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EFFECT OF DROUGHT EPISODES ON YIELD AND BIOCHEMICAL CONTENTS OF RICE (*Oryza sativa* L.) ACCESSIONS IN SOKOTO AGRO-CLIMATIC ZONE

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ABSTRACT
The study was carried out to evaluate the effects of the drought episodes on days to 50% heading and maturity of different rice (*Oryza sativa* L.) accessions in Sokoto Agro-climatic zone. A total of fifteen (15) upland rice accessions were collected from National Cereal Research Institute (NCRI) Baddegi in Niger State, Nigeria. Field experiment was conducted in Kwalkwalawa village of Wamakko Local Government of Sokoto State. Seeds of selected rice accessions were first raised in nursery bed and 21 days old uniformly germinated seedlings were transplanted in to three plots under different drought episodes which are watered once a week (W1), watered twice a week (W2) and watered everyday or control (W0). The seedlings were raised in a completely randomized block design (CRBD) and replicated three times. The result on yield attributes and biochemical contents all showed significant difference at ($P \leq 0.5$) for both stresses and control groups. FARO 21, 26, 66, 45, 47 and 48 showed drought tolerance suggesting genetic variability for drought tolerance while FARO 26, 27, 66 and 45 matured earlier suggesting better performance under drought condition. Thus, early maturing and drought resistance accession should be used by farmers to escape drought.

Keywords: Drought, Rice, Accessions, Heading, Maturity

INTRODUCTION
Rice belongs to the genus *Oryza* and family Poaceae. The genus is made of about 20–25 species with a pan-tropical and sub-tropical distribution. The genus *Oryza* includes two (2) cultivated (2n=24, AA) and 22 wild species (2n=24, 48) representing the AA, BB, CC, BBCC, CCDD, EE, FF, GG, KKLL and HHJJ genome types (Sanchez *et al.*,2014). The cultivated species are *Oryza sativa* (cosmopolitan in distributions grown all over the world) and *Oryza glaberrima* (endemic to West Africa and cultivated only in Africa for the last 3500 years) (Molina *et al.*, 2011).African rice is now only rarely grown in pure stands, but it is instead grown in mixture with the Asian rice in various proportions, though, even this mixed cultivation of the two (2) species is diminishing recently as it is being replaced with 'pure' Asian rice cultivation (Nayar, 2010). Rice has a vast germplasm of cultivated and wild species (Nakagahra *et al.*, 1997; Vaughan *et al*., 2003). The wild species of *Oryza* are grass-like plants with phenotypically inferior agronomic characters (grain shattering and poor grain type), great diversity in morphological traits (height, tillering, panicle, culm and awn) and adaptations to different habitats (Sanchez *et al.*, 2014).
Rice is a model system for cereal Biology with the smallest genome consisting of 430 Mb across 12 chromosomes. The tremendous growth of human population worldwide has increased the demand for rice production (Liang *et al.*, 2010) requiring an improvement of 50% by the year 2025 (Khush, 2001). Abiotic stress like drought and salinity are the most limiting factor of crop productivity and it is estimated to account for more than 50% decline in the average yields of major crops worldwide (Bray, 1997).
Rice, being a water loving crop is severally affected by drought stress that decreases yield by 15- 50% depending on the vigour and period of stress (Kumar *et al.*, 2008 and Srividhya *et al.*, 2011). Rice is grown under different conditions and production system, but submergence in water is the most common method used worldwide. Rice is the only cereal crop that can grow for long period of time in standing water (Hung *et al.*, 2012). According to Nasser *et al.*, (2021), about 57% of rice is grown on irrigated land, 25% on rain fed low land, 10% on the upland, 6% in deep water and 2% in tidal wetlands. Rice, a monocot, is normally grown as an annual plant, although in tropical areas, it can survive as a perennial and can produce a ratoon crop for up to 30 years. The rice plant can grow to 1-1.8m tall occasionally more depending on the variety and soil fertility. It has long slender leaves 50-100cm long, 2-2.5cm broad. The small wind pollinated flowers are produced in a branched arching to pendulous in florescence 30-50cm long. The edible seed is a grain (caryopsis) 5-12mm long and 2-3m thick (Molina *et al.*, 2011).
Drought is a metrological term commonly defined as the inadequacy of water availability including period without significant rainfall that affects crop growth (Nasser et al., 2021) and it occurs when the available water in the soil is reduced and atmospheric conditions cause continuous loss of water by transpiration or evaporation. Drought stress tolerance is seen in almost all plants but its extent varies from species to species, even within the species. However, the impact of drought stress on various morpho-physiological changes significantly differs among rice cultivars (Kumar *et al.*, 2015) which underscore 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 characterized by reduction of water content, diminished leaf water potential, turgor pressure, stomatal activity, decrease in cell enlargement and arrest of phot,osynthesis (Sokoto and Muhammad, 2014).Nasser *et al.* (2021) and Debabrata *et al.* (2021) opined that drought affects different growth stages of rice (vegetative growth, flowing 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, carbohydrates 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.

