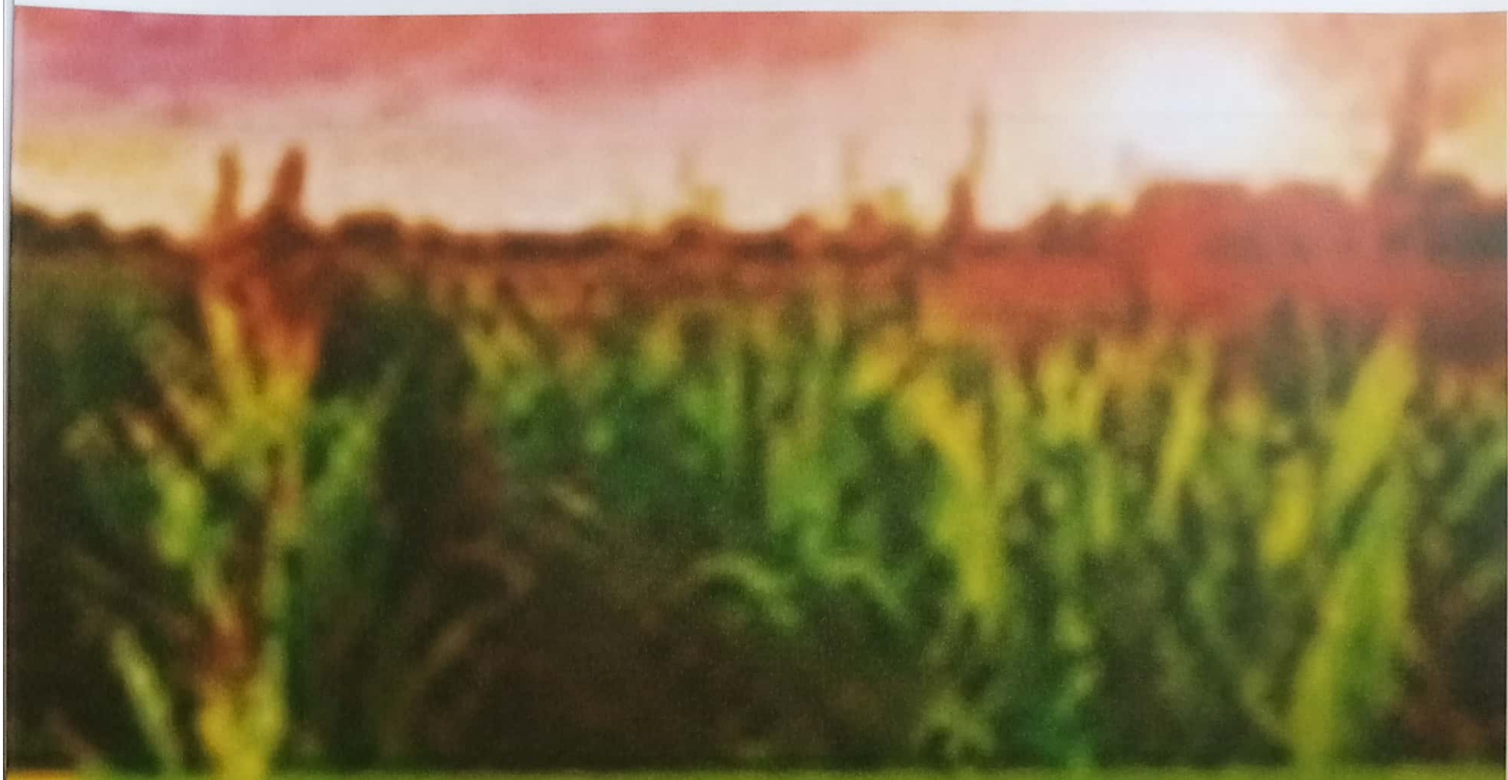

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RESEARCH

Upland Rice (*Oryza sativa* L.) Varieties Response to Weed Management Practices and Plant Stand Densities in a Moist Savanna of Nigeria

