Pak. J. Weed Sci. Res., 19(3): 257- 273, 2013

WEED TOLERANCE, SUPPRESSION AND GRAIN YIELD OF INTER AND INTRA SPECIFIC RICE VARIETIES IN NIGERIA

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ABSTRACT

Field experiment was conducted in wet seasons of 2006, 2007 and 2008 to ascertain the weed tolerance, suppression and productivity of inter and intra specific rice varieties, FARO 43, 44, 48, 49 and 55 in Minna, Southern Guinea savanna of Nigeria. The rice varieties were sown at 75cm inter-row and 25cm intra-row distance. The experiment was laid out in a randomized complete block design (RCBD) and replicated four times. The weed types prevalent were 75, 21 and 4% broadleaves, grasses and sedges, respectively. However, broadleaves that were observed to occur in high density were Ageratum conyzoides Linn., Cassia mimosoides Linn., Chromoleana odorata L., Comelina spp., Gladiolus spp., Hyptis suaveolus Poit, Spegilia authelmia Linn., Tephrosia bracteolata Guill & Poir and Tridax procumbens Linn., while the grasses had Brachiara spp., Paspalum spp., Pennisetum pedicellatum Trin and the Setaria pumila (Poir) Reom and Schult were ubiquitous and the sedges were generally low in occurrence. The mean weed density for the three years indicated a significant lower density in FARO 55 compared to FARO 48 at 4 weeks after sowing (WAS) and significant lower weed dry biomass in FARO 44 compared to FARO 43 at the same period. At 10 WAS FARO 43 has significantly lower weed density compared to other varieties while FARO 55 was significantly more suppressive by producing significantly lower weed dry biomass. At 16 WAS, FARO 43, 44 and 55 were at par in the level of weed infestation, however, FARO 55 was significantly most suppressive in terms of weed dry biomass production. FARO 44 had significantly higher number of rice tillers at 9 WAS and lower panicle weight. All the rice varieties had similar grain yield ha^{-1}; however, FARO 48 had significantly higher weight for 1000 grain weight. It is therefore concluded that all the rice varieties were tolerant to weed infestation; however, FARO 55 was significantly much more suppressive than the other varieties.

Key words: grain yield, rice, suppression, tolerance.

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INTRODUCTION

It was reported by FAO (2008) that about one third of world population depends on rice for 50% of their daily calories intake. In Nigeria rice is among the staple food crops and has a great potential to contribute to food security, income generation and poverty alleviation. It is in realization of this, that the Nigerian Government in 2003 procured two tonnes of FARO 55 foundation seeds from the West African Rice Development Association (WARDA) for multiplication and distribution to farmers to actualize the government policy of rice self-sufficiency and for export in 2007 (FAO/WFP, 2004).

In the rain fed slash-and-burn agriculture, reduced fallow periods have aggravated weed pressure and general decline in land quality through soil erosion, nutrients depletion and soil mining (Olderman and Hakkeling, 1990; Vander-Pol, 1992). Increase in population pressure also aggravates the situation, resulting in low and unstable rice yields. Coupled with these factors is the weed competition in rice at subsistence level (Johnson, 1997) which further reduces crop yield and labour productivity. Presence of weed is a constraint and their improper management further accentuates the effect, therefore, efficient weed management is a primary desire of rice farmers. The cultural and chemical methods of weed management in rice in Nigeria are no longer sustainable due to poor resource base of the farmers who cannot afford the cost of hiring labor. These farmers also lack the exquisite technical knowledge about the critical peak of weed interference in rice plants. Also more importantly and fundamentally are the scarcity and expensive labor cost at critical periods of weed interference, the unavailability and prohibitive cost of herbicides and other inputs at critical periods. As a consequence of increased herbicides resistance due to incorrect usage (Labrada, 2003), rising cost of rice production and increased in environmental protection, particularly at this euphobic periods of climatic change, there is need to evaluate rice cultivars being cultivated by small holder farmers for weed tolerance, suppression and productivity with a view to identify those that are weed tolerant and suppressive.

Rice varieties differ in competitive ability with weeds. Attributes such as vegetative vigor, large leaf plant height and high nitrogen absorption at early growth are related to competitive ability (Kawano, 1974). Therefore, the development of competitive rice cultivars could provide a safe and ecologically benign tool for integrated weed management. Jannink *et al*. (2001) have observed that differences in weed suppressive ability could be determined by assessing variation in weed biomass in plots under weed competition. They also asserted that cultivar-weed competitiveness is a function of weed tolerance or the ability of the crop to maintain high yields despite weed competition, while weed suppression is the tendency to reduce weed growth through competition.

