EFFECTS OF WATER DEFICITS ON RICE (*Oryza sativa*) CULTIVARS YIELD PERFORMANCE

ABSTRACT

The experiment was conducted at the screen house of the Department of Biological Science Abubakar Tafawa Balewa University Yelwa Campus Bauchi State, Nigeria, located at 10º 16' 52'' N 9º 19'' longitude and latitude. From June 2021 to September 2021. The objective of this experiment is to identify rice cultivar with high yield potential and stability under water deficit condition among the selected rice cultivars. A total of thirteen rice cultivars for the research was randomly collected. The whole experiment was randomized using Microsoft excel in completely randomized block design (CRBD) with four replication, the germinated seedlings of each cultivar from the petri-dish were planted into two each in plastic pots measuring 30cm with drainage holes at the bottom and the soil of 1.5kg was filled into the pot, the seedling was later thinned to one per pot. All seedlings were given continuous flooding for 28 days after sowing (DAS) to slightly above soil saturation. Adequate irrigation was maintained for the control treatments (CF), while irrigation was withheld until the soil moisture reduces in the drought stress treatments (WD). Irrigation was resumed on the water deficit treatments after some days and continuous alternate wetting and drying were maintained in the water deficits treatment up to rice maturity. Compound fertilizer (NPK 15-15-15) corresponding to 200kg/ha^{-1} applications (2weeks after transferring to the pots and at panicle initiation stage), and application of Urea 45 DAP. The results showed that FARO 38, FARO 45, FARO 52, and FARO 64 recorded appreciable performed.

Key words: Effects, water deficits, Rice, Cultivars, and performance

INTRODUCTION

Rice has become a key crop in many industrialized countries where its consumption has expanded significantly. It is the food crop that holds the most economic significance in many developing countries (Ajala and Gana, 2015). Among all the cereal crops, it is the most significant and reliable source of food for more than half of the world's population (Dogara and Jumare, 2014). Depending on the needs of the specific variety, rice is one of the main grains that are extensively farmed for food in Nigeria. It can be grown in paddies or on upland fields (The Punch, 2016). Nigeria was listed as the world's second-largest importer of rice as of December 2016, according to the Punch daily. Nigeria's high rate of rice importation has compelled the government to take action to reverse the trend, which includes outlawing rice imports completely and launching a new drive to increase domestic production. All of these take place in light of the nation's enormous rice-producing potential and capacity for self-sufficiency (Akinbile et al., 2018). Nigeria's consumption of rice was ranked 12th in the world in 2009, while its production was ranked 17th worldwide, third in Africa, and first in West Africa (FAO, 2011). According to the literature that is currently available, the annual production of rice raised from 5.5 million tons in 2015 to 5.8 million tons in 2017 (Udemezue, 2018).The increase in rice production was due to increased land being used for rice farming, not an increase in yield. However, at roughly 1.5 t/ha, the usual rice production is consistently low (RIFAN, 2017). Rice needs a lot of water for optimal development and yield, hence drought is a major barrier to rice production in Northern Nigeria. According to Kami et al. (2020), rice needs between 1200 and 1600 mm of rainfall spread uniformly over the course of its growth season. Drought stress primarily affects rice during its vegetative and reproductive phases. When an irreversible reproductive process and drought stress coexist, grain yield is drastically reduced (Pantuwan et al., 2002). Uplands experience a more severe drought than lowlands do (Kamai et al., 2020). According to Matanmi et al. (2011), almost 40% of the respondents stated that their ability to produce rice was hampered by climatic fluctuations. In tropical and sub-tropical savannas, decreased precipitation combined with sporadic drought is a typical occurrence (Mohammed et al., 2015). According to estimates, 25% of the upland crop production fields are vulnerable to yield decline due to drought (Jeong et al., 2010). Farmers have greater access to drought-tolerant plant breeding varieties than to expensive agronomic techniques or irrigation upgrades that may need a significant financial outlay (Zheng et al., 2010). Plants may make a number of adjustments to their morphology, structure, or ultrastructure to avoid stresses and reduce their potential effects (Ruiz-Lozano *et al*. 2006; Fusconi and Berta 2012). As an alternative, plants can modify their physiology and biochemistry in order to reduce the damage brought on by stress or to aid in the repair of harmed systems (Fusconi and Berta 2012; Patakas 2012). Notably, by externally applying chemicals and other sustainable efforts, the adoption of the aforementioned strategies by plants can be regulated to obtain enhanced plant productivity and yield (Asgher *et al*. 2015; Khan *et al*. 2015, 2016). The most typical traits of rice under drought stress are losses in grain weight and size, the 1000-grain weight, the seed-setting rate, and increases in spikelet sterility (Mostajera *et al*., 2008; Wang *et al*., 2012). (Kumar *et al*.,2011). Water shortages shorten the grain filling period, reducing grain yields (Shahryari *et al*., 2008). According to Kamai et al. (2020), rice varieties that are suggested for northern Nigeria are therefore those that belong to the early and medium maturity classes and have the ability to either avoid or tolerate drought.