Therefore, this work is aimed to evaluate the effect of drought episodes on days to heading, 50% heading and maturity of different rice accessions in Sokoto Agro- Climatic Zone.

MATERIALS AND METHODS

A total of Fifteen (15) rice accessions were obtained from National Cereals Research Institute (NCRI) Baddegi, Niger state, Nigeria. The seeds were carefully sorted, labelled and stored in air tight containers at room temperature. The accession include FARO 4, 15, 21, 26, 27, 31, 34,38, 41, 45, 47, 48, 49, 51, 58 and 66.

The field experiment was conducted in dry season in Kwalkwalwa village of Wamakko Local Government of Sokoto state (Latitude 13º06'28ºN and Longitude 05º 12º46ºE). According to Abubakar *et al*. (2018), it has a mean annual rainfall of about 600mm falling between June and September, during which small scale irrigation using tube well is practiced by farmers along Sokoto Rima River Banks Seedlings of selected rice accessions were first raised in nursery bed measuring 40cm x 40cm in the Fadama Area and 21 days old uniformly germinated seedlings were transplanted into three (3) plots measuring 3.5m x8.5m each. Each plot consists of 15 units or subplots one 1m each and 50cm between the units or subplots. The gap between the plots is 1m. The seedlings were raised in a completely randomized block design (CRBD) the three (3) replicates. Stress was imposed on two (2) plots while the remaining plot serve as control. In the stress plots, one was watered once in a week and the other one was watered twice in one week, while the controlled group was watered every day.

Determination of Yield And Biochemical Contents of Rice Accessions

Determination of days to 50% heading: The data were obtained by counting number of days of flowering of the different rice accessions in each plot within each drought episodes when half of all the rice plants had already flowered Abdulrahaman (2020).

Determination to Days to maturity: Days to maturity were determined from the day the seedling were planted to the day they were harvested. The rice seedlings were harvested at physiological maturity when the entire plants had turned yellow and grain fully filled and at hard drought stage. The rice plants within plots were cut at ground level and bundled into sheaves. Each plot harvested was threshed by putting into polythene sack and beaten with sticks. The rice seeds collected for each plot were cleaned by winnowing, sun-dried and weighed using the weighing balance (top loading weighing scale). The average days to maturity of the replicates were computed and recorded.

Determination of Yield Attributes: Yield attributes of the rice accessions at reproductive and maturity in each drought episodes were determined and recorded. The yield attributes measured are number of panicles, length of panicles (cm), number of spikelet, number of rice seeds, grain weight (g) and dry shoot weight (g) and all measurements followed standard methods as also adopted by Alhassan (2021).

Determination of Biochemical contents: Extraction and determination of free was performed according to the method of Gumi et al(2018); ground sample (1g) of plant mate5rial was extracted with 3% sulphosalicylic acid and filtered through Whitman's filter paper and the extract (2ml) was held for one hr in boiling water by adding 2ml minhydrin and 2ml glacid acetic, after which cold toluene (4ml) was added. Proline content was measured spectophotometrically at 520nm and calculated as umolg-1 DW against standard proline while Extraction and determination of Betaine was carried out according to the method of senthikumar et al (2021) and Shafaqat *et al* (2020). Betaine was extracted by using (2g) of finely ground dried sample with demineralized water at 100ºC for I hour. Betaine content was determined spectrophotometrically after reaction with potassium iodide (KI-I2) at 365nm.

