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Research Article

SCREENING OF THREE RICE CULTIVARS FOR THEIR RESPONSES TO DROUGHT

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ABSTRACT

Drought stress is a major constraint to the production and yield stability of crops. Rice (*Oryza sativa* L.) is considered as a drought-sensitive crop species. Within this species, there are considerable varietal differences in sensitivity to this environmental stress. An experiment was conducted at the Green House of the Department of Applied Ecology, Abubakar Tafawa Balewa University (ATBU), Bauchi State of Nigeria during the months of September to November 2018 to evaluate 3 rice cultivars for drought tolerance in their tillers, height, shoot and root biomass. The experiment was laid out in a complete randomized design with four replications. The result showed that with increasing level of water stress, performance in all the varieties was decreased, except Faro 4L which was tolerant to drought. Also, Faro 52L showed some tolerance in its tillers, root and shoot biomass. Therefore, two rice cultivars (Faro 4L and Faro 52L) showed good performance under drought condition, while Faro 44L was not tolerant.

Keywords: Drought, Production, Crops, Green House, Rice.

INTRODUCTION

Rice is a monocot plant and cereal grain. It is the most staple food for large part of the world's human population, especially in Asia and the West Indies. It is the grain with the second-highest worldwide production, after maize (corn), according to Food and Agriculture Organization of the United Nations 2003. Rice is one of the most important staple food crops, accounting for more than half of human race caloric intake globally. It is generally valued for its high nutritional benefits apart from being rich in calories; it is high in fiber, vitamins and minerals and low cholesterol and sodium, suggesting it is a healthy source of energy. Asia is the largest producer and consumer of rice (Anujan *et al*., 2012; Sellamuthu *et al*., 2011). In 2009, Nigeria was rank 12th in the world's list of rice-consuming countries, while it is ranked 17th globally, 3rd in Africa and the 1st in West Africa, as producers of rice. However, Nigerian rice production does not meet up with the current demand or have the capacity to cope with an expanding population. Production is also suggested to declining due to effects of climate change particularly through drought, heat, flooding and pests and diseases (Vreeland *et al*., 2000).

Drought is recognized as a major abiotic stress that limits rice productivity and adversely affects grain quality in rain-fed and upland ecosystems (Bimpong *et al*., 2011; Yang & Weinberg, 2008). Rice is most sensitive to drought stress during reproductive development at which time moderate water shortages can result in a significant reduction in grain yield (Venuprasad *et al*., 2008). Most farmers in the developing countries are faced with the challenges of climate change which affects rice production. Decreased rain fall coupled with intermittent drought is a common feature in the tropical and sub-tropical savannas. It has been estimated that 25% of the fields used for upland crop production are prone to yield reductions as a consequence of drought (Jeong *et al*., 2010). Drought may happen at any time during the growing season and may occur every year in some areas.

The extent to which drought affects yield varies depending on the intensity and the time of occurrence of

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the stress within the crop growth cycle (Srividhya *et al*., 2011). Yield losses ranging from 15 to 50% have been reported (Srividhya *et al*., 2011). The situation becomes more serious with increasing global climate change. Hence, the development of high-yielding and drought tolerant varieties for rain-fed regions is a major goal of rice breeding.

Drought-tolerant varieties developed through plant breeding are more accessible to farmers than costly agronomic practices or irrigation enhancements that might require large investments by farmers (Jeong *et al*., 2010). Plant responses to drought are well known and believed to be complex involving numerous changes at the physiological, biochemical and molecular levels. Tolerance to drought stress is therefore the result of expression of a number of traits over the stress time period. Thus, no single trait is likely to improve crop productivity, in response to water-deficits. Various traits associated with rice performance under drought stress, including root morphology, root penetrability and distribution, leaf rolling, reduced leaf area, early flowering and early seed maturity, osmotic adjustment (accumulation of compatible solutes such as proline and soluble sugars), and stomatal closure have been reported (Bimpong *et al*., 2011; Price *et al*., 2000).

