological characteristics to rice to escape detection and hence removal in direct-seeded rice fields. Besides, labour availability is uncertain during peak and critical periods of crop-weed competition and sometimes unfavorable weather condition at weeding times make timeliness of weeding difficult to attain, leading to greater yield losses (Adigun *et al.*, 2014). Herbicide use, on the other has been consistently reported not to give a season long weed control (Adigun *et al.*, 2005; Adigun *et al.* 2016) although it is efficient and reduces labour requirement and its attendant costs.Consequently, an improved weed management system that integrates two or more control methods within the context of integrated weed management is needed for adequate weed control and sustainable upland rice production in Nigeria. Appropriate nitrogen fertilizer level that will increase the competitive ability of the crop against weeds combined with reduced dosage of herbicide spray and hoe-weeding may be a viable option to control weed and attain optimum upland rice yield. Such information is required to boost local production of rice and reduce foreign exchange spent on importation of the product. Hence, the objective of this study was to investigate the effect of nitrogen levels and weed control methods on the growth and yield as productivity of upland, rain-fed rice.

Materials and methods

Experimental site and treatments

Field trials were conducted at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Nigeria (07°15'N, 03°25'E) in the Forest-Savanna transition zone of South west Nigeria during 2014 and 2015 rainy seasons. The experimental field was disc-ploughed and harrowed at two weeks interval, and later pulverized and leveled manually before marking into various plots. Gross and net plot sizes were (4.5 x 3.0)m^2 and (3.0 x 3.0)m^2, respectively. Three nitrogen levels (0, 60 and 90)kg ha^{-1} constituted the main plot treatments. The sub-plot treatments were seven weed control methods: Propanil +2, 4-D (*Orizoplus*) at 2.0kg a.i. ha^{-1}; *Orizoplus* at 2.0kg a.i. ha^{-1} followed by supplementary hoe-weeding (fb SHW) at 6 weeks after sowing (WAS); Butachlor (*Buster*) at 1.0kg a.i. ha^{-1}; *Buster* at 1.0kg a.i. ha^{-1} fb SHW at 6 WAS; two hoe-weedings at 3 and 6 WAS; three hoe-weedings at 3, 6 and 9 WAS (season-long weed control); and weedy check. All treatments in different combinations were arranged in a split-plot design with three replications. Rice seed (variety - NERICA 8) was sown manually by drilling method at inter-row spacing of 75cm in both years. Nitrogen fertilizer treatments were applied by basal method at sowing of rice. Herbicides treatments were applied pre-emergence, one day after sowing of rice with knapsack sprayer (CP 15) in a spraying volume of about 250 l ha^{-1} using a green deflector nozzle at a pressure of 2.1kg cm^{-2}.

Data collection and analysis

Weed cover score, weed density, weed dry matter production, crop vigour score, plant height, number of tillers, leaf area, panicle length, panicle weight, number of grain per panicle, 1000 grain weight and grain yield were used to evaluate the performance of various treatments. A periodic observation of various parameters were taken from five tagged plants at net plot at various stages of crop growth and were subjected to analysis of variance (ANOVA) using GENSTAT (VSN International, Hemel Hempstead, UK) discovery package to determine the level of significance of the treatments. Treatment means were separated using the least significant difference (LSD at $P \leq 0.05$) where F-value was significant.

Results and discussion

The soil types at the experimental sites in 2014 and 2015 were sandy loam with high proportion of sand (88.0 and 84.0% respectively), 6.6 and 6.8% silt, 5.4 and 8.8% clay in 2014 and 2015 respectively (Table 1). Soil pH of the experimental site in 2014 was near neutral (6.7) whereas that of 2015 was slightly alkaline with pH of 7.9. The soil in the experimental site in 2015 was richer in percentage nitrogen (0.5%) than that of 2014 (0.1%).

Table 1. Physicochemical properties of the soil of experimental sites at Abeokuta in 2014 and 2015.