Rice and weeds compete for sunlight, water, nutrients and space. This competition reduces rice growth and yield and is more serious in upland rice than in low land rice because water lessens weed growth in low rice. Losses caused by the weeds vary from one country to another, depending on the predominant weed flora and control methods practiced by the farmers. However, (WARDA, 1984) have estimated losses due to weed in low land and upland to be 33-75% and 70-100%, respectively.

The food and Agriculture Organization (FAO, 2008) put global and Africa rice production in 2008 at 613 and 182 million metric tones, respectively. In Nigeria, rice production in terms of cultivated land areas consisted of 48, 30, 16, 5, and 1% rain fed low land; rain fed upland, irrigated fields, deep water and mangrove swamps, respectively (NCRI, 2008). From 1999 to 2007, a total of 12.9 million of hectares of land were cultivated to rice in Nigeria, of which Niger State had a share of 1.5 million representing about 12%. This, therefore, makes Niger State the foremost rice producing state in Nigeria (NFRA, 2009). This was further corroborated by its net output of 3.9 MMT which was 27.8% of Nigerian national rice output within the same periods (FRA, 2009).

This study, therefore, seek to identify rice varieties that could provide a safe and ecologically friendly weed management through tolerance and suppressive ability with sustainable grain yield.

MATERIALS AND METHODS

Field experiment was carried out at the Teaching and Research farms of Federal University of Technology, Gidan Gwano, Minna (Lat. 9° 41'N; Long. 6° 31'E) in the Southern Guinea Savanna of Nigeria during the wet season of 2006, 2007 and 2008. Total rainfall were 1398.0 mm. 2066.0mm and 2472.8mm in 2006, 2007 and 2008, respectively (Table 1) in an elevation of 400m above sea level. The soils of experimental sites were slightly acidic in water and of the sandy clay loam textural class with physical and chemical properties as shown in Table-2.

Table-1. Minna monthly and annual rainfall (mm) during the study periods (2006–08)

Years	Jan.	Feb.	Mar.	Apr.	May	Jun	July	Aug	Sept.	Oct.	Nov.	Dec.	Total
2006	00	00	10.0	96.0	156.0	210.0	257.0	263.0	297.0	102.0	7.0	00	1398.0 mm
2007	00	00	15	109.0	178.0	266.0	352.0	437.0	567.0	237.0	5.0	00	2066.0 mm
2008	00	00	00	80.4	293.6	499.8	610.2	488.6	517.8	282.4	00	00	2472.8 mm

Source: Nimet, Minna (2006, 2007 and 2008)

Table-2. Physical and chemical characteristics of soils of experimental sites
at a depth of (0-15 cm) in 2006, 2007 and 2008 wet seasons at Minna

Characteristics **Physical proper-ties %**	2006	2007	2008
Clay	29.0	30.0	30.0
Sand	51.0	50.0	49.0
Silt	20.0	20.0	21.0
Textural class	SCL	SCL	SCL
Chemical properties			
pH in water (I :.1)	6.3	6.5	6.1
pH in 0.01M $CaCI_2$ (1:2)	5.0	5.2	5.0
Organic Carbon 00	0.89	0.88	0.86
Organic matter %	1.54	1.52	1.49
Available Phosphorus (ppm)	17.85	20.00	19.20
Total nitrogen	0.18	0.23	0.20
Exchangeable cations (Cmol-Kg soil)			
Ca	3.68	2.70	4.00
Mg	1.76	1.50	2.00
K	0.35	*OAO*	0.33
Na	0.0087	0.05	0.008
Exchangeable acidity	13.20	12.00	14.25

SCL = Sandy Clay Loam

The site was located on a gently undulating plain and drained by overland flow into a natural depression down the slope. The natural vegetation consisted of savanna grassland interspersed with many trees and shrubs. The plots were previously grown to soybean and groundnut and left fallow for three years prior to this study. The natural bush re-growth at the end of the fallow period consisted of broadleaves, grasses and sedges (Table-4).

Weed types and distribution

The fields were surveyed for weed types and distribution by random placement of a meter square quadrat and all the weed species found inside the quadrat were counted and identified. The average of weed species found within the quadrat was scored visually on a 1-9 scale, where 1-3 = low density, 4-6 = medium density and 7-9 = high density (Table-4). The weed species were identified using weed identification guide books (Shashina, 1989; Akobundu and Agyakwa, 1997).