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Abstract

Planting of weed- competitive rice cultivar at optimum seedling per hill is an efficient weed management practice that can contribute to weed suppression and increased grain yield. A study was conducted on a farmer's field at Badeggi, Nigeria to determine the response of upland rice varieties to weed management practices and plant stand densities. Lower weed dry matter was observed in NERICA 7 compared to NERICA 1, 2 and 4. While NERICA 4 produced more tillers, NERICA 1, 4 and 7 produced longer panicles and NERICA 7 more grains per panicle. Higher grain yield was associated with NERICA 1 and 4 varieties. Hoeing at 3 and 6 weeks after sowing (WAS) and application of pre-emergence (PE) butachlor followed by (fb) hoeing at 6 WAS reduced weed dry matter production compared to the weedy check. Production of longer panicles, more grains and higher grain yield were associated with PE butachlor fb post-emergence (POE) Orizoplus, PE butachlor fb hoeing at 6 WAS, and hoeing at 3 and 6 WAS. Weed dry matter produced was generally low with six plant stands per hill treatment. Two and four plant stands per hill produced panicles with more grains, while four and six plant stands per hill produced plants with more panicles and grains per unit area. This result suggests that NERICA 7 combined with hoeing at 3 and 6 WAS orapplication of PE butachlor fb hoeing at 6 WAS, and 6 plant stands per hill can effectively control weeds. The use of NERICA 1, NERICA 4 in combination with PE butachlor fb POE Orizoplus, or hoeing at 3 and 6 WAS and 4 or 6 plant stands per hill resulted in increased grain yield of upland rice.

Keywords NERICA · Plant stand · Upland rice · Variety · Weed management

Introduction

Rice (*Oryza sativa* L.) is a crop of global importance and serves as the basis of life for half of the world's population. West Africa accounts for 64.2 % and 61.9 % of total rice production and consumption in Sub-Saharan Africa, respectively (Norhidayati et al., 2015). Except for Burkina Faso and Niger, rice is a staple crop throughout West African countries. In West Africa, Nigeria ranks highest as the producer and consumer of the commodity with figures slightly above 50 % (Udemezue, 2018). In recent times, rice consumption in Nigeria has risen tremendously, at about 10 % per annum due to changing consumer preferences as a result of population growth rate (+2.8 % per annum), and increasing per capita consumption (+7.3 % per annum) (Ajala & Gana, 2015; Udemezue, 2018).

In a survey of upland rice producing countries covering 80 % of the total production area, weeds were the most widely reported biological constraint to yields. Upland rice, in particular, competes poorly with weeds such that uncontrolled weed growth often results in negligible or zero yields (Kapila et al., 2020; Kolo & Umaru, 2012; Tilahun & Kifle, 2015). Elsewhere in West Africa, yields of upland rice with farmers' weed were 44 % lower than on-station researcher weeded plots. Mola and Belachew (2015) reported that losses due to uncontrolled weed growth in upland rice were up to 90 % in India, and in both lowland and upland systems elsewhere in Africa losses due to weed infestation were 28–100%. To address the challenge of low rice productivity in Africa rice areas, West Africa Rice Development Association (WARDA) introduced New Rice for Africa (NERICA) varieties.

Rice is a weak weed—competitive crop. However, several studies have revealed the existence of genetic variation in weed competitiveness among rice cultivars grown in the

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sub-Sahara Africa (Saito et al., 2010). A group of rice cultivars that has the morphological plasticity of canopy development, and combines the weed suppression ability are the NERICA rice cultivars (Amadou et al., 2011). The differences between rice cultivars in response to weed competition have been recognized by several workers (Gulshan et al., 2014). Generally, cultivars may perform differently in different regions and growing conditions. Therefore, choosing a competitive crop could be a way to potentially suppress weed growth without sacrificing crop yield (Anchal et al., 2017). Yet identification of the number of weed—competitive rice cultivars with high adaptation to the African agro – ecosystems is still limited (Amadou et al., 2011).

Planting of rice at optimum densities is a major yield attribute determinant in rice production and different genotypes show differential responses to increasing plant densities per unit area (Oghalo, 2011). Optimum plant density in terms of spacing and number of seedlings per hill are key factors that determine upland rice production (Dejen, 2018; Matsumoto et al., 2017). It is also claimed that number of plants per hill can influence tillers formation and solar radiation intercept (Danmaigoro et al., 2015). Similarly, plant population and number of seedlings per hill can influence stand geometry, increase tiller population per unit area for higher rice yield (Dejen, 2018). Whereas lot of information is available on the effect of plant density in lowland rice, there has been little information available on optimum plant population effect in upland rice population (Matsumoto et al., 2017).