Soil Properties	2014	2015
pH	6.7	7.9
Sand (%)	88.0	84.0
Clay (%)	5.4	8.8
Silt (%)	6.6	6.8
Organic carbon	1.2	4.8
Total N	0.1	0.5
Available P	11.5	9.9
Total K	0.49	0.48
Exchangeable bases	g kg^{-1}	g kg^{-1}
Ca	89.0	20.4
Mg	10.8	5.0
Na	6.1	3.5
K	2.1	1.4

Total amounts of rainfall during the period of crop growth were 521.9 and 584.1mm in 2014 and 2015, respectively (Table 2). There was higher total amount of rainfall during the period of crop growth in 2015 than in 2014. However, the total amount of rainfall was higher during the critical period of crop growth (July-August) in 2014 than in 2015. More than half (324.2mm) of the total amount of rainfall occurred after the critical period (September-October) in 2015.

Whereas the rainfall was more evenly distributed throughout the period of crop growth in 2014 (Table 2).

Table 2. Rainfall, temperature and relative humidity during the experimental period in 2014 and 2015 at Abeokuta, Nigeria.

Month	Total Rainfall (mm)		Relative Humidity (%)		Temperature (°C)	
	2014	2015	2014	2015	2014	2015
June	53.7	164.9	71.0	70.8	27.2	26.8
July	202.6	65.6	76.2	73.0	25.6	27.2
August	35.2	29.4	71.7	70.3	24.3	26.2
September	136.0	165.1	69.7	71.9	25.6	26.3
October	94.4	159.1	67.2	69.2	27.0	26.3
Total	521.9	584.1				

Source: Department of Agro-Meteorology and Water Resources Management, Federal University of Agriculture, Abeokuta, Ogun state, Nigeria.

Effect of nitrogen level and weed control methods on weed growth in rice in 2014 and 2015

Table 3 shows the different categories of weed infestation and their levels of occurrence at the experimental sites which include broad leaf weeds, grasses and sedges. The fields on which the trials were sited were heavily infested with weeds as indicated by cumulative weed dry matter production of 3734 and 3948kg ha^{-1} obtained from the weedy check in 2014 and 2015 wet seasons, respectively (Table 4). The higher weed infestation observed in 2015 than in 2014 could be attributed to the higher rainfall in the former than in the later (Table 2). These results are in agreement with the findings of (Shahidul *et al.*, 2011) that higher rainfall favours weed species abundance, prevalence, spread and their competitiveness within weed and crop communities. Baskin and Baskin (2001) also observed that weed seed germination and growth were influenced directly or indirectly by environmental factors such as temperature, moisture and light.

Application of nitrogen did not have significant effect on weed cover score, weed density and cumulative weed dry matter production throughout the period of observation in both years of the study (Table 4). Sharma *et al.* (2007) also observed that nitrogen levels of 40, 80 and 120kg ha^{-1} had no significant effect on weed density and percentage composition of grasses, broad-leaved and sedges weeds in direct seeded rice under conditions of sandy loam soils at Kumarganj. Similarly, Satorre and Snaydon (1992) corroborated this finding by stating that no special effects of varying nitrogen levels were observed on weed population under observation. The trend also indicated that interaction between nitrogen levels and weed control methods on all the weed growth parameters were not significant throughout the period of observation in both years. Gonzalez (1998) earlier observed that interaction between applied nitrogen and weed control methods were not significant.

All weed control methods caused significant reduction in weed growth compared to the weedy check throughout the period of observation (Table 4). These results corroborates those of Adigun *et al.* (2005) and Ahmed *et al.* (2005) who reported that the maximum weed dry matter production was produced in weedy check which was significantly higher than all weed control methods. Among the various weed control treatments, the use of *Orizoplus* caused significant reduction in weed growth similar to that of hoe-weeding both of which resulted in significantly lower weed growth compared to the use of *Buster* in both years of experimentation. At 9 WAS in both years, *Orizoplus* at 2.0kg a.i. ha^{-1} and *Buster* at 1.0kg a.i. ha^{-1} each supplemented by hoe-weeding at 6 WAS resulted in significantly lower weed cover score and weed density compared to either herbicide applied alone. Similarly, pre-emergence application of Orizoplus at 2.0kg a.i. ha^{-1} and *Buster* at 1.0kg a.i. ha^{-1} each supplemented by hoe-weeding at 6 WAS caused significant reduction in cumulative weed dry matter production similar to 2 and 3 hoe-weedings in both years. This implies that pre-emergence herbicides require supplementary hoe-weeding to provide season long weed control in rice particularly considering the fact that rice is a long duration crop.