Drought and depleted soil nutrients such as NPK are among the limiting abiotic factors affecting rice production. Nitrogen is the most deficient essential element in most tropical soils followed by potassium, which is why NPK fertilizer is required in order to obtain good yield. The systematic increase in the price of inorganic fertilizer especially NPK is now out of reach of most farmers in the 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 boost rice production in Africa. Prominent was the introduction of NERICA (New Rice for Africa), a cultivar developed in West Africa by the crossing between African rice, *Oryza glaberrima Steud* and Asian rice, *Oryza sativa L.* (Futakuchi *et al*., 2003).

Selection and use of these traits in breeding programmes could lead to sustainable production in drought prone regions. *O. sativa L* is known for its tolerance to drought and has the attribute of superior ability to obtain soil water, a trait that is related to their root architecture. This resistance to drought has not been fully investigated in NERICA and most rice cultivars. Although, genes from *O. glaberrima* species were used to develop NERICA lines with improved yield, earliness, weed competitive ability and tolerance to abiotic stresses, by inter specific hybridization with *O. sativa*. The determination of the mechanisms directly involved in drought tolerance and nutrient use efficiency remain a challenge (Price & Lanyon, 2002). The identification of cultivars with potentials to limiting water and nutrient tolerance and the isolation of genes associated with these traits are of major importance in order to better understand this trait and increase the efficiency in developing nutrient use efficiency and drought tolerant varieties (Venuprasad *et al*., 2008; Vreeland *et al*., 2000).

Rice farmers are aware of the importance of inorganic fertilizers 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. Quantities applied are below upland rice requirements in the area. Manyong *et al*. (2001) reported an average application of only 40kg of N/ha in northern Nigeria. For rice production, average applications of nutrients are in the ranges of 26.75-30.5kg N, 1.64-3.28kg P and 3.12-6.25kg K/ha. These values are low considering that for the production of 1 ton of upland rice paddy, rice needs to take up 15-40kg N, 0.8-3.5kg P and 14.3-40kg K per hectare, which correspond to the application of 51-133kg N, 8-35kg P and 48-133kg K/ha for a recovery fraction of 30% N,10% P and 30% K applied. They are also far below the generalized recommendation of 76kg N, 13kg P and 25kg K/ha, regardless of soil type. Many reasons may explain the lack of adoption full-dose fertilization, including poor response under certain circumstances, the cost of the fertilizer at recommended rate being beyond the reach of farmers, and farmers' lack of proper fertilizer-management skills. As a result, low average paddy yields are recorded: 0.7t/ha on uplands (Ahmed *et al*., 2009), compared to the national average of about 1.5t/ha. What is important therefore, is finding rice cultivars that have resource and drought use efficiency.

MATERIALS AND METHODS

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

The experiment (research project work) was conducted at the Green House of Abubakar Tafawa Balewa University [ATBU] Bauchi State, Nigeria in the months of September through November , 2018 when the average temperature was about 32-33℃.

Plant Samples

Cultivars of rice used for the experiment were Faro 4L, Faro 44L and Faro 52L which were all obtained from my project supervisor in person of Prof. Ahmad Abdulhameed of the Department of Applied Ecology, Abubakar Tafawa Balewa University (ATBU), Bauchi State of Nigeria.

Experimental Measurements

The recommended agricultural dose of NPK fertilizer in Bauchi the experimental location is in the ratio of 120:30:30kg/ha respectively (180kg/ha). Even though, some farmers go beyond the ratio almost up to 200kg/ha. Hence, a full dose of NPK fertilizer were applied to each plastic pot some few distance away from the rice plant at the third week of planting. This is to enhance their growth as required.

Treatments

The experiment as arranged in a completely randomized block design with three treatments. Each treatment had four replications. The treatments were, irrigation for 63 days with full dose (FD) of NPK (180kg/ha)=WD63, then at week three, One week Alternate wetting and drying after28days of watering with full dose (FD) of NPK (180kg/ha)=WD28 which was later brought down to 2 days intervals at week 5 because of the low relative humidity. At week 6, the alternate wetting and drying treatment was also reduced to 1 day intermittently. The irrigated treatment WD63 was the control for water.