Land preparation and cultural practices

The existing vegetation on the sites was cleared using cutlass and ridges constructed with hand hoe. The experimental plot was 7.5 m x 2 m (15 m^2) made of five ridges of 2 m long each with inter-row spacing of 0.75 m, inter plot interval of 0.75 m and inter block interval of 1.50 m. Five rice varieties; FARO 43, 44, 48, 49 and 55 (NERICA 1) were evaluated for weed tolerance and suppression. The rice varieties were seed dressed using Apron star, a fungicide/insecticide mixture of 200 g/kg thiamethoxam + 200 g/kg Metalaxyl-M + 20 g/kg difenoconazole at the rate of 2.5 g/kg of rice seed.

The rice varieties were sown at the rate of 60-70 kg/ha at 0.75 m inter-row and 0.25 m intra-row spacing and thinned to six plants per stand at 4 weeks after sowing (WAS). Two weedings were manually carried out at 4 and 10 WAS using hand hoe. Fertilizer was band applied at 4 WAS immediately after first weeding operation as recommended by FPDD (1987) for southern guinea savanna. The experimental plots received a uniform application of 20 Kg N, 20 Kg P_2O and 40 Kg K_2O ha^{-1} of NPK 15:15:15. This rate of fertilizer was applied in view of moderate total nitrogen, available phosphorus and low potassium observed in the analyzed soil samples from sites (Table-2). The experiment was laid out in randomized complete block design (RCBD) and replicated four times.

Data collection

Weed density and dry biomass were determined at 4, 10 and 16 WAS. Weed dry biomass was determined by sun drying the harvested weeds within 1 m^2 quadrat and removing the roots before oven drying to a constant weight. Rice plant height was measured at 9 and 16 WAS, also number of tillers were recorded at 9 WAS, while yield parameters such as panicle length, number of spikelets per panicle, panicle weight, rice grain yield and 1000 grain weight were taken.

Vertebrate pest control

The menacing activities of rodents particularly cane rats *(Thryonomys swinderianus* Temmick) and the black rats *(Rattus rattus* L.) were controlled by keeping the entire field borders one meter free of bushes coupled with the use of baited snap-back traps. For the birds, scarecrows and flash tapes were displayed in the air within the fields to scare away migratory and highly gregarious village weaver bird, *(Ploceus cucullatus* Muller), black-headed weaver *(Ploceus melanocehalus* L.), red-billed quealea *(Quealea quealea* L.), red-headed quealea *(Quealea erythrops* Hartlaub) and the red-bishop *(Euplectes orix* L.). These were further checked by spraying 150 ml of a monocrotophos insecticide (Vitacron) in 20 litres of water on the rice panicles at milk stage, using lever operated knapsack sprayer (CP 15).

Data Analysis

All data collected were subjected to analysis of variance (ANOVA) using computer software, Statistical Analysis Systems (SAS),(2002) and Fisher's least significant difference (FLSD) at 5 % level of probability was used to separate the treatment means (Akindele, 1996).

RESULTS AND DISCUSSION

Weed occurrence in experimental sites

Morphologically, three classes of weeds were identified; broadleaves, grasses and sedges. However, broadleaves with high density of occurrence were *Ageratum conyzoides* Linn., *Cassia mimosoides* Linn., *Chromoleana odorata* L., *Commelina* spp., *Gladiolus* spp., *Hyptis suaveolus* Poit, *Spegilia anthelmia* Linn., *Tephrosia bracetolata* Guill & Poir and *Tridax procumbens* Linn. The grasses with high density of occurrence were *Brachiaria* spp, *Paspalum* spp., *Pennisetum pedicellatum* Trin. and the obiquitous *Setaria pumila* (Poir) Reom and Schult, the sedges were low in density (Table-3).

Almost all the weeds associated with the rice crop are C_4 plants unlike rice which is a C_3 plant. The implications or the inability of rice plants to compete with these weeds might be related to their physiology of photosynthesis. The C_4 plants are more efficient at taking up carbon dioxide than C_3 plants. These weeds (C_4 plants) could remove carbon dioxide from atmosphere down to 0.1 parts per million (ppm) compared with the 50-100 ppm of rice plants (Taylor *et al.,* 2002). Second, the carbon dioxide- acceptor for these weeds is phosphoenlpyruvate (PEP) and the enzyme is PEP carboxylase which is much more efficient than the enzyme of rice plants. The carbon dioxide- acceptor for rice plant is ribulose biphosphate (RuBP) and the enzyme is RuBP carboxylase. PEP carboxylase has a much higher affinity for carbon dioxide and is not competitively inhibited by oxygen unlike RuBP carboxylase (Taylor *et al.,* 2002) hence the ability of these weeds to dominate and prevail over rice and reduce its yield. Also C_4 plants have much more efficient mechanisms for CO_2 scavenging and water conservation by restricting stomatal aperture at high temperatures Ware (2000).