To reduce weed infestation in direct seeded rice production, judicious weed management is required in achieving increased crop yield and sustained food security in the world (Tahir & Pompe, 2015). Numerous weed management practices in rice production have been reported by Chauham et al. (2010). For example, hand weeding is an effective method in controlling weeds in rice; it is however, limited by the numerous economic and technical issues associated with it (Za-Ul-Haq 2019). In case of chemical weed control method, several pre-emergence herbicides such as Pendimethalin, Oxadiazon, Butachlor and Nitrofen among others have been found to be effective in controlling weeds in rice (Tahir & Pompe, 2015; Za-Ul-Haq, 2019). For effective control of all types of weed species in rice production, sequential application of herbicides alone or in mixture of two or more along with other cultural practices is necessary (Tahir & Pompe, 2015; Za-Ul-Haq, 2019). If optimum conditions for pre-emergence herbicides application are not available, post-emergence herbicides application may be better option to manage the several weed species in rice fields (Mahajan and Chauhan, 2013).

Therefore, the present study was undertaken to evaluate the combined effect of weed control treatment and plant stand density on weed suppression, growth and yield of some upland rice varieties.

Materials and Methods

Experimental Site

The experiment was carried out in a farmer's field, near National Cereals Research Institute (NCRI), Badeggi (Lat. 9° 45N, Long. 6° 07E; 70.5 m above sea level), located in moist Savanna of Nigeria. Field trial was conducted during the rainy seasons of 2017 and 2018. The total rainfall received during the crop growing period from June to October was 790 mm in 2017 and 1115.3 mm in 2018 (Fig. 1). The average air temperature during the experimental period was 13.5 to 18.1°C in 2017 and 11.4 to 20°C in 2018 (Fig. 2). Prior to field establishment, the soil of the experimental site in 2017 was sandy clay in texture. The soil reaction was 6.64. Organic carbon was also 0.61 g kg^{-1}, total nitrogen was 0.12g kg^{-1}available P_2O_5 was 55.25 ppm and exchangeable potassium was 0.23 Cmol kg^{-1}. The soil of the experimental site in 2018 was sandy clay in texture. The soil reaction was 6.70. Organic carbon was also 0.51g kg^{-1}, available nitrogen was 0.15g kg^{-1}, available P2O5 was 56.3 ppm and exchangeable potassium was 0.15 Cmol kg^{-1}.

Treatments and Experimental Design

The experiment was initiated in the third week of June in each year of study. The treatments were a factorial combination of four early maturing upland rice varieties: NERICA 1, 2, 4, 7 and four weed management practices: weedy check, pre-emergence (PE) application of butachlor at 2.0 kg a.i ha^{-1} followed by (fb) hoe weeding (HW) at 6 weeks after sowing (WAS), 2 HW at 3 and 6 WAS, PE application of butachlor + propanil plus 2,4-D (Orizo Plus, Proficol Calle, Baranquilla, Colombia) at the rate of 3.5 kg a.i. ha^{-1}at 6 WAS using a knapsack (CP3) sprayer and a spray volume of 250 L ha^{-1}at 206 KPa; and three plant stands per hill: 2, 4 and 6 per hill. Main plot treatments were the combination of upland rice varieties and weed management practices, and sub- plot treatments was the plant stands per hill. The treatments were laid in a split-plot design with three replications. Plot size was 3 m × 4 m (12 m^2) consisting of 15 rows of 4 m long each. An alley of 1 m was left between plots and replicates.

Agronomic Practices

The field was cleared of shrubs, ploughed with a tractor and leveled manually into plots. Land preparation was carried out in farmer's field on 15 June 2017 and 2018. The rice varieties NERICA 1, 2, 4, 7 used were obtained from the rice breeding unit, National Cereals Research Institute, Badeggi, Nigeria. The agronomic characteristics of the rice varieties

