

Effect of Weed Phytosociological Characteristics on Control Practices in Upland Rice Production Under Sudan Savanna of Nigeria

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Abstract

Weed infestations usually consist of several species present at various densities and frequencies and emerge at different times to compete with the crop for essential farm resources. The experiments were conducted in 2016 and 2017 raining seasons at Bayero University Kano in the Sudan savanna agro-ecological zone of Nigeria to evaluate the effect of weed phytosociological characters on their control methods in upland rice. The experiment consisted of twenty weed control strategies by the use of Butachlor at two levels i.e 1.0 and 1.5 kg a.i. ha⁻¹ (pre-emergence), Orizo-plus (2,4-D+Propanil) at two levels i.e. 2.8 and 4.5 kg a.i. ha⁻¹, Rainbow-SD (Penoxsulam) at two levels i.e 0.025 and 0.030 kg a.i. ha⁻¹ and Solito 320 EC (Pretilachlor +Pyribenzoxim) also at two levels i.e 0.320 and 0.480 kg a.i. ha⁻¹ (post-emergence). All the post-emergence herbicides were applied in various combinations with Butachlor and in some cases followed by supplementary hoe weeding (SHW) at 4, 8 and 4 & 8 weeks after sowing (WAS). Weed free and weedy plots were employed to serve as control. The experiments were laid out in a randomized complete block design and replicated four times. The result indicated that use of Butachlor at 1.5 kg a.i. ha⁻¹fb Orizo plus at 4.5 kg a.i. ha⁻¹ to produce significantly lower weed cover score and dry weight, as well as higher weed control efficiency and paddy yield. It also revealed that in area with high relative density and frequency of grassy weed like *Rottboelia cochinchinensis*, *Digitaria horizontalis*, *Cynodon dactylon*, and sedges such as *Cyprus rotundus*, *Fimbriyalis ferruginea*, *Kyalingya squamulata* to resist normal doses of herbicides unless followed by supplementary hoe weeding at later stages of the crop growth.

Keywords: Herbicides, Phytosociological, Rice, Weed.

Introduction

Weeds are a serious constraint to rice production which resulted from continuous rice cropping and this allows weeds to emerge in successive flushes. Identification of weeds is the basic step for planning sound weed management programme. Depending upon the weed species, different weed management options are given keeping in view their susceptibility when growing in a crop (Walia, 2006). Cultural and/or chemical methods are generally employed to control weeds. Manual weeding though effective is getting increasingly difficult due to labor scarcity, rising wages and its dependence on weather conditions. Thus, herbicides usage seems indispensable for weed management in direct seeded rice (Azmi *et al.*, 2005). Weed management in direct seeded systems is more critical than transplanted systems as weeds in direct seeded system can emerge at the same time or before the rice plants, resulting in a serious problem of competition (Johnson *et al.*, 2004). Weed species resistant to herbicides have been reported in countries with high adoption rates and this might be as a result of the use of the same herbicides for long time.

Nigeria has the potential to be self-sufficient in rice production, both for food and industrial raw material needs and for export. However, a number of constraints have been identified as limiting to rice production efforts by farmers. Ukungwu and Abo (2004) reported that weed is the greatest bottleneck to increased yields and quality of rice in Nigeria, particularly in the upland ecology and rank only second to drought stress. Accurate estimates of weed population's abundance and distribution variables are very important if we are to manage agricultural land for higher productivity.

Weed phytosociological characteristics entails the study of weed distribution, description, classification and overall information of all the weed species in a community of plant population and compare them in a crop-weed ecosystem (Zimdahl, 2007; Das, 2011). Although weed-crop competition reduces the yield and other yield component of rice but mere presence of weed without considering their density and threshold effect on crop will not be economical to start the process of controlling it. Many issues related weed control in direct seeded rice (DSR) still remain unaddressed and a lot of work remains to be done to develop technologies which are site-specific, effective and economically viable. The

objectives of this study were to determine the effect of weed phytosociological characteristics on rice yield and the effectiveness of various weed control methods used to overcome their infestation.