The soils of the site was suitable for the production of rice, Idoga *et al.* (1998) and FPDD (1989) have reported that soils of basement complex origin are generally more fertile than those formed from shale or sandstone. Those soils that are of basement complex origin are formed *in situ* and are therefore not easily leachable (Idoga *et al.,* 1998).

The sandy clay loam textural class of the sites could be explained in context of the sandy nature of their parent materials and the constant deposition of recent alluvial material through fluvial processes. This is quite obvious since the site finally drains into rivers Niger. The textural class of site was also in concordance with the findings of Angulu (2003) and Idoga *et al.* (1998). Idoga *et al.* (1998) however, postulated that the clay distribution suggests a picture of a young soil undergoing the processes of pedogenic eluviation and illuviation. The soil textural class is suitable for upland rice cultivation provided there is adequate water from rain or irrigation Idoga *et al.* (1998).

The moderately to slightly acidic soil reactions could be due to moderate precipitation which is not enough to warrant appreciable leaching of exchangeable bases from the surface layer of soils. The pumping effect of vegetation returning bases to the surface could also be responsible for this pH range in the sites (Jones and Wild 1975). Similar soil reactions were reported by Odofin (2005) and Angulu (2003). NCRI (2008) recommended a pH range of 5.5 - 6.5 for upland rice production in southern guinea savanna of Nigeria.

Generally, soils derived from basement complex have peculiar low levels of organic carbon and matter. Also, the low levels of organic carbon and matter could be due to rapid organic matter mineralization and the effect of bush burning on the upland soil (Esu and Ojanuga, 1985). Recurrent bush burning and cattle grazing are common phenomena lending credence to the low levels of organic matter in the southern guinea savanna of Nigeria. The moderate levels of available P and total N in the study areas were in conformity with the fertility map of Nigeria (FPDD, 1989) because Minna falls within the available P and total N deficient areas. The moderate impacts of these minerals might be due to research activities on the site. The low Ca in the site is peculiar to southern guinea savanna of Nigeria (Adeoye and Chude, 2006) and it is an indication of the soil acidity profile which is not enough to adversely affect rice nutrition which is usually the deficiency of essential plant nutrients and toxicity of minor elements FPDD (1989). The Na content in site was very low probably as a result of adequate rainfall in the area. In general, the cations exchangeable complex corroborates the findings of Fagbami and Akamigbo (1986).

Table-3. Weed species occurrence in 2006, 2007 and 2008 wet season at Minna

Broadleaves	**Family**	**Life –form**	**Density**
Acanthospermun hispidum DC	Asteraceae	Annual	+
Ageratum conyzoides Linn.	Asteraceae	Annual	+++
Amaranthis spinusus Linn.	Amaranthhaceae	Annual	+
Aspilia africana (Pers.) C.D Adams	Asteraceae	Annual	+
Boerhavia diffusa L.	Nyctaginaceae	Annual	++
*Blumea urita(*Linn. F.) DC	ASteraceae	Annual	+
Cassia mimosoides Linn	Caesalpiniaceae	Annual	+
*Chromoleana odorata (*L.)	Asteraaceae	Perennial	+++
Commelina spp	Commelinaceae	Annual	+++
Cleome viscose L.	Cleomaceae	Annual	++
Daniella oliveri (Rolfe) Hutch & Dalz	Caesalpiniaceae	Perennial	+
Desmodium scorpiurus (SW)	Eabaceae	Annual	+
Euphorbia hetrophylla Linn.	Euphorbiaceae	Annual	+
Euphorbia hirta Linn	Euphorbiaceae	Annual	++
Gladiolus spp	Aracceae	Perennial	+++
Gomphrena celosoides Mart.	Maranthaceae	Annual	
Hyptis suaveolus Poit.	Lamaiaceae	Annuall	+++
Indigofera spp	Fabaceae	Annual	+
Ipmoea spp	Convolvulaceae	Annual	+
Ludwigia spp	Onagraceae	Annual	+
Malvastrum coromandelianum (Linn.) Garcke	Malvaceae	Annual	++
Malanthera scandens (Shum &Thonn) Vatke	Asteraceae	Perennial	++
Momordica charantia Linn.	Cucurbitaceae	Annual	+
Nauclea latifolia Sm.	Rubiaceae	Perennial	+
Oldlandia herbacea (Linn) Roxb	Rubiaceae	Annual	+
Pentodoon pentandrus (Schum. & thonn) Vatke	Rubiaceae	Annual	+
Piliostigma thonningii (Schum) Milne-Redhead	Caesalpiniaaceae	Perennial	++
Prosopsis Africana	Fabacaeae	Perennial	+
Phyllanthus amara Schum *et* Thonn.	Euphorbiaceae	Annual	+
Sida corymbosa. E. Fries	Malvaceae	Annual	+
Spegila anthelmia Inn.	Loganiaceae	Annual	+++
Synedrell anodiflora Geartn	Asteraceae	Annual	++