Therefore, it's crucial to comprehend how secondary features are passed down genetically in various populations of interspecific lines. Drought tolerance, drought avoidance, and drought escape all comprise the mechanism for drought resistance. The objective of this experiment is to identify rice cultivar with high yield potential and stability under water deficit condition among the selected rice cultivars.

MATERIAL AND METHODS

Experimental Site

The experiment was conducted at the screen house of the Department of Biological Science Abubakar Tafawa Balewa University Yelwa Campus Bauchi State, Nigeria, located at 10º16’ 52’’ N 9º 19’’ longitude and latitude. From June 2021 to September 2021. Bauchi is located at an elevation of 600.1 meters (1968.83 feet) above sea level, Bauchi has a Tropical wet and dry or savanna climate (Classification: Aw). The city’s yearly temperature is 28.97ºC (84.15ºF). Bauchi typically receives about 85.87 millimeters (3.38 inches) of precipitation and has 115.72 rainy days (31.7% of the time) annually, annual average temperature of 33.23°C (91.81°F) (https://en.wikipedia.org/wiki/Bauchi_State 2021).

Seeds sample collection

A total of thirteen rice cultivars for the research was randomly collected from Bauchi State Agricultural Development Programme (BSADP) and National Cereal Research Institutes (NCRI) Bhadeggi. The following were the rice cultivars used for the experiment.

Table 1:Rice cultivar used for the experiments

Cultivar name	Species	source	Ecology
FARO 37	*O. sativa*	NCRI	Lowland
FARO 38	*O. sativa*	NCRI	Upland
FARO 45	*O. sativa*	NCRI	Upland
FARO 47	*O. sativa*	NCRI	Upland
FARO 48	*O. sativa*	NCRI	Upland
FARO 51	*O. sativa*	BSADP	Lowland
FARO 52	*O. sativa*	BSADP	Lowland
FARO 60	*O. sativa*	NCRI	Lowland
FARO 61	*O. sativa*	NCRI	Lowland
FARO 62	*O. sativa*	NCRI	Lowland
FARO 64	*O. sativa*	NCRI	Upland
FARO 65	*O. sativa*	NCRI	Upland
FARO 66	*O. sativa*	NCRI	Lowland

Source Bauchi State Agricultural Development Programme (BSADP, 2021) National Cereal Research Institutes (NCRI, 2021)

Experimental procedure

Seed preparation and planting

The rice seed was sterilized in 10% Na-hypochlorite solution for 20 minutes to prevent fungal growth, and it was then washed with distilled water (Di salvatiCarafa *et al*., 2008). Seeds was then pre-germinated in a petri-dish. The whole experiment was randomized using Microsoft excel in completely randomized block design (CRBD) with four replication, the germinated seedlings of each cultivar from the petri-dish were planted into two each in plastic pots measuring 30cm with drainage holes at the bottom and the soil of 1.5kg was filled into the pot, the seedling was later thinned to one per pot.

Water deficits treatments

All seedlings were given continuous flooding for 28 days after sowing (DAS) to slightly above soil saturation. Adequate irrigation was maintained for the control treatments (CF), while irrigation was withheld until the soil moisture reduces in the drought stress treatments (WD). Irrigation was resumed on the water deficit treatments after some days and continuous alternate wetting and drying were maintained in the water deficits treatment up to rice maturity (ndjiondjop *et al.*, 2010).

Soil preparation and analysis

The soil sample was collected from a school farm at Yelwa campus of Abubakar Tafawa Balewa University Bauchi, and processed using a 2mm sieve, properties of the soil for the study will be analysed following standard protocols for tropical soil Anderson *et al*.,(1993).

Table 2: Soil Sample Analysis

Parameter/ID	RESULT
Ph	6.7
E/Conductivity (µs/cm)	30
N (mg/kg)	6.89
NO3 (mg/kg)	30.50
P (mg/kg)	0.01
PO4 (mg/kg)	0.02
TOC (%)	0.635
TOM (%)	0.758
CECmeq/100g	10.45
Zinc Zn (mg/kg)	0.08278
Magnesium Mg (mg/kg)	2.575
Sodium Na (mg/kg)	2046.8
Calcium Ca (mg/kg)	280.44
Potassium K (mg/kg)	51.56
Soil Texture Class	Loamy Sand
Sand %	73.77
Silt %	12.29
Clay %	13.93

Fertilizer Application

Compound fertilizer (NPK 15-15-15) corresponding to 200kg/ha^{-1} applications **(2weeks after transferring to the pots and at panicle initiation stage), and application of Urea 45 DAP.** The rice seedlings were kept weeds free throughout the experiment by regular hand weeding.