This confirms the earlier report by (Akobundu, 1987) that most pre-emergence herbicide treatments gave early weed control of emerging weed seedlings but lost efficacy early thereby allowing late emerging weeds to re-infest plots.

The need for supplementary hoe-weeding of pre-emergence herbicide application for season long weed control in various crop production systems have earlier been emphasized (Adigun *et al.*, 2016; Ismaila *et al.*, 2011; Osipitan *et al.*, 2013).

Table 3. Common weed species found on the experimental sites at Abeokuta in 2014 and 2015.

Weed species	2014	2015
Broad Leaves		
Abutilion maritamim (Jacq.)	+	++
Chochorus olitorus (L.)	++	++
Euphobia heterophylla (Linn.)	+++	++
Gomphrena celozoides (mart.)	++	+++
Talinum triangulare (Jacq.) Wild.	++	++
Tridax procumbens (Linn.)	+++	++
Amaranthus spinosus (L.)	++	++
Boerhavia coccinea Mill	++	++
Tithonia diversifolia (Hemsl.) A. Gray	+	+
Senna hirsuta (Linn) Irwin	++	++
Acanthospermum hispidium DC	++	++
Grasses		
Andopogon gayanus (Kunth var.)	+++	-
Commelina bengalensis (L.)	++	+
Cynodon dactylion (Linn.)	+	++
Imperata cylindrica (Linn.)	++	-
Panicum maximum (Jacq.)	++	+
Sedges		
Cyperus rotundus (Linn)	+	-
Kylinga squaminata (Thonn)	+++	+
Mariscus alternifolius (Vahl)	+	+

+++ = High infestation (60-90% occurrence)
++ = Moderate infestation (30-59% occurrence)
+ = Low infestation (1-29% occurrence)
- = No infestation

Table 4. Effect of nitrogen levels and weed control methods on weed cover, weed density and weed dry matter in upland rice in 2014 and 2015.

Treatments	Weed cover score		Weed density (no m^{-2})		Weed dry matter (kg ha^{-1})	
	9 WAS		9 WAS		12 WAS	
	2014	2015	2014	2015	2014	2014
Nitrogen level (kg ha^{-1})						
0	3.3	5.8	20	31	1526	2648
60	3.3	5.2	19	44	1568	3188
90	3.5	5.3	20	38	1568	3104
LSD (5%)	ns	ns	ns	ns	ns	ns
Weed control						
Orizoplus at 2 kg a.i. ha^{-1}	4.0	5.9	15	16	1120	2360
Orizoplus at 2 kg a.i. ha^{-1} fb[1] SHW[2] at 6 WAS[3]	1.2	4.2	6	7	1046	2280
Buster at 1.0 kg a.i. ha^{-1}	7.0	5.8	21	25	1582	2788
Buster at 1.0 kg a.i. ha^{-1} fb SHW	2.3	5.0	8	10	1260	2444
2 Hoe-weeding at 6 and 9 WAS	1.3	4.6	10	12	1068	2148
3 Hoe-weeding at 3, 6 and 9WAS	1.1	4.7	14	27	1082	2508
Weedy check	6.7	8.1	62	168	3734	3948
LSD (5%)	0.6	1.4	1.7	6.8	310	336
Nitrogen level × Weed control	ns	ns	ns	ns	ns	ns

[1] fb = Followed by; [2] SHW = Supplementary hoe-weeding; [3] WAS = Weeks after sowing; ns = Not significant at 5% probability level.

