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RESPONSE OF SELECTED RICE CULTIVARS TO NUTRIENT DEFICIENCY

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Abstract

Majority of rice farmers cannot afford fertilizers to replace nutrients removed from the soils through harvested crops and leaching. It is a global challenge of sustainable rice cultivation to find or develop rice varieties that can grow even with limited nutrients while at the same time maintaining or improving grain yields. This study tried to identify rice cultivars that can perform with half of the recommended agricultural dose of fertilizer in Bauchi, by determining the root and shoot mass and tiller numbers. The experimental materials comprised of Three rice cultivars Faro 55 (Nerica 1), Srilanka, and Faro 44 (Sippi) and Two treatments , 180kg/ha NPK i.e. the recommended agricultural dose of NPK for rice farming in Bauchi (control) and 90kg/ha NPK which is half dose. A split plot experimental design with three replications was used to generate data for this study. Data were collected on Tiller numbers and recorded weekly for each cultivar. Biomass of the shoot and root were also determined. All the cultivars showed resilience to NPK. The findings of this research suggest that NPK fertilizer input of on these cultivars could be reduced. This means that farmers could spend less money to buy fertilizer and as well reduce environmental impact due to excessive usage of the fertilizer.

Keywords: Rice; Full dose (FD), Half dose (HD) NPK

INTRODUCTION

Rice (*Oriza sativa*) is a very important cereal crop which requires nutrients for high productivity. Depleted soil nutrients such as NPK are among the common limiting abiotic factors affecting rice production. Nitrogen is the most deficient essential element in Nigerian soil followed by potassium(Abe *et al.* 2009), which is why NPK application is required in order to obtain good yield. But the price of inorganic fertilizer (NPK) is expensive and thus not within the reach of most farmers in developing world. This has caused decline in rice production over the years. This problem is exacerbated by the ever increasing population in Africa and the number of mouth to feed. A number of steps have been taken to burst rice production in Africa. Prominent was the introduction of New Rice for Africa (NERICA), a cultivar developed in West Africa by the crossing between African rice, *Oryza glaberrima* Steud and Asian rice, *Oryza sativa* L. (WARDA 1999; Futakuchi *et al*., 2003).

Rice farmers are aware of the importance of fertilizers (organic and/or inorganic) in providing consistent benefit from farming activity. But subsistence farming consisting of sub-optimal use of fertilizers and other soil management practices leaves little opportunity for farmers to afford fertilizers to replace nutrients removed from their soils through harvested crops. They usually apply cow dung on their farms prior to crop establishment and some mineral fertilizers. Manyong*et al.,* 2001 reported an average application of only 40 kg N/ha in northern Nigeria. Average applications of nutrients ranges 26.75–30.5 kg N, 1.64–3.28 kg P and 3.12–6.25 kg K/ha for upland rice production (Ezui et *al.,* 2008).These values are low considering that for the production of 1 ton of upland rice paddy, rice needs to take up 15–40 kg N, 0.8–3.5 kg P and 14.3–40 kg K per hectare (Koopmans,1990), which correspond to the application of 51–133 kg N,8–35kg P and 48–133 kg K/ha for a recovery fraction of 30% N,10% P and30% K applied. They are also far below the generalized recommendation of 76 kg N, 13kg P and 25 kg K/ha, regardless of soil type. As a result, low average paddy yields are recorded: 0.7 t/ha on uplands (Ahmed *et al.*, 2009), compared to the national average of about 1.5 t/ha (Fashola *et al.*, 2006). What is important therefore, is finding rice cultivars that have resource use efficiency.The objective of this study is to test the resilience of selected rice cultivars to vary quantity of NPK application.

MATERIALS AND METHODS

Experimental site (10° 16' 52'' N, 9° 47' 19'' E)

The experiment was conducted in the green house of Abubakar Tafawa Balewa University, Bauchi State Nigeria in the months of March and April, 2013 when the average temperature was about 32°C.

Plant Samples

The seed used for the experiment were Faro 55 (Nerica 1), Srilanka and Faro 44 (Sippi), which were obtained from Bauchi State Agricultural Development program (BSADP).