Layout of the treatments

The thirteen rice cultivars will be given the following treatment

i. T_1= CF+NPK(200kg/ha^{-1})

ii. T_2=WD+NPK(200kg/ha^{-1})

Evaluating effects of water deficits on grain yield rice cultivars.

To determine the effect of water deficits on rice cultivars, After grain harvests the seeds of rice plants were harvested put into brown envelop and were oven drying at 70^{o} C to a constant weight for 24hrs, weight was recorded using an electronic weighing balance (Model:EK3000i, company) (Vasant, 2012). 100 grain yields were recorded per gram per pots, and weighting, thereby taking their mean and then the data was converted into kg ha^{-1}. All the procedures above were adopt from SES (IRRI, 2002). For stress tolerance level (TOL), Rosielle and Hamblin (1981) methods who defined stress tolerance (TOL) as the differences in yield between the stress and non-stress environments was adopted for this study, i.e., TOL= (Yi)NS - (Yi)S. Let (Yi)S and (Yi)NS denote the yield of the ith genotype under stress and non-stress (irrigated) condition, respectively.

Results and Discussion

Yield potential and stability under water deficit condition among the FARO rice cultivars.

The data presented in Table 3 are results of the yield potential and stability of different FARO rice cultivar under water deficit conditions. The interpretation scale used was adopted from Rosielle and Hamblin, (1981), which shows that values moving closer to zero represent higher yield potential and greater stability under water deficit conditions, while values exceeding one indicate diminished yield potential and reduced stability. The collected data presented showed that FARO 38 produced tolerance value of 0.88g, FARO 45 recorded 0.25g, and FARO 52 recorded 0.1g, reflecting notably high yield potential and stability under the water deficit conditions. Furthermore, FARO 64 recorded a mean of 1.20g, FARO 51 produced 1.25g, FARO 60 gave1.90g, and FARO 41 recorded a mean of 1.99g, signifying a relatively moderate level of yield potential and stability. However, FARO 62 produced a mean of 2.1g, FARO 65 recorded 2.2g, FARO 37 2.83g, FARO 48 exhibited a mean value of 3.4g, while FARO 61 produced a substantial value of 4.23g, FARO 66 recorded a mean of 4.67g, indicating reduced yield potential and stability under water deficit conditions. Kumar et al. (2014) observed analogous results, noting that IR55419-04 exhibited the lowest TOL value at 0.78, followed by IR84895-B-127-CRA-5-1-1, IR83376-B-B-24-2, and IR83387-B-B-40-1, while IR64 displayed a notably higher value of 3.54. A lower TOL value suggests a greater capacity for stress tolerance within a given cultivar. Raman et al. (2012) also reported similar findings. The Stress Susceptibility Index (SSI) measures the reduction in yield resulting from unfavourable conditions in comparison to favourable ones. Lower SSI values indicate less disparity in yield between non-stress and stress conditions, signifying increased drought tolerance. SSI serves as a metric for assessing yield stability. These findings provide valuable insights into the performance of various FARO crop varieties, specifically in the context of water deficit, offering critical information for agricultural decision-making.

Table 3: Yield potential and stability under water deficit condition among some FARO rice cultivars.

	Treatments		
Cultivars	**CF+FD(g)**	**WD+FD(g)**	**TOL(g)**
FARO 37	7.08	4.25	2.83
FARO 38	6.73	5.85	0.88
FARO 41	6.27	4.28	1.99
FARO 45	4.85	4.60	0.25
FARO 48	7.03	3.63	3.4
FARO 51	5.40	4.15	1.25
FARO 52	4.35	4.25	0.1
FARO 60	4.70	2.80	1.9
FARO 61	6.53	2.30	4.23
FARO 62	7.80	5.70	2.1
FARO 64	2.60	1.40	1.2
FARO 65	5.35	3.15	2.2

FARO 66	8.85	4.18	4.67

STATISTICAL ANALYSIS.

Data collected for grain yield was subjected to ANOVA using Minitab The difference between (i.e T_1= CF+FD (200kg/ha^{-1}), and T_2= WD+FD (200kg/ha^{-1}) will be compared on the yield of all the rice cultivars.

CONCLUSION

This study focus on the rice cultivars performance under water deficits on yield of FARO 37, FARO 38, FARO 41, FARO 45, FARO 48, FARO 51, FARO 52, FARO 60, FARO 61, FARO 62, FARO 64, FARO 65, and FARO 66 rice cultivars. In conclusion the results of the research found that FARO 38, FARO 45, FARO 52, and FARO 64 recorded appreciable performed.

RECOMMENDATION

There is need to further conduct molecular analysis to identify genes responsible for the performance of FARO 38, FARO 45, FARO 52, and FARO 64 rice cultivars under water deficit.

CONFLICT OF INTERESTS

The author declare that they have no conflict of interest regarding the publication of this paper

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