Data Analysis

The data collected form the observations were subjected to multivariate analysis and differences between significant means were separated using Turkey 95% confidence interval at 5% level of probability as described by Gomez and Gomez (1984) in Alhassan (2021). The relationship between characters was determined through simple correlation analysis as described by little and Hills (1978).

RESULTS AND DISCUSSION

The results on the number of days to 50% heading of rice accessions as affected under three different Drought episodes effects as well as the significant effects of different interactions between the factors (accessions and drought episodes) in figure 1 showed that there is no significant difference between the numbers of days to 50% heading of rice accessions due to drought episodes effects at 5% level of significance ($P>0.05$). The result also showed that there is significant difference between the average numbers of days to 50% heading of rice accessions for all drought episodes at 5% level of significance ($P<0.05$). This result revealed that FARO 21 and 15 have the highest average numbers of days to 50% heading, followed by FARO 38 and 49 while FARO 27, 26 and 45 have the lowest number days to 50% heading among the rice accessions. The results for interaction effects of Drought episodes and Accessions revealed that the interaction effects on the numbers of days to 50% heading of the rice accessions are statistically significant at 5% level of significance ($P<0.05$).

Accessions FARO 21 (Watered twice a week (WTW) and FARO 21 (Control) have the highest number of days to 50% heading days each followed FARO 15 (Watered once a week (WOW), FARO 15 (Watered twice a week (WTW)), FARO 38 (Watered twice a week (WTW), FARO 41 (Watered twice a week (WTW), FARO 49 (Watered twice a week (WTW) while FARO 26 (Watered twice a week (WTW), FARO 27 (Watered twice a week (WTW)), FARO 45 (Watered twice a week (WTW)), FARO 26 (Control), FARO 27 (Control) had the lowest number of days to 50% heading days.

The results on days to maturity of rice accessions as affected under three different watering regimes in figure 2 showed that there is significant difference in the numbers of days to maturity of rice accessions due to different watering regimes at 5% level of significance. This result revealed that the number of days to maturity of rice is higher in those watered once a week than those that were watered twice a week and watered everyday (control). The result also revealed that there is significant difference between the average numbers of days to maturity of rice accessions for all the drought episodes at 5% level of significance. This shows that FARO 21 has the highest average numbers of days to maturity, followed by FARO 15, followed by FARO 41, FARO 38 and 49 while

FARO 26, 27, 45 have the lowest number of days to maturity among the rice accessions.

The result on number of panicle showed that there is significant increase in average numbers of panicles produced by rice accessions for all drought episodes at 5% level of significance (P<0.05). This result revealed that FARO 49, 41, 47, 51, 34, 31, 48, 38, 45 and 66 have the highest average number of panicles under all the drought episodes while FARO 27 has the lowest number of panicles.

The results on the length of panicles of rice accessions as affected by three different watering regimes in figure 3 showed that there is significant difference between the length of panicles of rice accessions due to different watering regimes at 5% level of significance(P<0.05). The result revealed that those watered twice a week and those watered every day (control) have higher length of panicles than those watered once a week. The result showed that FARO 21 had the highest average length of panicles under all different drought episodes while FARO 47 and 45 has the lowest length of panicles.

The results on the numbers of spikelets produced by rice accession as affected by three different watering regimes in figure 4 showed that there is significant increase in numbers of spikelets produced by accessions due to different watering regimes 5% level of significance (P<0.05). The result revealed that those watered twice a week and those watered everyday (W0) produced higher numbers of spikelets than those watered once a week. The result also showed that FARO 49 , 41, 47, 26, 66 and 27 have the highest average number of spikelets under all the different drought episodes while FARO 51 and 21 have the lowest number of spikelets.