Tephrosia bracteolate Guill & Peir	Fabaceae	Annual	+++
Tridax procumbens Linn.	Asteraceae	Annual	+++
Urena lobata Linn.	Malvaceaeae	Annual	++
Vernonia spp.	Asteraceae	Annual	++
Vtellaria paradoxum (Gearth .F.) Hepper	Sapotaceae	Perennial	+
Vitex doniana sweet.	Verbenaceae	Perennial	+
Grasses			
Andropogon gayanus Kunth	Poaceae	Perennial	+
Brachiaria Spp.	Poaceae	Annual	+++
Digitaria horizontalis Willd.	Poaceae	Annual	+
Eragrostis spp.	Poaceae	Annual	++
Hyparrthennia involucrate Stapf.	Poaceae	Annual	+
Panicum spp.	Poaceae	Annual	+
Paspalum spp.	Poaceae	Annual	++
Pennisetum pedicellatum Trin.	Poaceae	Annual	+++
Perotis indica (Linn) O. Ktze.	Poaceae	Annual	++
Rottboellia spp	Poaceae	Annual	+
Setaria pumila (Poir) Roem & Schult	Poaceae	Annual	+++
Sedges			
Cyperus spp	Cyperaceae	Perennial	+
Mariscus spp	Cyperaceae	Perennial	+

+ = Low density, ++ = Medium density, +++ = High density

Results of selected characteristics of soil used for the trials are shown in Table-2. The soil was sandy clay loam textural class slightly acidic in water. The organic carbon and organic matter were low. The available P and total N were moderate. Calcium and magnesium was low. The K was low while sodium was very low. The exchangeable acidity was moderate.

Weed density and dry biomass at 4 WAS

In 2007, a significant higher weed density was observed in FARO 49 than FAROs 43, 44 and 55 but similar to FARO 48. The weed densities were similar across the years except FARO 55 that had significantly lower density. The weed dry biomass were similar in all the three seasons.

The insignificant levels of weed density at 30 DAS could be probably attributed to the soil weed seed bank status at the time of study. The site has been areas of intensive cultivation and annual routine bush burning which consequently imposed a near constant in the soil weed seed bank.

The attainment of significant higher number of tillers in upland rice varieties in 2007 could be ascribed to appropriate seeding depth and adequate soil moisture at the time of sowing. Mahapatra and Shrivastra (1983) observed that to obtain a uniform stand and more shoot tillers, there must be adequate moisture. The lower number of tillers observed in 2006 was due to low soil moisture at seeding periods as a consequence of delayed rainfall (Table-1). Sowing of rice depends upon enough rain to soak the topsoil, however in the tropics onset of rain is erratic such that rice is seeded in dry seed beds (Mahapatra and Shrivastra, 1983). They further observed that tillering is said to be inhibited if seeds are sown in dry soil.

Table-4. Weed density and dry biomass at 4 WAS in 2006, 2007 and 2008 cropping seasons at Minna

Treatments	Weed density (N/m^2)				Weed dry biomass(g/m^2)			
Rice variety	2006	2007	2008	Mean	2006	2007	2008	Mean
FARO 43	31.0	28.8	31.3	30.3	21.8	11.7	8.6	14.0
FARO 44	36.3	30.5	34.5	33.8	14.8	8.3	7.2	10.1
FARO 48	33.0	35.0	35.5	34.5	22.2	8.4	9.8	13.5
FARO 49	28.0	41.3	33.5	34.3	18.8	7.8	6.7	11.1
FARO 55	25.0	31.3	31.0	29.1	21.6	8.1	6.9	12.2
SE (±)	4.7	3.3	3.3	2.2	3.4	2.2	1.3	1.4
LSD (5 %)	Ns	8.2	Ns	5.2	Ns	Ns	Ns	3.3

NS = Not significant at P = 0.05, SE (±) = Standard error of the mean.

Weed density and dry biomass at 10 WAS

Weed density in 2006 and 2007 were similar, in 2008 season FARO 43 had significantly lower weed density than FARO 49 and 55. The means for the years showed a significant lower weed density in FARO 43 than 49 and 55. In 2006 FARO 44 had greater weed dry biomass than FARO 48 only while in 2007 FARO 48 had significantly greater weed dry biomass than FARO 55 only. The weed dry biomass in 2008 and the mean of the three years were significantly higher in FARO 48 than all other varieties except FARO 44, respectively.