Effect of nitrogen level and weed control methods on growth and yield of rice in 2014 and 2015

Nitrogen levels had significant effect on crop vigour score and plant height at 6 and 9 WAS in both years, number of tillers and leaf area at 6 and 9 WAS in 2014 and 9 WAS in 2015, length and weight of panicle in 2015 as well as grain yield in both years (Table 5 and 6). In all the cases, 60 and 90kg N ha^{-1} produced significantly improved crop growth than those without nitrogen application. This suggests that some external fertilizer application is needed to enhance a more competitive crop growth and to sustain rice yield. A similar suggestion has been earlier reported by Saeed *et al.* (2010). Except at 9 WAS in 2015, where 90kg N ha^{-1} resulted in significantly taller plants, there was no significant difference in plant height of rice that received either 60 or 90kg N ha^{-1} throughout the period of observation in both years. However, number of tillers was significantly increased with application of 90kg N ha^{-1} than 60 and 0kg N ha^{-1}. This confirms the effectiveness of higher nitrogen level in promoting rice growth and tillering as earlier reported by (Lampayan *et al.*, 2010). Alagesan and Raja Babu (2011) similarly reported that rice tillers was significantly increased with application of 120kg N ha^{-1} compared with 80 and 40kg N ha^{-1}.

Table 5. Effect of nitrogen levels and weed control methods on crop vigour, plant height and number of tiller of upland rice in 2014 and 2015

Treatments	Crop vigour score				Plant height (cm)				Number of tillers			
	6 WAS		9 WAS		6 WAS		9 WAS		6 WAS		9 WAS	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Nitrogen level (kg ha^{-1})												
0	4.0	5.3	6.0	6.2	44.6	42.2	83.8	48.2	13	10	33	33
60	9.0	6.7	8.5	6.6	53.1	47.2	93.5	55.3	30	10	46	35
90	8.2	6.9	7.9	6.8	53.6	45.6	94.4	54.7	33	11	51	38
LSD (5%)	0.3	0.2	0.4	0.1	1.2	0.6	2.7	0.9	1.1	0.03	2.8	ns
Weed control												
Orizoplus at 2 kg a.i. ha^{-1}	6.5	6.2	7.3	7.1	51.9	44.6	90.4	54.4	26	20	42	34
Orizoplus at 2 kg a.i. ha^{-1} fb[1] SHW[2] at 6 WAS[3]	7.6	6.3	9.2	6.3	50.7	46.2	96.3	53.1	25	10	56	32
Buster at 1.0 kg a.i. ha^{-1}	6.5	6.7	5.3	6.6	52.1	41.8	88.8	50.7	25	10	31	35
Buster at 1.0 kg a.i. ha^{-1} fb SHW	7.6	6.7	8.6	7.3	52.1	46.0	91.6	53.3	26	20	46	38
2 Hoe-weeding at 6 and 9 WAS	8.2	7.0	8.8	6.8	52.1	47.0	94.2	55.0	26	20	49	35
3 Hoe-weeding at 3, 6 and 9WAS	7.7	6.8	8.8	6.8	51.3	47.4	95.5	54.4	28	20	53	35
Weedy check	5.8	4.1	4.4	4.7	42.6	42.6	77.2	48.2	23	10	29	30
LSD (5%)	0.5	0.4	0.6	0.4	1.8	0.9	4.1	1.4	1.8	3.5	4.4	ns
Nitrogen level × Weed control	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

[1] fb = Followed by; [2] SHW = Supplementary hoe-weeding; [3] WAS = Weeks after sowing; ns = Not significant at 5% probability level.

Table 6. Effect of nitrogen levels and weed control methods on leaf area, panicle length, number of grain per panicle, 1000 grain weight, panicle weight and grain yield of upland rice in 2014 and 2015.

Treatments	Leaf area (cm^2 plant^{-1})				Panicle length (cm)		No of grain/panicle		1000 grain weight (g)		Panicle weight (kg ha^{-1})		Grain yield (t ha^{-1})	
	6 WAS		9 WAS											
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Nitrogen level (kg ha^{-1})														
0	76	40	97	52	24	18	173	116	35	25	53	23	1.2	1.6
60	93	44	117	53	24	20	185	140	35	23	57	33	3.2	2.2
90	94	40	120	53	26	20.	178	120	37	26	54	46	4.8	3.1
LSD (5%)	5.7	1.5	4.6	ns	ns	1.6	ns	ns	ns	ns	ns	6.3	0.1	0.1
Weed control														
Orizoplus at 2 kg a.i. ha^{-1}	95	43	121	55	25	18	194	139	36	26	61	33	3.6	2.3
Orizoplus at 2 kg a.i. ha^{-1} fb[1] SHW[2] at 6 WAS[3]	99	42	128	51	25	19	205	158	36	26	62	36	5.0	2.4
Buster at 1.0 kg a.i. ha^{-1}	88	45	109	57	25	19	174	134	37	26	52	35	2.8	2.4
Buster at 1.0 kg a.i. ha^{-1} fb SHW at 6 WAS	92	40	119	53	30	20	190	124	37	26	57	35	4.0	2.4