Experimental Sites

The experiments were conducted in 2016 and 2017 raining seasons at Bayero University Kano (BUK) Teaching and Research Farm (11° 39' N; 08° 02'E) in Kano State within the Sudan savanna agro-ecological zone of Nigeria. The total amount of rainfall received in the area was 863 mm and 820 mm for 2016 and 2017 respectively. The minimum and maximum temperatures were 24.1°C and 32.6°C for 2016, and 23.8°C and 33.4°C for 2017 respectively. The soil was sandy loam and the soil pH was neutral. Total nitrogen content was generally low; very low organic carbon and high available P. It also indicated moderate potassium and calcium content and low cation exchange capacity (CEC).

Treatments and Experimental Design

This consisted of twenty weed control strategies by the use of Butachlor at two levels (1 and 1.5 kg a.i. ha⁻¹), 2,4-D + Propanil mixture (Orizo-plus) at two levels 2.8 kg a.i. ha⁻¹ (1.0 2,4-D + 1.8 Propanil) and 4.5 kg a.i. ha⁻¹ (1.6 2,4-D + 2.88 Propanil), Penoxsulam (Rainbow-SD) at two levels (0.025g and 0.030g a.i. ha⁻¹) and Pretilachlor + Pyribenzoxim mixture (Solito 320 EC) also at two levels 0.320 g a.i. ha⁻¹ and 0.480 g a.i. ha⁻¹ they were all applied in various combinations with Butachlor as pre-emergence and in some cases followed by supplementary hoe weeding (SHW). Weed free and weedy plots were employed to serve as control among the treatments. The experiment was laid out using randomized complete block design and replicated four times. The gross size of the plot was 3x3m while the net plot is 2.4x2.4m. However, a discard of 1m and 50cm was provided between the blocks and individual plots respectively.

Rice Variety Used

The rice variety used for the trial is NERICA 8 (FARO 59). It is a hybrid between *Oryza sativa* and *Oryza glabberima* developed by WARDA in 1994. The variety is an upland type, medium height, it has 50% days to heading of 55 - 60 days, it matures in 80 -90 days, it has long grain and potential yield of 5 t ha⁻¹. It is resistant to leaf blast disease and lodging. (Gridley *et al.*, 2002) The seed was supplied by Greenspore Agric. Nigeria Ltd.

Data Collection

Weed Species Composition

Weeds were harvested from the 1m² quadrant placed randomly once in each of the treatment plots at harvest. The harvested weed samples were identified, classified by species with the help of hand book of West African Weeds by Akobundu and Agyakwa (1998). The weeds were counted to get the number of individual species which was used to compute the weed abundance, frequency, density, relative abundance, relative frequency, relative density and importance value index as described by Das (2011).

Weed Dry Weight (g)

This was done by harvesting all the weeds that were within the 1m² quadrant that was placed at random in each of the plots, the weeds were oven dried to a constant temperature of 70 °C.

Weed Control Efficiency (WCE) (%)

This was done by using 1m² quadrant that was placed in each of the treatments plot at random and the weeds within the quadrant were harvested and oven dried to get the WCE by the use of the formulae:

$$\text{WCE} = \frac{\text{weed dry weight in weedy check} - \text{weed dry weight of treatment in question}}{\text{weed dry weight in weedy check}} \times 100$$

Relative Density (RD) %

It measures the numerical strength of a species of a plant in an area in relation to total number of individuals of all species in a community.

$$\text{Relative density (RD)} = \frac{\text{Density of a specie}}{\text{Density of species}} \times 100$$

Relative Frequency (RF) %

It measures the degree of uniformity of occurrence or dispersion of a species of plant in an area in relation to total occurrence of individuals of all species.

$$\text{Relative frequency} = \frac{\text{Frequency of specie}}{\text{Frequency of all species}} \times 100$$