Experimental Design and Procedure

A split plot experiment with three replications was used for this study. Two treatments were administered for each cultivar namely; full dose (FD)of NPK (180kg/ha) which was the control and half dose (HD) of NPK (90kg/ha). The rice seeds obtained from (BSADP) were sown in plastic pots, filled with 3.6kg of soil and saturated with water and kept in the Green House of Abubakar Tafawa Balewa University Bauchi. All treatments were irrigated for 63 days.

Data collection

Data were collected on the tiller numbers, biomass of the shoot and root.

Determination of Biomass

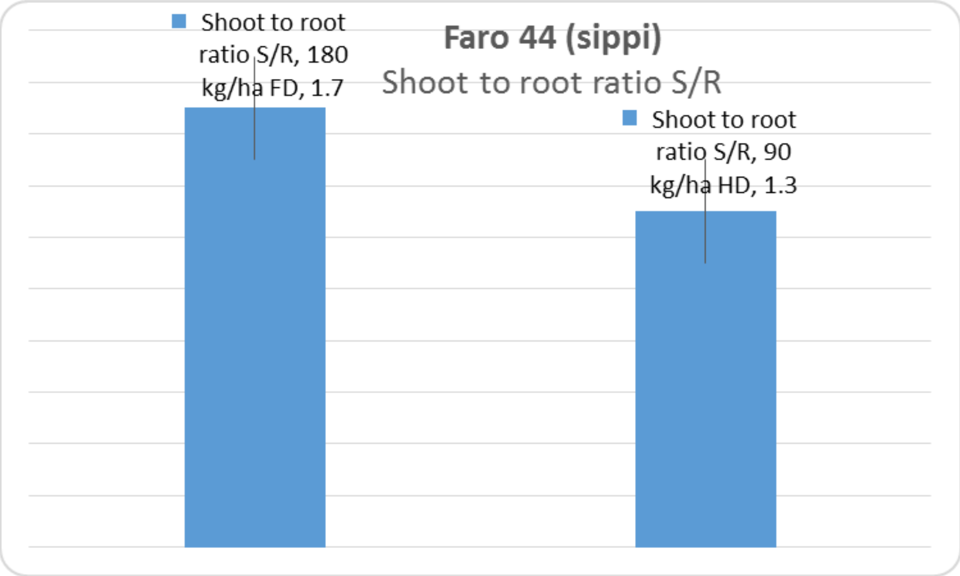
The plants were harvested from the pots gently, and the soil was washed off from the roots with water. The shoots were separated from the roots using a sharp knife. Shoots and roots of each cultivar were placed in a labelled brown envelope separately and were spread in the green house to dry. After two weeks of drying, all the envelopes containing shoots and root were moved to the laboratory where the weight of each shoot and root was recorded (Degenkolbe *et al.*, 2009).