The results on the numbers of seeds produced by rice accessions in table 4a as affected by three different watering regimes in figure 5 showed that there is significant difference in the numbers of seeds produced by rice accessions due to different watering regimes at 5% level of significance. The result revealed that those watered everyday produced more seeds than those watered twice and once a week. FARO 47, 49, 41 and 15 have the highest average number of seeds under all the different drought episodes while FARO 45, 34, 21 have the lowest number of seeds.

The result on biochemical contents of the rice accessions as affected by different drought episodes all showed that there is significant different in the level of proline and glycine butaine contents. The result revealed that those watered once a week have more levels of proline and glycine butaine content than those watered twice and those watered everyday.

Table 1: Effect of Drought on Proline and Glycine Butane Contents (g)

ACCESSIONS	**Proline**			**Glycine butane**		
	W1	**W2**	**W0**	**W1**	**W2**	**W0**
FARO 4	-	-	-	-	-	-
FARO 15	$0.49{\pm}0.07^{d}$	$0.30{\pm}0.04^{e}$	$0.18{\pm}0.02^{g}$	$1.47{\pm}0.21^{d}$	$0.90{\pm}0.13^{f}$	$0.54{\pm}0.08^{h}$
FARO 21	$0.29{\pm}0.04^{f}$	$0.19{\pm}0.03^{e}$	$0.15{\pm}0.02^{g}$	$0.88{\pm}0.12^{g}$	$0.63{\pm}0.08^{h}$	$0.45{\pm}0.06^{i}$
FARO 26	$0.29{\pm}0.04^{f}$	$0.25{\pm}0.03^{f}$	$0.22{\pm}0.03^{f}$	$0.78{\pm}0.08^{g}$	$0.78{\pm}0.11^{g}$	$0.67{\pm}0.09^{h}$
FARO 27	$0.35{\pm}0.05^{e}$	$0.27{\pm}0.04^{f}$	$0.22{\pm}0.03^{f}$	$1.05{\pm}0.15^{f}$	$0.84{\pm}0.08^{g}$	$0.82{\pm}0.12^{g}$
FARO 31	$0.52{\pm}0.07^{c}$	$0.38{\pm}0.05^{e}$	$0.19{\pm}0.03^{g}$	$1.15{\pm}0.16^{f}$	$1.09{\pm}0.08^{f}$	$0.55{\pm}0.08^{h}$
FARO 34	$0.30{\pm}0.04^{e}$	$0.28{\pm}0.04^{f}$	$0.13{\pm}0.02^{g}$	$0.86{\pm}0.12^{g}$	$0.72{\pm}0.08^{g}$	$0.39{\pm}0.06^{i}$
FARO 38	$0.48{\pm}0.06^{d}$	$0.46{\pm}0.06^{d}$	$0.25{\pm}0.04^{f}$	$1.45{\pm}0.21^{d}$	$1.07{\pm}0.08^{f}$	$0.97{\pm}0.14^{f}$
FARO 41	$0.77{\pm}0.10^{a}$	$0.60{\pm}0.08^{b}$	$0.23{\pm}0.03^{f}$	$1.79{\pm}0.25^{b}$	$1.60{\pm}0.08^{c}$	$0.67{\pm}0.09^{h}$
FARO 45	$0.45{\pm}0.06^{d}$	$0.30{\pm}0.04^{e}$	$0.16{\pm}0.02^{g}$	$0.93{\pm}0.08^{f}$	$0.93{\pm}0.13^{f}$	$0.51{\pm}0.07^{h}$
FARO 47	$0.40{\pm}0.06^{d}$	$0.37{\pm}0.05^{e}$	$0.18{\pm}0.02^{g}$	$1.23{\pm}0.18^{e}$	$0.96{\pm}0.08^{f}$	$0.54{\pm}0.07^{h}$
FARO 48	$0.37{\pm}0.05^{e}$	$0.35{\pm}0.05^{e}$	$0.22{\pm}0.03^{f}$	$1.13{\pm}0.16^{f}$	$0.95{\pm}0.08^{f}$	$0.66{\pm}0.09^{h}$
FARO 49	$0.45{\pm}0.06^{d}$	$0.25{\pm}0.03^{f}$	$0.24{\pm}0.04^{f}$	$2.13{\pm}0.30^{a}$	$1.20{\pm}0.08^{e}$	$0.73{\pm}0.11^{g}$
FARO 51	$0.49{\pm}0.07^{d}$	$0.36{\pm}0.05^{e}$	$0.23{\pm}0.03^{f}$	$0.78{\pm}0.08^{g}$	$0.71{\pm}0.10^{g}$	$0.35{\pm}0.05^{i}$
FARO 66	$0.31{\pm}0.04^{e}$	$0.26{\pm}0.13^{f}$	$0.24{\pm}0.03^{f}$	$0.96{\pm}0.14^{f}$	$0.71{\pm}0.08^{g}$	$0.40{\pm}0.06^{i}$