2 Hoe-weeding at 6 and 9 WAS	98	43	123	56	25	20	188	151	35	26	58	41	3.3	2.8
3 Hoe-weeding at 3, 6 and 9 WAS	94	42	120	53	24	20	189	157	3	27	55	36	4.9	2.4
Weedy check	49	35	61	43	18	18	11	11	33	18	37	21	0.9	1.4
LSD (5%)	5.7	2.1	7.0	3.2	2.9	ns	13.5	11.2	ns	4.4	5.0	9.9	0.2	0.2
Nitrogen level × Weed Control	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

[1] fb = Followed by; [2] SHW = Supplementary hoe-weeding; [3] WAS = Weeks after sowing; ns = Not significant at 5% probability level

Application of 60kg N ha^{-1} resulted in significantly higher leaf area of rice than application of 90kg N ha^{-1} at 6 WAS in 2015. There was significant increase in length and weight of panicle as well as grain yield of rice as nitrogen level was raised from 0 to 60 and 60 to 90 N ha^{-1} in both years. In 2014, application of nitrogen at 90kg ha^{-1} resulted in 33 and 75% increase in rice grain yield compared to 0 and 60kg ha^{-1} respectively. The corresponding values in 2015 were 48 and 29% increase with application of 90kg N ha^{-1} compared to 0 and 60kg N ha^{-1} respectively, and 27% increase with application of 60kg N ha^{-1} compared to 0kg N ha^{-1}. The significant responses of the parameters to nitrogen fertilization could be attributed to the fact that among various nutrients, nitrogen has the strongest influence on growth of Rice (Ahmed *et al.*, 2005). In addition, nitrogen is an important component of chlorophyll which enhances photosynthesis thus promoting vegetative growth which leads to increased production of assimilates and consequently better yield of rice. These results are in harmony with that of Mandana *et al.* (2014) who reported 39 and 33% increase in rice grain yield with 90 and 60kg N ha^{-1} respectively compared with no nitrogen application. The results from soil samples analyzed (Table 1) showed that the soil is poor in nitrogen thus the positive responses to nitrogen observed.

All weed control methods produced significantly higher crop growth compared to the weedy check (Table 5 and 6). At 6 and 9 WAS in 2014, pre-emergence application of *Orizoplus* at 2.0kg a.i. ha^{-1} and *Buster* at 1.0kg a.i. ha^{-1} each supplemented by hoe-weeding at 6 WAS resulted in significantly higher crop vigour score than either herbicides applied alone (Table 5).

Similarly, at 9 WAS in 2014 and 6 WAS in 2015, pre-emergence application of *Orizoplus* at 2.0kg a.i. ha^{-1} and *Buster* at 1.0kg a.i. ha^{-1} each supplemented by hoe-weeding at 6 WAS caused significant increase in plant height and number of tillers similar to two and three hoe-weedings but significantly higher than those obtained when either herbicide were applied alone (Table 5). Furthermore, at 9 WAS in both years, herbicidal treatments followed by supplementary hoe-weeding at 6 WAS caused significant increase in leaf area similar to two and three hoe-weedings but significantly higher than either herbicides applied alone (Table 6).

In 2014, pre-emergence application of *Buster* at 1.0kg a.i. ha^{-1} followed by supplementary hoe-weeding at 6 WAS gave the maximum panicle length which was significantly higher than those of other weed control methods. In the same year, all herbicidal treatments supplemented with hoe-weeding at 6 WAS and two or three hoe-weedings gave comparable number of grains per panicle which was significantly higher than when the herbicides were applied alone (Table 6). In 2014, pre emergence application of *Orizoplus* at 2.0kg a.i. ha^{-1} applied alone or supplemented with hoe-weeding at 6 WAS gave significantly higher panicle weight compared to other weed control methods (Table 6). However, in 2015, all herbicidal treatments and two or three hoe-weedings gave comparable panicle and 1000 grain weights in 2015 (Table 6).