Table-5. Weed density and dry biomass at 10 WAS in 2006, 2007 and 2008 cropping seasons at Minna

Treatments	Weed density (N/m^2)				Weed dry biomass (g/m^2)			
Rice variety	2006	2007	2008	Mean	2006	2007	2008	Mean
FARO 43	44.3	45.3	46.0	45.2	85.4	140.8	109.4	111.8
FARO 44	52.8	54.8	52.5	5.·U	97.5	149.0	118.7	121.7
FARO 48	50.0	58.8	56.0	54.8	78.9	167.7	144.7	130.4
FARO 4f)	55.8	57.8	59.0	57.5	80.8	139.3	122.0	114.0
FARO 55	49.5	61.8	61.5	57.6	89.1	121.3	101.0	103.8
SE (±)	4.5	4.7	3.2	2.5	7.0	14.6	8.9	6.3
LSD (5%)	11.3	11.9	8.2	5.9	17.7	36.7	22.5	15.0

P = 0.05, SE (±) = Standard error of the mean.

Weed density and dry biomass at 16 WAS

In 2006, FARO 49 produced significant higher weed density than FARO 43 at 16 WAS (Table-6). In 2007, 2008 and the mean of the three years FARO 43.44 and 55 significantly had lower weed density compared to FARO 49. In 2006 wet season weed dry biomass observed in FARO 44, 48 and 49 were similar but significantly higher than those in FARO 43 and 55 (Table-6). In 2007 season, there was a significantly higher weed dry biomass in FARO 43 than all other varieties which were similar. In 2008, there was similar weed dry biomass in all the rice varieties except for FARO 48 which significantly had lower weed dry biomass. The mean of the three years shows FARO 44 and 55 produced significant lower weed dry biomass than FARO 48 while FARO 43, 44 and 49 were similar. Also FARO 55 significantly had lower weed dry biomass than all other rice varieties.

Table-6. Weed density and dry biomass at 16 WAS in 2006, 2007 and 2008
cropping seasons at Minna

Treatments	Weed density (N/m^2)				Weed dry biomass (g/m^2)			
Rice variety	2006	2007	2008	Mean	2006	2007	2008	Mean
FAR043	36.8	40.0	33.0	36.6	41.7	94.7	73.1	69.8
FARO 44	45.3	37.0	32.8	38.3	67.7	67.0	66.6	67.1
FARO.+8	42.5	48.5	40.0	43.7	54.2	78.3	93.0	75.2
FARO.+9	48.3	50.5	43.5	47.4	60.2	75.9	73.8	70.0
FARO 55	41.8	42.0	36.5	40.1	37.6	61.1	63.4	54.0
SE (±)	4.5	2.6	2.5	1.9	6.3	5.2	4.0	3.2
LSD (5 %)	11.4	6.6	6.4	.+.5	15.8	13.1	10.1	7.7

P = 0.0.:5. SE (±) = Standard error of the mean

Rice plant height at 9 and 16 WAS.

In 2006, at 9 WAS FARO 48 consistently maintained significantly taller plant height compared to other rice varieties while FARO 43, 49 and 55 were similar in height but taller than FARO 44 (Table-7). In 2007, the rice varieties had similar plant height except FARO 44 which was shorter than all others. In 2008, FARO 49 was significantly taller than all the other varieties except FARO 48. At 9 WAS across the years showed that FARO 48 and 49 were significantly taller than all the rest while FARO 44 was significantly shorter than all others. FARO 43, 49 and 55 had similar height (Table-7). At 16 WAS in 2006 FARO 48 and 43 were significantly taller compared to others while FARO 49 and 55 had similar plant height (Table-7). In 2007, FARO 43 and 44 were taller than other varieties which were at par. In 2008 FARO 43 was significantly taller than other varieties which were similar in height. The results showed that FARO 43 had the tallest rice plant across the three years when compared to other varieties. FARO 44, 49 and 55 had similar plant height.

Table-7. Rice plant height (cm) at 9 and 16 WAS in 2006, 2007 and 2008
cropping seasons at Minna

Treatments Rice variety	**Plant height at 9 WAS (cm)**				**Plant height at 16 WAS (cm)**			
	2006	**2007**	**2008**	**Mean**	**2006**	**2007**	**2008**	**Mean**
FARO 43	78.0	65.0	63.3	68.8	98.8	108.3	106.4	104.6
FARO 44	39.0	46.3	48.0	44.7	70.0	105.5	96.0	90.3
FARO 48	87.3	66.3	68.3	73.9	101.5	94.5	96.5	97.5
FARO49	75.3	72.5	70.8	72.8	86.5	95.0	96.5	92.3
FARO 55	74.3	66.3	65.3	68.6	87.3	91.5	92.4	90.4
SE (±)	2.1	2.5	1.4	1.4	1.8	2.3	2.0	1.2
LSD (5%)	5.3	6.3	3.4	3.4	4.6	5.8	5.0	2.8