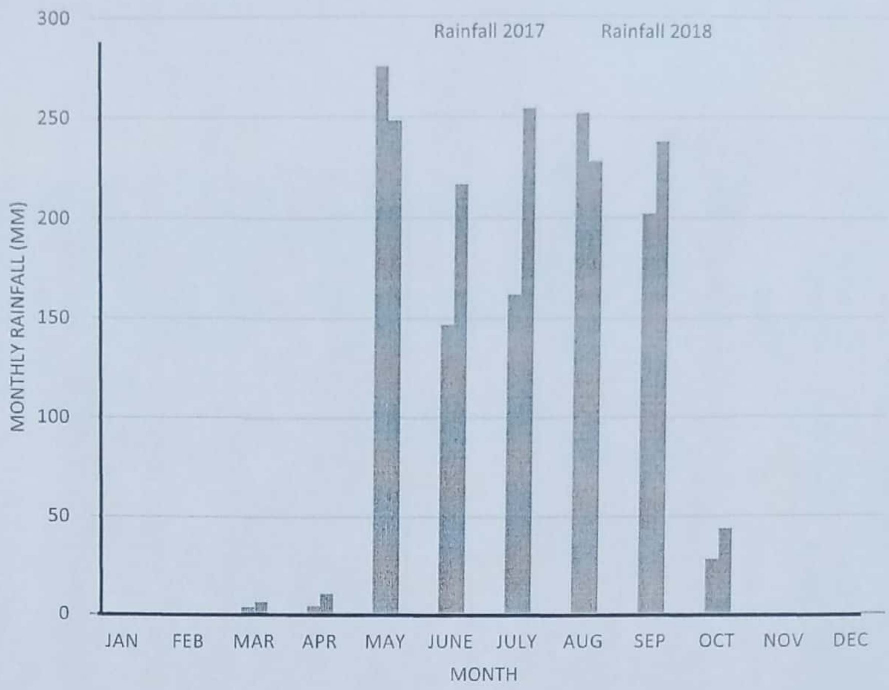

Fig. 1 Average monthly rainfall at Badeggi in 2017 and 2018

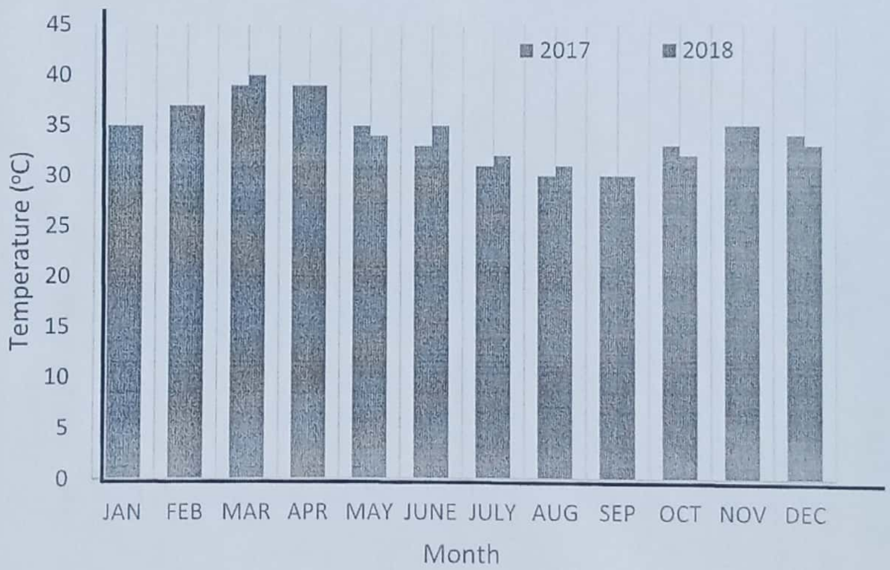

Fig. 2 Average monthly temperature at Badeggi in 2017 and 2018

used i n this study is shown in Table 1. The dry rice seeds were directly sown at 60 kg ha^{-1} by dibbling in rows at 20 cm apart. Fertilizer NPK 15:15:15 was used to supply 60 kg N, 30 kg P2O5 ha^{-1}. A half dose of N and full doses of P2O5 and K2O was applied at (3 WAS), while the other half dose and 30 kg K_2O ha of N was surface applied at 6 WAS. Weeding and herbicide application were carried out according to the treatments.At full maturity, the rice plants were harvested from the net area of 1 × 4 m (4 m^{-2}) per plot after leaving out 5 rows on each side of the plot. This was done when most of the rice plants have turned golden yellow in color using a sickle to cut the stem of the rice plants close to the base.