EFFECT 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 10° 16' 52" N, 9° 19'' longitude and latitude. From June 2021 to September 2021. The objective of this experiment is to identify rice cultivars with high yield potential and stability under water deficit conditions among the selected rice cultivars. A total of thirteen rice cultivars for the research were randomly collected. Using Microsoft Excel, the entire experiment was randomized in a completely randomized block design (CRBD) with four replications. The seedlings of each cultivar that germinated from the petri dish were placed in two of each in 30-cm plastic pots with drainage holes at the bottom, and 1.5 kg of soil was added to each pot. The seedlings were then 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 deficit treatment up to rice maturity. Compound fertilizer (NPK 15-15-15) corresponding to 200 kg/ha-1 applications (2 weeks after transferring to the pots and at the panicle initiation stage) and application of urea 45 DAP. The results showed that FARO 38, FARO 45, FARO 52, and FARO 64 have high yield potential and stability under water stress experiments among the thirteen rice cultivars randomly selected.

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

INTRODUCTION
Rice (Oryza sativa L.) is a staple food that is used by more than 50% of the human population globally (Hadiarto *et al*., 2010; Rasheed *et al*., 2020c). Rice provides the caloric demand of the human population in different parts of the world (Rasheed *et al*., 2020a, 2020b). Drought stress has been one of the major threats to world rice production (Swamy and Kumar, 2017; Sahebi *et al*., 2018). Delphine *et al*. (2010) and Nasser *et al*. (2021) defined drought tolerance as the ability of a plant to survive under low tissue water content. It is the ability to which a plant maintains its biomass production during arid or drought conditions. Rice cultivars displayed different abilities to resist drought, and rice cultivars could be classified into three categories based on their responses to drought. They include highly drought-tolerant cultivars, moderately drought-tolerant cultivars, and drought-sensitive cultivars (Sumontip and Prapaporn 2013). Drought stress tolerance is very key in all plants, although the response varies from one species to another and even within the species. The impact of drought stress on various morpho-physiological changes significantly differs among rice cultivars (Kumar *et al*., 2015), which underscores the importance of screening rice germplasm for drought tolerance. For easy selection of rice genotypes under drought stress, it is necessary to do a proper drought screening, which clearly distinguishes drought-susceptible genotypes from drought-tolerant genotypes (Seema *et al*., 2022).Drought is defined by a decrease in water content, reduced leaf water potential, diminished turgor pressure, decreased stomatal activity, inhibited cell expansion, and cessation of photosynthesis (Sokoto and Muhammad, 2014).Nasser *et al*. (2021) and Debabrata *et al*. (2021) opined that drought affects

different growth stages of rice (vegetative growth, flowering or reproductive stage, and terminal stage) and causes spikelet sterility that leads to unfilled grains. Drought also reduces rice growth by affecting various physiological and biochemical processes such as photosynthesis, respiration, translocation, ion uptake, carbohydrate nutrient metabolism, and growth promoters (Farooq *et al*., 2008; Sokoto and Muhammad, 2014; Kumar *et al*., 2015; Henry *et al*., 2016). As the demand for water for domestic, municipal, industrial, and environmental purposes rises in the future, less water will be available for agriculture. Rice needs about 1200 mm to 1600 mm of rainfall evenly distributed throughout its growing period. This volume of rainfall is rare even in the southern parts of the country that usually receive more rain than the northern parts (Kamai *et al*. 2021). The effects of drought are evident in uplands compared to lowlands (fadamas). Due to the effects of drought, rice varieties recommended for Northern Nigeria should fall within early and medium maturity classes that have the tolerance to and/or the capacity to avoid drought (Kamai *et al*. 2021). Northeast Nigeria is geographically located between the semi-desert Sahel savannah and the tropical West Sudan savanna eco-region, which has experienced a 25% decrease in precipitation on average in the last 30 years (Amachukwu *et al*.; 2015). The proximity of northeast Nigeria to the Sahara Desert makes the area the driest part of the country, and hence, it is exposed to drought and desertification. Ozor (2009) reported that northeast Nigeria is being affected by drought, desertification, and heat stress as a result of climate change (Kamai *et al*. 2021). Therefore, this work is aimed at evaluating the effect of drought episodes on days to heading, 50% heading, and maturity of different rice accessions in Sokoto Agro- Climatic Zone.
Finding out the rice cultivars' potential yield and stability in the event of a water deficit is the goal of this study.

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 millimetres (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° 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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