P = 0.05. SE (±) = Standard error of the mean

Rice shoot tiller at 9 WAS

The number of tillers produced in 2006 was statistically higher in FARO 43 and 44 compared to those of FARO 49 and 55 while in 2007 FARO 44 and 49 had similar number of tillers which were significantly more than that of FARO 48 (Table-8). However, FARO 43, 48 and 55 had similar number of tillers. In 2008, FARO 44 again had significantly more tillers than all others. Across the three years FARO 44 was most prolific in terms of tiller production than the rest varieties.

Table-8. Number of rice shoot tillers at 9 WAS in 2006, 2007 and 2008 cropping seasons at Minna

Treatments	No. of tillers			
Rice variety	2006	2007	2008	Mean
FARO 43	15.8	29.5	29.5	24.9
FARO 44	15.8	33.3	37.5	28.8
FARO 48	14.0	27.8	28.0	23.3
FARO 49	12.3	32.5	30.5	25.1
FARO 55	13.3	31.8	30.5	25.2
SE (±)	0.5	1.3	0.6	0.6
LSD (5%)	1.3	3.2	1.5	1.4

P = 0.05, SE (±) = Standard error of the mean

Rice panicle length, number of spikelets per panicle and panicle weight

In 2006, all the rice varieties produced similar panicle lengths, except FARO 48 and 49 that produced shorter panicles while in 2007, 2008 and across the three years FARO 43 and 44 had significant longer panicles than other varieties (Table-9). The other three rice varieties had similar panicle length across the three years. Also in 2006, FARO 43, 48 and 49 produced similar and significantly higher number of spikelets compared to FARO 44 only, which was similar to FARO 55 (Table-9). In 2007, FARO 43, 48 and 55 significantly had higher number of spikelets compared to FARO 44. The number of spikelets was significantly higher in FARO 43 than in FARO 44 and 48 while FARO 48, 49 and 55 produced similar number of spikelets. In 2008 and the mean of the three years, the number of spikelets were significantly more in FARO 43 than other varieties except in FARO 55(Table-9). FARO 48 and 49 had similar number of spikelets which were greater than that of FARO 44 in 2008 and the mean of the three years.

In 2006 all the rice varieties except FARO 44 had similar panicle weights which were significantly heavier than FARO 44 (Table-9). In 2007, all the rice varieties produced similar panicle weight except FARO 44 while in 2008; FARO 43, 48 and 49 had heavier panicles than FARO 44, which was similar to FARO 55. The panicle mean weight of the three years shows that rice varieties FARO 43, 48, 49 and 55 produced significantly heavier panicles than FARO 44.

FARO 44 and 43 generally had more spikelets per panicle and number of panicles (Table-9). Adeosun and Lagoke (2005) had reported spikelet production to be positively correlated with efficient weed management. Therefore, it is probable to assert that spikelet production was more a function of better weed management. It is therefore apt to postulate that the rice varieties responded to individual spikelet production potential. This work disagrees with Adeosun and Lagoke (2005) that the longer the panicle the more number of spikelets. It is pertinent to state here that FARO 44 was deviation from Adeosun and Lagoke (2005) preposition because it generally had longer panicle and fewer spikelets. FARO 44 generally had significantly longer and less panicle weight probably because of its small seed size and fewer spikelets while FARO 49 had heavier panicles because of its larger seeds. This is probably an inherent genetic potential of each rice cultivar than weed management functions.

Table-9. Rice panicle length (cm), number of spikelets/panicle and panicle weight in 2006, 2007 and 2008 cropping seasons at Minna

Treatments	Panicle length (cm)				No. of spikelets/Panicle				Panicle weight (g)			
Rice variety	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean
FARO 43	23.5	24.3	24.8	24.2	13.8	11.7	12.6	12.7	4.7	3.6	3.7	4.0
FARO 44	23.4	23.6	24.0	*13.7*	11.3	9.6	9.9	10.2	2.8	2.6	2.7	2.7
FARO 48	21.2	21.3	22.0	21.5	13.3	11.0	11.7	12.0	4.8	3.7	3.9	4.1
FARO 49	21.6	20.6	21.4	21.2	13.3	10.9	121	12.1	4.8	3.6	3.9	4.2
FARO 55	22.2	20.6	21.2	21.3	12.5	12.2	12.3	12.3	5.1	3.3	3.1	3.7
SE (±)	0.7	0.7	0.4	0.3	0.5	0.4	0.2	0.2	0.3	0.4	0.2	0.2
LSD (5%)	1. 7	1. 7	1.0	0.8	1.3	0.9	0.5	0.5	0.7	0.9	0.6	0.4