Relative Abundance (RA) %

This measures the dominance of a species of a plant in an area in relation to total dominance of individuals of all species in a community.

$$\text{Relative Abundance (RA)} = \frac{\text{Abundance of specie}}{\text{Abundance of species}} \times 100$$

Importance Value Index (IVI)

Describes which species are the most important within the study area.

$$\text{IVI} = \text{Relative density (RD)} + \text{Relative frequency (RF)} + \text{Relative abundance (RA)}$$

Paddy Yield (kg ha⁻¹)

The paddy yield was measured after threshing the sun-dried plants harvested from each net plot and the yield was adjusted at 10 % seed moisture content.

Data Analysis

Data generated were subjected to analysis of variance as described by Snedecor and Cochran (1967) using the general linear model in SAS (SAS, 1987). Where significant, the treatments means were separated by using Student-Newman-Keuls test (SNK).

RESULTS**Weed Species and Phytosociological Characteristics**

The weed species composition and Phytosociological Characteristics during 2016 and 2017 rainy seasons is presented in Table 1. There was a total of thirteen (13) weed species identified in 2016 with grass family being six (6), broad leaved five (5) and sedges were two (2). *Rottboelia cochinchinensis* had the highest number of relative density and frequency and importance value index (IVI). However, *Fimbryistylis furreginea* had the highest relative abundance while the lowest relative density and importance value index was recorded by *Cyperus esculantus* but *Commelina benghalensis* had the least relative abundance. In 2017 however, a total of sixteen (16) weed species were identified. Weeds from grass family are seven (7), and broad leaves weeds were five (5) while sedges are four (4). *Rottboelia cochinchinensis* had the highest number relative frequency, relative density and importance value index.

Weed Dry Weight (g)

Effect of weed control strategies on weed dry weight in 2016 and 2017 rainy seasons is presented in Table 2. The result on weed dry weight (WDW) was significantly different ($P < 0.05$) at both growing seasons. Weedy check produced the heaviest WDW while the least WDW was recorded by the application of Butachlor at 1.0 kg a.i.ha⁻¹ fb SHW at 8 WAS in 2016 and by hoe weeded control (HWC) in 2017 wet season.

Weed Control Efficiency (%)

Effect of weed control strategies on weed control efficiency (WCE) for 2016 and 2017 rainy seasons is presented in Table 2. WCE was significantly affected by the methods of weed control in both growing seasons. Application of Butachlor at 1.5 kg a.i.ha⁻¹ fb SHW at 4 & 8 WAS produced the highest weed control efficiency but was at par with application of Butachlor at 1.5 kg a.i.ha⁻¹ fb SHW at 4 WAS, at 4 & 8 WAS, HWC at 2,4,6 & 8 WAS and Butachlor at 1.5 kg a.i.ha⁻¹ fb Orizo plus at 4.5 kg a.i.ha⁻¹ in 2016 rainy season. In 2017, however, the highest WCE was produced by HWC at 2, 4, 6 & 8 WAS but at par with considerable number of treatments.

Paddy Yield (kg ha⁻¹)