In 2014, maximum yield (5t ha^{-1}) was obtained with pre- emergence application of *Orizoplus* at 2.0 kg a.i. ha^{-1} while in 2015, two hoe-weedings gave the maximum (2.8t ha^{-1}) yield significantly higher than ot her weed control methods (Table 6).

In 2014, pre-emergence application of *Orizoplus* at 2.0kg a.i. ha^{-1} and *Buster* at 1.0kg a.i. ha^{-1} each supplemented by hoe-weeding at 6 WAS gave comparable rice grain yield significantly higher than those obtained with either herbicides applied alone.

Furthermore, the use of *Orizoplus* at 2.0kg a.i ha^{-1} and *Buster* at 1.0kg a.i. ha^{-1} each supplemented by hoe-weeding at 6 WAS gave comparable grain yield with that of three hoe-weedings. Similarly, in 2015, all herbicidal treatments gave comparable grain yield with that of three hoe-weedings. Improved growth and yield obtained with pre-emergence application of *Orizoplus* at 2.0kg a.i. ha^{-1} and *Buster* at 1.0kg a.i. ha^{-1} each supplemented by hoe-weeding at 6 WAS can be attributed to the initial weed control of either herbicides as well as the relatively effectiveness of the supplementary hoe-weeding in controlling subsequent weeds that emerged, thereby sustaining effectiveness in weed control till harvest. This clearly underscores the importance of integrated weed management in enhancing better weed control compared with the use of single weed control. Other authors (Ismaila *et al.*, 2011; Parthipan *et al.*, 2003) also reported the effectiveness of pre-emergence herbicides supplemented by hoe-weeding for increased growth and yield of rice.

In this study, higher growth and yield of rice was obtained in 2014 than in 2015 as reflected in all the growth and yield parameters (Table 5 and 6). Maximum grain yield of 5.0t ha^{-1} was obtained in 2014 compared with 3.1t ha^{-1} in 2015. Although, there was higher total amount of rainfall during the period of crop growth in 2015 (584.1 mm) than in 2014 (521.9mm), however, the improved growth and yield of rice in 2014 than in 2015 can be attributed to the better rainfall distribution especially at the critical rice growth period (July - August) in the former than in the later (Table 2). This is in consonance with the report of (Jana and De Dattta, 1975) which showed that rainfall distribution is more important than seasonal total amount of rainfall because rice is very sensitive to water stress. This result was also corroborated by Basak *et al.* (2009), which indicated that better rainfall distribution have positive effect on cereals yield. Furthermore, the observed higher weed infestation in 2015 occasioned by higher total amount of rainfall compared to that of 2014 (Table 3) must have further contributed to the lower yield of rice in the former than in the later. Rice being a C3 plant had lower extraction capacity than most weeds hence lower growth with reduced productivity.

Unchecked weed growth resulted in 82 and 50% reduction in rice grain yield compared to the maximum obtained in 2014 and 2015, respectively.

Conclusion

From this study, it can be concluded that application of 90kg N ha^{-1} was found to give higher growth and yield of upland rice compared to 0 and 60kg N ha^{-1} in sandy loam soils of Abeokuta region of South Western Nigeria. The results of this study also suggest that farmers can cut down on labour input with the use of pre-emergence herbicides for weed control in upland rice production. Herbicides showing promise for effective weed control are *Orizoplus* at 2.0kg a.i. ha^{-1} and *Buster* at 1.0kg a.i. ha^{-1} each followed by supplementary hoe-weeding at 6 WAS. In principle, this study suggest that increased nitrogen level and early weed control with a pre-emergence herbicide followed by supplementary weed removal at 6 WAS would help to improve growth and yield of upland rice. It is therefore recommended that farmers could apply 90kg N ha^{-1} in combination with *Orizoplus* at 2.0kg a.i. ha^{-1} or *Buster* at 1.0kg a.i. ha^{-1} followed by supplementary hoe-weeding at 6 WAS for effective weed control and consequently optimum growth and yield of upland rice in the forest savannah transition zone and other similar agro-ecological zones.

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