Values=Mean± SD,
Means followed by the same letter along the columns are not significantly different
* = significant at 5%,
NS = Not Significant
SD= Standard deviation
S.E= Standard Error
W1= Watered once a week
W2 = Watered twice a week
W0 = Watered everyday (control)

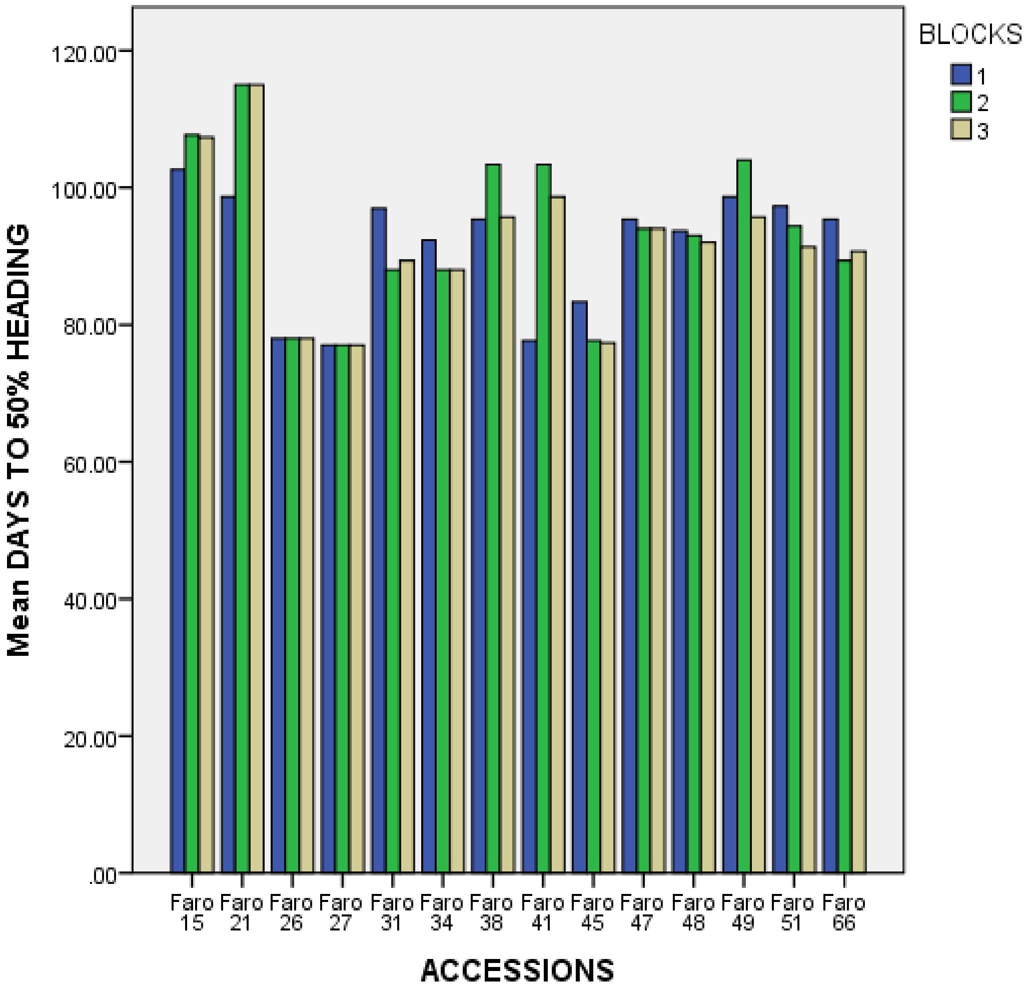

Figure 1: Days to 50% Heading as affected by different drought episodes
Block 1: Watered once a week (W1)
Block 2: Watered twice a week (W2)
Block 3: watered everyday (Wo)