Effect of weed control methods on paddy yield of upland rice in 2016 and 2017 wet seasons is presented in Table 3. Paddy yield was significantly affected ($P < 0.05$) by weed control strategies at both growing seasons. Application of Butachlor at 1.5 kg a.i.ha⁻¹ fb Orizo at 4.5 kg a.i.ha⁻¹ produced the statistically highest paddy yield in both 2016 and 2017 rainy seasons. The second higher position was occupied by all the treatments except the application of Butachlor at 1.5ha⁻¹ fb Rainbow at 0.025 kg a.i.ha⁻¹, Butachlor at 1.5 kg a.i. ha⁻¹ fb Rainbow at 0.030 kg a.i.ha⁻¹, Butachlor at 1.0 kg a.i. ha⁻¹ fb Solito at 0.480 kg a.i.ha⁻¹, Butachlor at 1.5 kg a.i. ha⁻¹ fb Solito at 0.320 kg a.i.ha⁻¹ and Butachlor at 1.5 kg a.i. ha⁻¹ fb Solito at 0.480 g a.i.ha⁻¹ in 2016. However, in 2017 it was at par with the application of Butachlor at 1.5 kg a.i. ha⁻¹ fb Solito at 0.320 kg a.i.ha⁻¹, Butachlor at 1.5 kg a.i.ha⁻¹ fb Solito at 0.480 kg a.i.ha⁻¹, Butachlor at 1.0 kg a.i.ha⁻¹ fb SHW at 4 WAS, Butachlor at 1.0 kg a.i.ha⁻¹ fb SHW at 8 WAS, Butachlor at 1.5 kg a.i.ha⁻¹ fb SHW at 8 WAS and the weed free control (HWC at 2, 4, 6, & 8 WAS). The weedy check had the least paddy yield in both seasons.

Discussion

Weeds are usually best adapted to survive in a crop with a similar life cycle, germination time, or growth habit. The most effective control methods are often based on the life cycle of a weed. Weed characteristics that allow them to grow and be competitive with desirable plant species include the ability to germinate and grow in different environments, rapid seedling growth, ease of pollination, ability to reproduce vegetatively and tolerate adverse environmental conditions. In a report by Akobundu (1987) and Zimdahl (2007) they asserted that, most grasses and sedges were adopted to overcrowding and can survive in a densely populated area. The weed flora of the experimental site was similar during both seasons and comprised *Rottboelia cochinchinensis*, *Digitaria horizontalis*, *Cynodon dactylon*, *Cyprus rotundus*, *Ipomoea asarifolia*, *Eluecine indica*, *Fimbriyalis ferruginea*, *Kyalingya squamulata* etc. All the weed control treatments significantly reduced the weed population over the weedy check. Maximum reduction in total weed density, frequency and total weed dry weight was recorded by the application of Butachlor at 1.5 kg a.i.ha⁻¹ fb Orizo plus at 4.5 kg a.i.ha⁻¹ and hoe weeded control. This is however, more visible in less or moderately dense area of the experimental site. High weed density and frequency retard crop growth, encourages disease problems, serve as alternate host for deleterious insects and diseases, slow down harvesting operation, increase the cost of production and reduce the market value of crops (Akobundu, 1987). *Rottboelia cochinchinensis* which is prevalent weed at the experimental site is an aggressive weed that is difficult to control due to its characteristic features like waxy and pubescent leaf surface, rapid growth, mimicry habit and very strong root system that enable it to withstand difficult environmental conditions. Similar result was recorded by Yahaya (1993) and Ishaya & Mahadi (2004) who both reported greater reduction in weed dry weight due to herbicides application in rice field. It could also be observed that weedy control plots recorded higher weed cover score and weed dry weight and this also corroborated with the work of Ibrahim (2001) and Ishaya (2004) who also registered higher weed dry weight in weedy plots compared to herbicides control treatments and manual hoe weeding.

It could be observed that application of Butachlor at 1.5 kg a.i.ha⁻¹ fb Orizo plus at 4.5 kg a.i.ha⁻¹ recorded higher paddy yield and its components in both growing seasons. This increase in paddy yield could be attributed to better crop growth by the absence of weed-crop competition for any of the growth factor. The weed free environment thus created helped the rice crop to put forth better growth without any competition for nutrients and in turn resulted in higher paddy yields. Sultana (2000) observed that weed infestation of 100 to 200 weeds per meter square reduced paddy yield by 51 to 64% compared with weed-free conditions. Mahajan *et al.* (2009) concluded that herbicides are the most effective means of securing rice yields against weeds. In another report Yawale *et al.* (2015) confirmed the Application of Butachlor at the rate of 2.25 kg a.i. ha⁻¹ followed by Propanil - 2, 4 - D mixture at the rate of 2.52 and 1.44 kg a.i. ha⁻¹ respectively, produced higher number of tillers per plant, grain bearing panicles and grain yield per hectare.