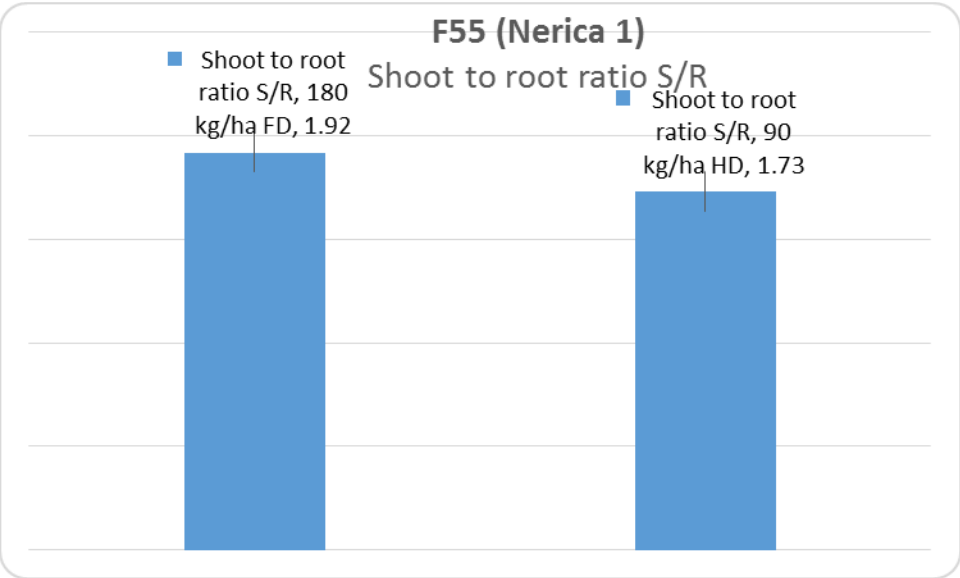
Data Analysis

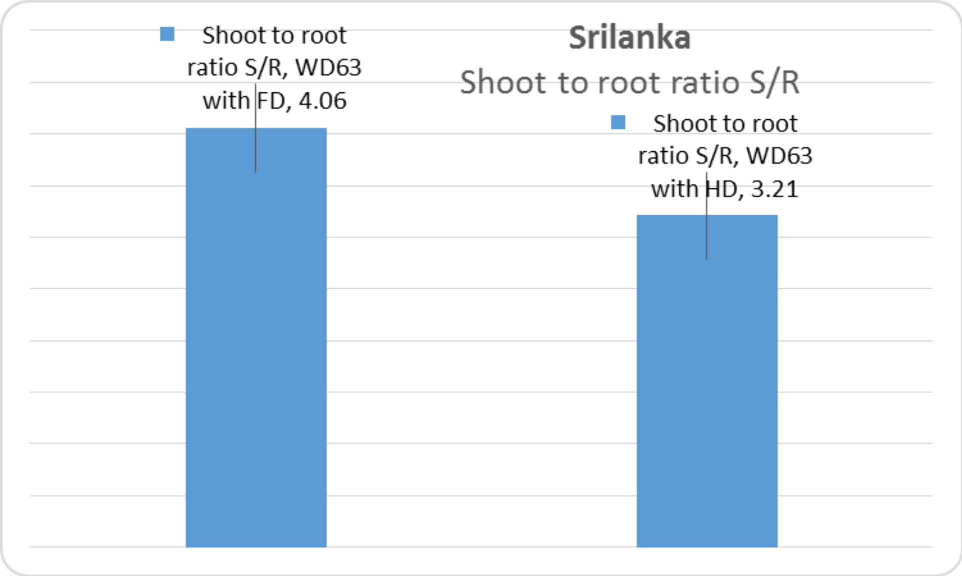
Data collected were analysed statistically with the General Linear Model (GLM) of ANOVA using Minitab version 16©and the graphs were plotted using Microsoft excel version 2013.

RESULTS AND DISCUSSION

The study was conducted to determine the resilience of each of the rice cultivars under investigation to low NPK i.e. 90kg/ha NPK which was chosen for this study being half the recommended agricultural dose (RAD) in the study area.


Faro 44 (sippi)
Shoot to root ratio S/R
Shoot to root ratio S/R, 180 kg/ha FD, 1.7
Shoot to root ratio S/R, 90 kg/ha HD, 1.3


F55 (Nerica 1)
Shoot to root ratio S/R
Shoot to root ratio S/R, 180 kg/ha FD, 1.92
Shoot to root ratio S/R, 90 kg/ha HD, 1.73



NPK Treatment

In terms of the response to low NPK dose (90kg/ha NPK) in treatment which is considered half of the agricultural dose in Bauchi, all the cultivars seemed to adapt to the very low NPK applications. This was indicated by the lack of significant difference in the root mass, shoot mass and tiller numbers with the control (180kg/ha). All the cultivars show different levels of resilience to low NPK. For instance Faro 44 (sippi) had higher accumulation of root mass, Faro 55 (Nerica1) had higher root mass, shoot mass and tiller numbers while Srilanka recorded higher root mass and tiller numbers. In terms of low NPK treatment, Faro 44 (Sippi)wasthe most tolerant cultivar and is able to accumulate more plant biomass and higher tiller numbers with low NPK. This cultivar could be a potential candidate for low NPK tolerance.