Procedure

Seeds of Faro4L, Faro 44L, Faro 52L were obtained from my project supervisor and were used for the experiment. The seeds were first pre-germinated in petri dishes, after shooting out, they were transferred and sown in plastic pots, filled with 3.6kg of soil and saturated with water therefore, were kept in the Green House of Abubakar Tafawa Balewa University Bauchi in a complete randomized block design using Microsoft excel. All treatments were irrigated for 28 days before the commencement of drought treatment. The experiment was set up thus: these set of experiments were given some droughted treatment (WD28) with only one application ofNPK fertilizer. This set had water deficit at day 28 i.e irrigation started from day 1 and ended at day 28, thereafter the treatment was subjected to one week of drought and one week of irrigation, later brought down to 2 days and 1 day interval intermittently till day 63 due to low relative humidity in Bauchi State. In the second irrigated treatment (WD63), there was only one set just as the droughted. Water was given from day 1 till day 63 with 180kg/ha (FD) of NPK fertilizer applied one time at the third week. Tiller numbers, plants' height (shoot length), and biomass of the shoot and root were recorded.

Determination of Biomass

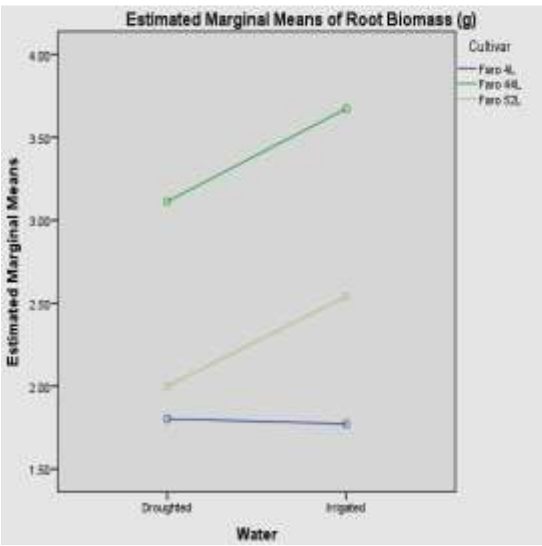
The plants were harvested from the pots gently, and the soil was washed from the roots with water. The shoots were separated from the roots using a sharp knife. Shoots and roots of each cultivar were placed in a labeled brown envelop separately and were spread in the green house to dry. After two weeks of drying, all the envelopes containing shoots and roots were taken to the laboratory where the weight of each shoot and root were recorded.

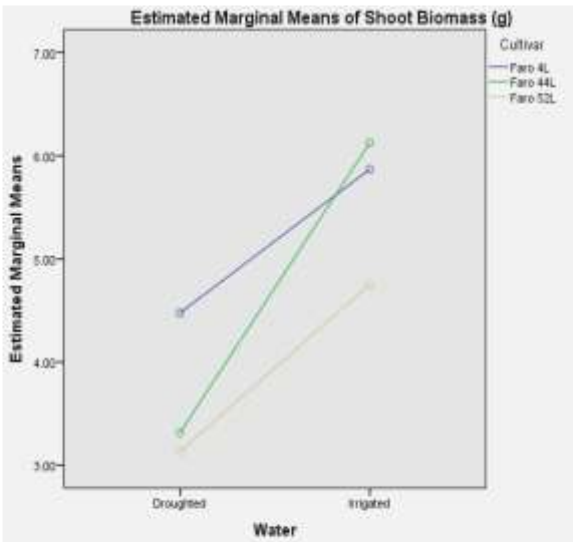
Statistical Analysis

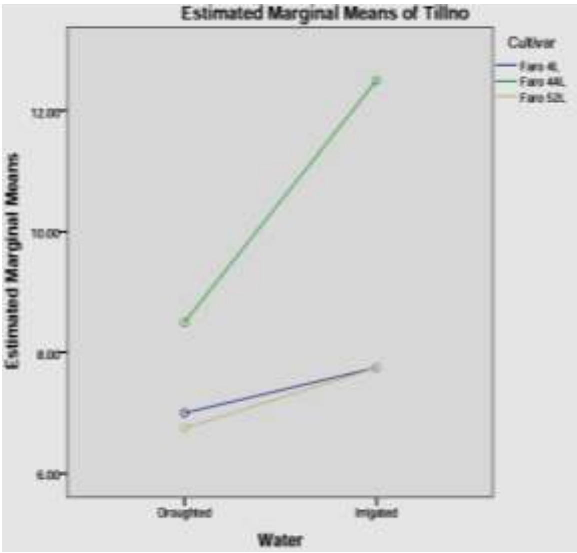
Data collected were subjected to ANOVA using Minitab version.