The results on days to maturity of rice accessions as affected under three different Drought episodes as well as the significant effects of different interactions between the factors (accessions and drought episodes) show that there is significant difference between the numbers of days to maturity of rice accessions due to different drought episodes effects at 5% level of significance ($P<0.05$). This result revealed that the numbers of day to maturity of rice accessions is higher in those watered once a week than those that are watered twice a week and watered everyday (control). The result also show that there is significant difference between the average numbers of days to maturity of rice accessions for all the drought episodes at 5% level of significance ($P<0.05$). This shows that FARO 21 has the highest average numbers of days to maturity, followed by FARO 15, followed by FARO 41, FARO 38 and 49 while FARO 26, FARO 27, FARO 45 have the lowest number of days to maturity among the rice accessions. The results for interaction effects Drought episodes and Accessions revealed that the interaction effects on the numbers of days to maturity of the accessions are statistically significant at 5% level of significance ($P<0.05$).

FARO 21 (Watered once a week (WOW) and FARO 21 (Watered twice a week (WTW) have the highest number of days to maturity followed by FARO 15 (Watered once a week (WOW), FARO 15 (Watered twice a week (WTW), FARO 15 (Control) while FARO 26 (Watered twice a week (WTW), FARO 27 (Watered twice a week (WTW), FARO 45 (Watered twice a week (WTW), FARO 26 (Control), FARO 27 (Control) and FARO 45 (Control) had the lowest numbers of days to maturity.

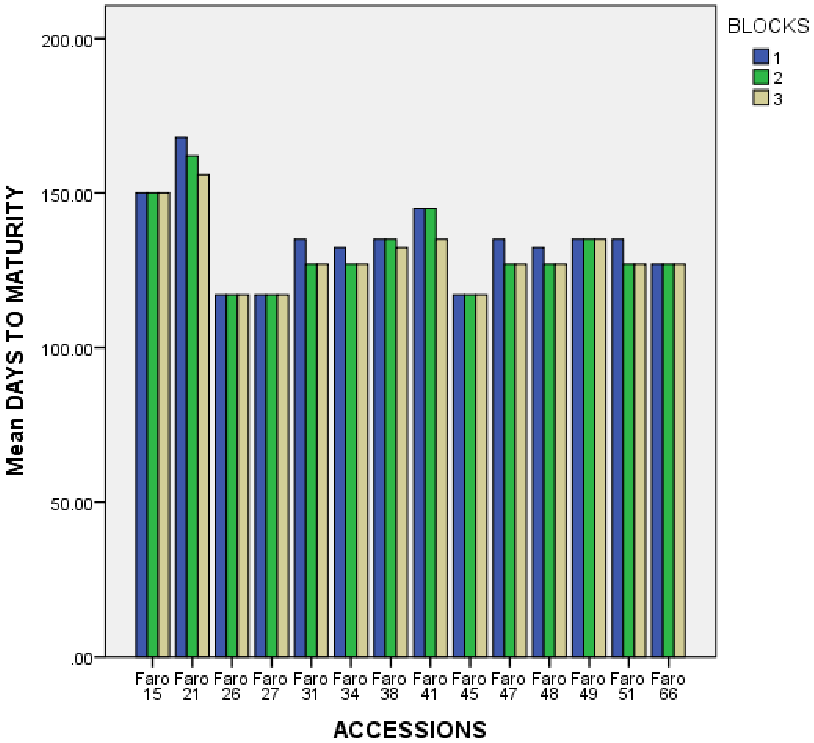

Figure 2: Days to Maturity affected by different drought episodes
Block 1: Watered once a week (W1)
Block 2: Watered twice a week (W2)
Block 3: watered everyday (Wo)