Table 1: Weed Species and Phytosociological Characteristics during 2016 and 2017 Rainy Seasons

Weed Species	2016				2017			
	RA %	RD %	RF %	IVI	RA %	RD %	RF %	IVI
Grasses								
<i>Roottbolia cochinchinensis</i>	8.4	51.7	42.3	102.4	35.5	8.6	21.2	65.3
<i>Imperata cylindrical</i>	-	-	-	-	1.2	2.2	3.0	6.4
<i>Panicum maximum</i>	10.7	2.2	1.4	14.3	3.1	8.1	2.0	13.2
<i>Digitaria hOrizotalis</i>	8.8	1.7	1.4	11.9	5.7	9.7	3.0	18.4
<i>Cynodon dactylon</i>	5.0	4.6	6.3	15.9	7.6	4.9	8.1	20.6
<i>Eluecine indica</i>	6.8	1.4	1.4	9.6	4.5	11.4	2.0	17.9
<i>Commelina benghalensis</i>	3.2	2.5	5.6	11.3	3.8	9.7	2.0	15.5
Broad leaves								
<i>Ipomea asarifolia</i>	4.5	12.4	1.4	11.9	19.9	7.9	13.1	40.9
<i>Seena occidentalis</i>	8.8	1.7	2.8	17.1	3.8	3.9	5.0	12.7
<i>Amaranthus spinosus</i>	10.2	4.1	18.6	35.5	4.5	5.7	4.0	14.2
<i>Acathusparnum hispidum</i>	-	-	-	-	-	-	-	-
<i>Tridex procumbens</i>	4.9	8.5	11.8	25.2	20.2	7.4	14.1	41.7
<i>Phylathus amarus</i>	6.7	3.8	4.2	12.9	7.6	4.3	9.1	21.0
					-	-	-	-
Sedges								
<i>Leersia hexandra</i>	-	-			1.9	4.9	2.0	8.8
<i>Cyperus esculantus</i>	7.8	0.8	0.7	9.3	3.5	6.0	7.3	16.8
<i>Kylingya squamulata</i>	-	-	-	-	4.1	10.5	3.0	17.6
<i>Fimbristylis ferruginea</i>	14.9	4.6	2.1	21.6	2.7	4.6	3.0	10.3

RA – relative abundance, RD – relative density, RF – relative frequency, IVI – importance value index

Table 2: Weed Dry Weight and Weed Control Efficiency of Upland Rice as Affected by Weed Control Strategies in 2016 and 2017 Rainy Seasons

Treatments	Rate (kg a.i.ha ⁻¹)	WDW (g)		WCE (%)	
		2016	2017	2016	2017
Buta fb Orizo	1 fb 2.8	168.0b-f	133.0b-e	44.2efg	42.6c-f
Buta fb Orizo	1 fb 4.5	138.3c-h	151.8bcd	50.0b-g	37.7def
Buta fb Orizo	1.5 fb 2.8	109e-h	92.5def	66.2a-e	64.1abc
Buta fb Orizo	1.5 fb 4.5	93.5f-i	72.0ef	69.2a-e	70.3ab
Buta fb Rbow	1 fb 0.025	130.5e-i	108.8def	69.2a-e	54.8-d
Buta fb Rbow	1 fb 0.030	222b	186.5bc	29.5g	23.8efg
Buta fb Rbow	1.5 fb 0.025	191b-e	86.4def	34.3fg	66.0abc
Buta fb Rbow	1.5 fb 0.030	210.8bcd	119.3def	46.8c-g	51.1a-d
Buta fb Solito	1 fb 0.320	154.3b-h	18.0b	46.8c-g	23.3efg
Buta fb Solito	1 fb 0.480	161.9b-g	196.0b	44.9d-g	18.8fg
Buta fb Solito	1.5 fb 0.320	218.5bc	107.8def	26.3g	53.9a-d
Buta fb Solito	1.5 fb 0.480	125.3e-i	136.0b-e	56.6a-f	44.1cde
Buta fb SHW @ 4 WAS	1	75.3hi	89.3def	73.7abc	62.4a-d
Buta fb SHW @ 8 WAS	1	61.3i	139.0b-e	79.5a	40.5c-f
Buta fb SHW @ 4 WAS	1.5	80.3igh	97.5def	71.8a-g	61.3a-d
Buta fb SHW @ 8 WAS	1.5	61.5i	117.8def	79.6a	51.9a-d
Buta fb SHW @ 4 & 8 WAS	1	79.0igh	121.3c-f	74.1ab	45.6b-e
Buta fb SHW @ 4 & 8 WAS	1.5	66.5i	134.3b-e	77.5ab	45.3b-e
MHW @ 2, 4, 6 & 8 WAS	—	92.3igh	59.8f	69.7a-e	74.1a
Weedy check	—	305a	262.3a	—	—
SE ±		50.9	40.1	16.3	15.4