RESULTS AND DISCUSSION

Drought tolerance in crops is an increasing relevant trait, as water availability is the limiting factor for rice production especially in Asia and Africa, where malnutrition is a major issue. However, drought tolerance is a quantitative agricultural trait that is very difficult and labor-intensive to determine. Additionally, drought tolerance depends very much on the target environment. Thus, marker search concentrates on features that predict traits contributing to drought tolerance in a defined environment (Lafitte *et al*., 2006). One of these traits is the ability to maintain a high biomass under drought stress at the juvenile stage enhances plant survival after transplanting as well as rapid recovery after drought. Both features increase yield. The soil is one topmost thin and composite layer of earth and it was made up of many things like weathered rock particles, decayed plant and animal matter with varying ratios of minerals, air, water and organic material (Yoganathan *et al*., 2017). This study was conducted to determine the response of each of the cultivars under investigation to water deficit. The response of the different rice cultivars can be accessed through the responses recorded from their shoot height, tiller numbers, shoot biomass as well as root biomass (Figure 1).







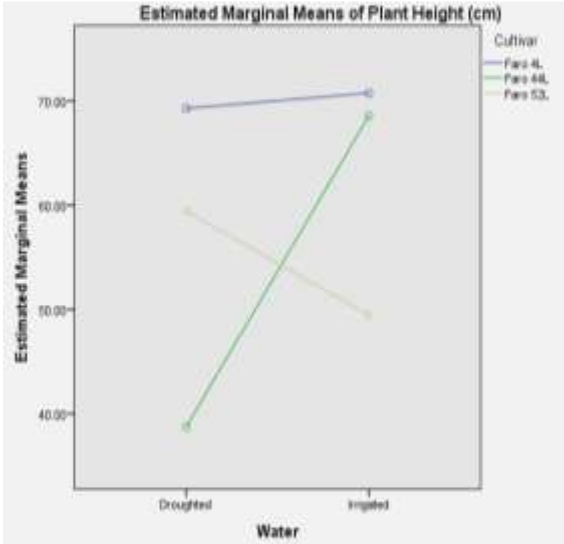


Figure 1. Tests between-various parameters.

In this study, the effects of water deficits between the HD63 and HD28 treatments (irrigation and drought) on tillers, plant height, shoot and root biomass in Faro 4L had no significant effect. Thus, this could indicate drought tolerance in or WUE in Faro4L.In Faro44L water deficits had significant effects on the plant height but showed no significant difference in its tillers, root and shoot biomass between HD63 and HD28 in the drought treatments. Decreased tiller number, plant height and shoot biomass was observed in this variety between the irrigated and drought treatments. This could possibly be as a result non-genetic and inability to withstand drought. In the case of Faro52L, water deficits had no significant effect on tillers, plant height, shoot and biomass(Jeong *et al*., 2010; Price & Lanyon, 2002). The results of this study is the opposite to findings reported by Datta *et al*., (2010)after conducting potted experiment in different moisture level on ten selected geneotypes of rice cultivars that were good performers in the biomass in the field and reported that water deficit had significant different on the plant height, shoot and root biomass.

CONCLUSION

From all the results obtained after carrying out the statistical analysis, it showed that faro 4L cultivar is tolerant to drought because there was no significant difference showed in all the parameters. Faro 44L only showed some tolerance in its root biomass, but its tiller number, plant height and shoot biomass were stressed up by drought. This means its roots are resilient to drought but cannot give good yields in drought prone areas. Faro 52L was affected by drought in its plant height but showed some good performance in its tillers, shoot and root biomass.

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