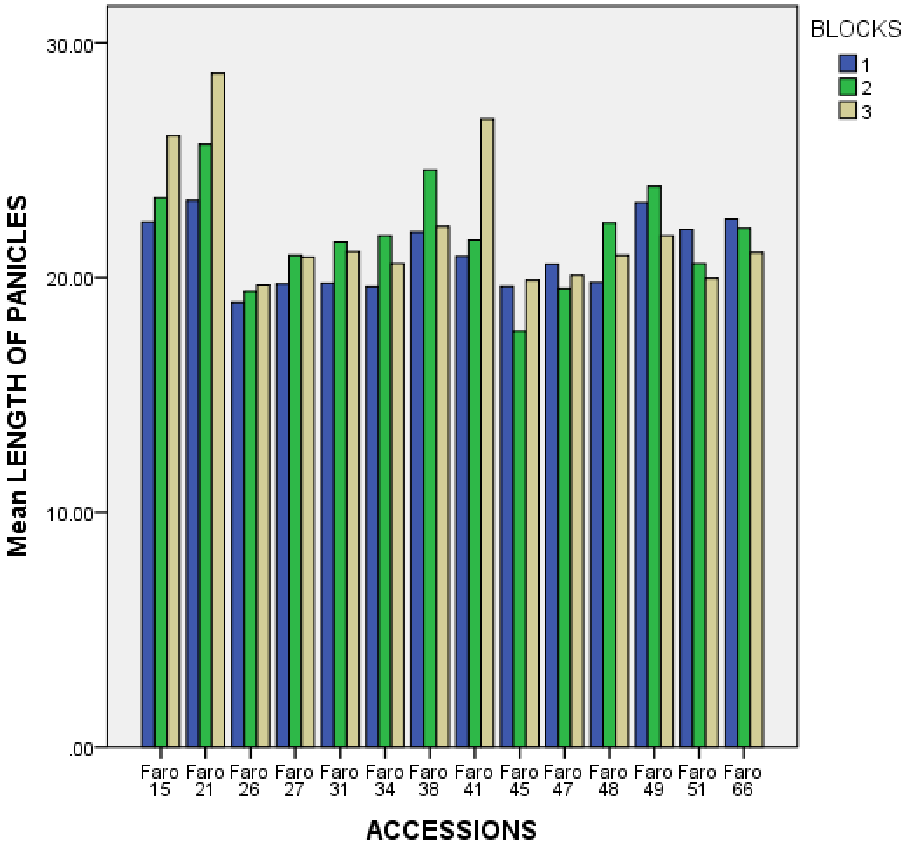

Figure 3: Length of panicles affected by different drought episodes
Block 1: Watered once a week (W1)
Block 2: Watered twice a week (W2)
Block 3: watered everyday (Wo)