Means with the same letter in the same column are not significantly different $P < 0.05$ using SNK, WAS – Week after sowing, WDW – weed dry weight, WCE – weed control efficiency, SHW – supplementary hoe weeding, HWC – hoe weeded control, Buta - butachlor

Table 3: Paddy Yield of Upland Rice as Affected by Weed Control Strategies in 2016 and 2017 Rainy Seasons

Treatments	Rate (kg a.i.ha ⁻¹)	Paddy yield (kg ha ⁻¹)			
		2016		2017	
Buta fb Orizo	1 fb 2.8	1419b-f		1428bc	
Buta fb Orizo	1 fb 4.5	1507b-f		1304bc	
Buta fb Orizo	1.5 fb 2.8	1783b		1722bc	
Buta fb Orizo	1.5 fb 4.5	2111a		2001a	
Buta fb Rbow	1 fb 0.0 25	1456b-f		1474bc	
Buta fb Rbow	1 fb 0.030	1558b-f		1514bc	
Buta fb Rbow	1.5 fb 0.025	1347c-f		1435bc	
Buta fb Rbow	1.5 fb 0.030	1257ef		1533bc	
Buta fb Solito	1 fb 0.320	1457b-f		1533bc	
Buta fb Solito	1 fb 0.480	1302def		1384bc	
Buta fb Solito	1.5 fb 0.320	1372c-f		1688abc	
Buta fb Solito	1.5 fb 0.480	1294ef		1697abc	
Buta fb SHW @ 4 WAS	1	1497b-f		1690abc	
Buta fb SHW @ 8 WAS	1	1726bc		1715abc	
Buta fb SHW @ 4 WAS	1.5	1723bc		1470bc	
Buta fb SHW @ 8 WAS	1.5	1642b-e		1577abc	
Buta fb SHW @ 4 & 8 WAS	1	1711bc		1455bc	
Buta fb SHW @ 4 & 8 WAS	1.5	1535b-f		1400bc	
HWC @ 2, 4, 6 & 8 WAS	–	1691bcd		1581abc	
Weedy check	–	1190f		1238c	
SE ±		230		273	

Means with the same letter in the same column are not significantly different $P < 0.05$ using SNK,

WAS – Week after sowing, SHW – supplementary hoe weeding, HWC – hoe weeded control, Buta - Butachlor

Conclusions

Base on the findings of this research work on upland rice production in the Sudan Savanna tropics, farmers shall apply both pre and post emergence herbicides especially Butachlor at 1.5 kg a.i.ha⁻¹ fb Orizo plus 4.5 kg a.i.ha⁻¹ for better weed management or the use of pre-emergence Butachlor at 1.5 kg a.i.ha⁻¹ fb supplementary hoe weeding at 4 & 8 WAS in places with high density and frequency of stubborn grasses and sedges.

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