P = 0.05, Se (±) = Standard error of the mean

Rice grain yield and 1000 grain weight

In 2006 FARO 48 again manifested significant higher grain yield compared to the other four varieties (Table-10). However, FARO 43, 49 and 55 were at par. The grain yield in 2007 was significantly higher in FARO 44 compared to in FARO 48 and 55, which was similar to those in FARO 43 and 49. In 2008, FARO 48 and 49 significantly produced higher grain yield than rice varieties FARO 43, 44 and 55. The mean grain yield of the three years in FARO 55 shows the lowest grain yield which was significantly lower than those in FARO 44, 48 and 49.

The rice 1000 grain weight in 2006 showed that FARO 48 had significantly heavier 1000 grain compared to other varieties (Table-10). FARO 49 was significantly heavier than FARO 43 and 55, which were also significantly heavier than FARO 44. In 2007 and 2008, FARO 48 and 49 significantly had heavier 1000 grain than those in FARO 43, 44 and 55, except in FARO 43. However, significant heavier 1000 grain was observed in FARO 48 compared to other varieties across the three years at (Table-10).

All the rice varieties had significant higher grain yield in 2007. This is as a result of weed control due to non coincidence of rains during weeding operations and thus did not create conditions that favoured weed re-establishment (Table-3). FARO 48 significantly had higher grain in all the seasons, probably because of its short plants which might be an exceptional advantage in photosynthesis for grain filling rather that vegetative growth. To determine the extent of yield reduction caused by weeds in rice varieties of different plant heights a trial was conducted by Ahmed and Hoque (1981) in which the results indicated that yield reduction from weeds was 0.25 t/ha^{-1} in the tallest variety, 0.46 t/ha^{-1} in intermediate plant height and 0.68t/ha^{-1} for shortest variety. However, Labrada (2006) reported contrary observation that short statured and erect leaved rice varieties permitted more light penetration compared to tall and leafy ones and that yield reduction by weeds was less in an improved dwarf-rice cultivar which was probably the case in this study.

The decline in grain yield in other varieties in 2006 and 2008 might be due to more vigorous intra and inter competition between rice plants and weeds respectively, (Kehinde, 2002). Another impediment to grain yield in the rice was the menacing activities of rodents particularly cane rats *(Thryonomys swinderianus* Temmick) and the black rats *(Rattus rattus* L.) which feeds on the rice plants. The rodents however, were controlled by keeping the entire field borders meter free of bushes and use of baited snap-back traps. For the birds, the use of scarecrows and flash tapes was not effective against the migratory and highly gregarious village weaver bird. *(Ploceus eucullatus* Muller), black-headed weaver, *(Ploceus melanocehalus* L.), red-billed quealea *(Quealca quealea* L), Red-headed quealea *(Quealea erythrops* Hartlaub) and the red-bishop *(Euplectes orix* L.).

Generally, FARO 48 and 49 consistently had superior higher weights for 1000 grains compared to others (Table-10). FARO 48 was marginally heavier because of its large seed size. Adeosun and Lagoke (2005) had reported that differences in 1000 grain weight might be attributable to varying yield potential of each rice cultivar than efficient weed management.

Table-10. Rice grain yield (Kg/ha) and 100 grain weight in 2006, 2007 and 2008 cropping seasons at Minna

Treatments Rice variety	Rice grain yield Kg/ha				1000 grain weight (g)			
	2006	2007	2008	Mean	2006	2007	2008	Mean
FARO -+3	751.4	1266.7	523.7	847.3	26.5	27.3	25.9	26.6
FARO 44	490.6	1638.9	553.3	894.3	23.1	24.0	22.8	23.3
FARO 48	1015.3	883.3	729.6	876.1	31. 7	35.7	29.9	32.4
FARO 49	716.4	1230.6	723.2	890.0	27.6	34.7	29.3	30.5
FARO 55	614.4	913.9	598.1	708.8	25.7	27.7	25.6	26.4
SE (±)	52.8	188.5	34.1	65.0	0.3	1.1	0.8	0.5
LSD (5%)	133.0	475.0	86.0	NS	0.8	2.8	2.0	1.1

P = 0.05, SE (±) = Standard error of the mean

CONCLUSION

The conclusion is that all the rice varieties were tolerant to weed infestation. The rice variety 'FARO 55' was though more suppressive than the rest of the varieties studied.

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