Table I, II and III could suggest paucity of information if any on the resilience of rice plants to low NPK. Most of the researches concentrated on other abiotic factors such as drought tolerance. This finding therefore, is milestone to rice farming. This means less money (50%) would be spent on the purchase of commercial fertiliser (NPK). Fertiliser is gradually too expensive to the common man.

This will also reduce the environmental impacts of accumulation of fertiliser in the environment.

When plants experience environmental stresses such as drought, salinity, high and low nutrients they activate a diverse set of physiological, metabolic and defence systems to survive and to sustain growth. Tolerance and susceptibility to abiotic stresses are very complex. Abiotic stress is the primary cause of crop loss worldwide, causing average yield losses of more than 50% for major crops. Plant traits that are associated with resistance mechanisms are multigenic and thus difficult to control and engineer. Transcriptomics, proteomics and gene expression studies have identified the activation and regulation of several stress-related transcripts and proteins, which are generally classified into two major groups. One group is involved in signalling cascades and in transcriptional control, whereas members of the other group function in membrane protection, as osmoprotectants, as antioxidants and as reactive oxygen species (ROS) scavengers. Manipulation of genes that protects and maintains cellular functions or that maintain the structure of cellular components has been the major target of attempts to produce plants that have enhanced stress tolerance. Among the various abiotic stresses, drought and low nutrients are the major factors that limit crop productivity worldwide. Exposure of plants to a low nitrogen and phosphorus during various developmental stages appears to activate various physiological and developmental changes (Somonte*et al.,* 2006 and Eagle *et al.,* 2000).

Shoot: root ratio

The increase in the shoot mass of the cultivars in this study compared to the root mass could be attributed to availability of sufficient nutrient in the soil. Though no studies were carried out on shoot: root ratio when comparing nutrients level applied in the soil, but (Boyer, 1985) reported decrease in shoot: root ration under water deficit in some rice cultivars.

CONCLUSION

This study has shown that the rice cultivars: Faro 44 (Sippi), Faro 55 (Nerica 1) and Srilanka can grow with half of the recommended agricultural dose of NPK (90kg/ha NPK). This dose is therefore recommended for rice farming in Bauchi.

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Table 1: Effect of NPK on tiller number, root and shoot biomass of Faro 44 (Sippi)

Treatment	Tiller number mean (± SE)	DF	F	P	Root mass mean (± SE)	DF	F	P	Shoot mass mean (± SE)	DF	F	P
NPK												
180kg/ha (FD)	13.67±2.29	1	0.04	0.844	4.55±1.1	1	0.25	0.645	7.74±1.01	1	0.13	0.733
180kg/ha (FD)	13±2.29				5.58±1.1				7.28±1.01			

DF = degree of freedom, F = F ratio, P = Probability level

Table 2:Effect of NPK on tiller number, root and shoot biomass of Faro 55(Nerica1)

Treatment	Tiller number mean (± SE)	DF	F	P	Root mass mean (± SE)	DF	F	P	Shoot mass mean (± SE)	DF	F	P
NPK												
WD63 with FD	4±3.97	1	6.00	0.070	1.12±1.90	1	9.42	0.037	2.15±1.74	1	660.920.000	
WD63 with HD	6±2.808				5.04±1.35				8.72±1.23			

DF = degree of freedom, F = F ratio, P = Probability level

Table 3: Effect of NPK on tiller number, root and shoot biomass of Srilanka

Treatment	Tiller number mean (± SE)	DF	F	P	Root mass mean (± SE)	DF	F	P	Shoot mass mean (± SE)	DF	F	P
NPK												
WD63 with FD	12±2.81	1	0.08	0.809	2.15±1.35	1	0.42	0.582	8.72±1.23	1	20.34	0.011
WD63 with HD	10±2.81				3.79±1.35				4.57±1.23			

DF = degree of freedom, F = F ratio, P = Probability level