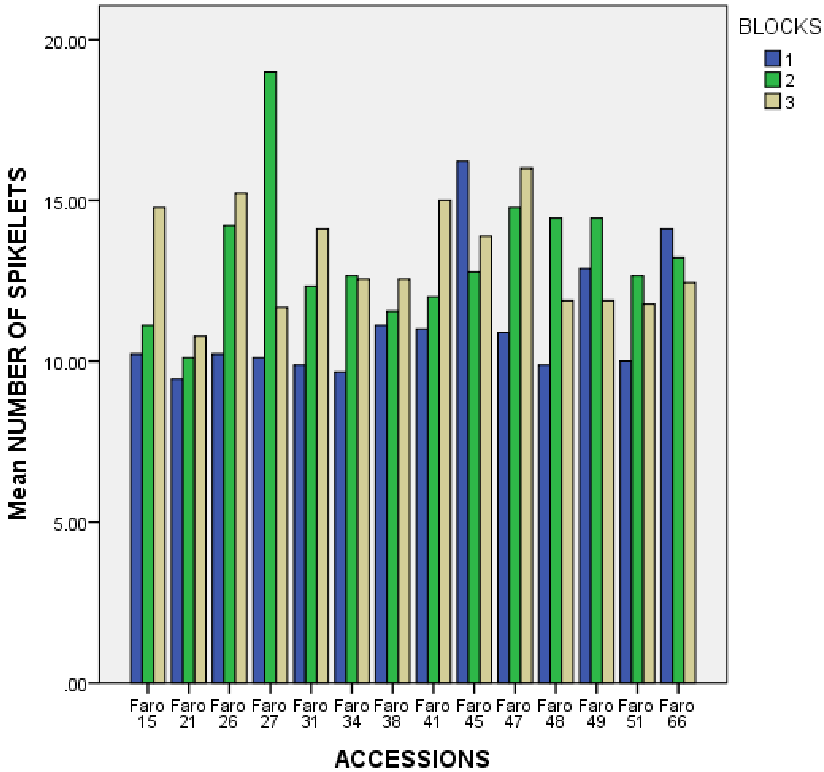

Figure 4: Number if spikelets affected by different drought episodes
Block 1: Watered once a week (W1)
Block 2: Watered twice a week (W2)
Block 3: watered everyday (Wo)

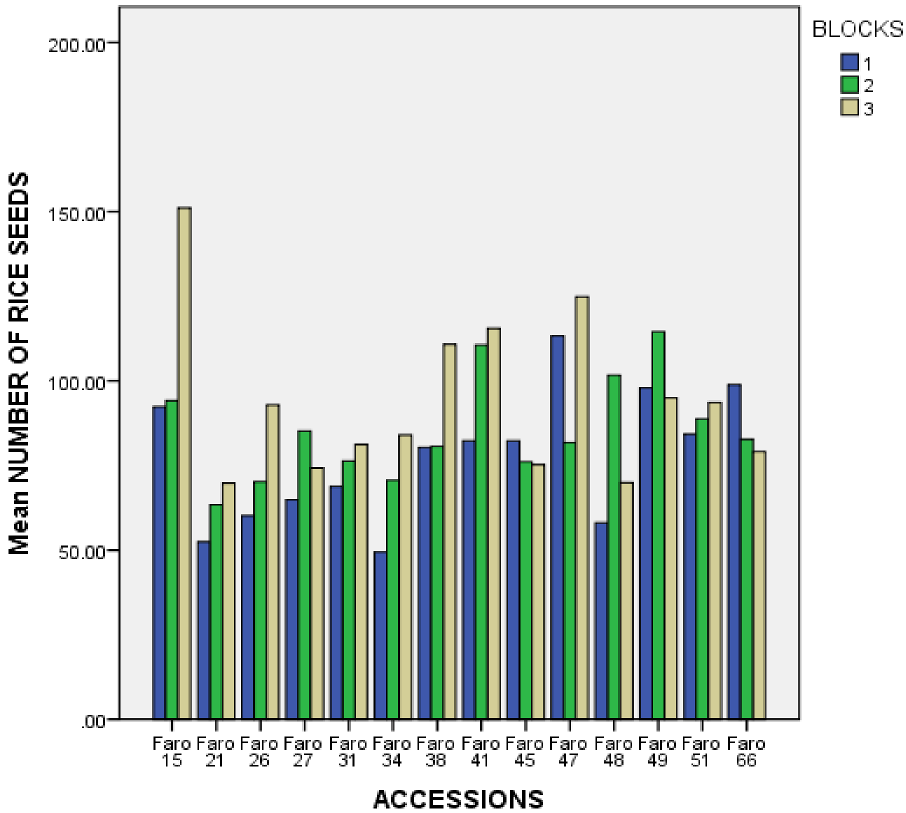

Figure 5: Number of Rice seeds affected by different drought episodes
Block 1: Watered once a week (W1)
Block 2: Watered twice a week (W2)
Block 3: watered everyday (Wo)

DISCUSSIONS

Drought stress is the most severe limitation to the productivity of rice (Chandral et al, 2012). Drought is a metrological term and is defined as the inadequacy of water availability including periods without significant rainfall that affects the crop growth (Rahman et al. 2002) and it occurs when the available water in the soil is reduced and atmospheric conditions cause continuous loss of water by transpiration or evapouration. Drought has serious effects on rice growth parameters and consequently reduces yield. The damage is a dependent on the duration, interlude of the stress and growth stage of the plant. The resultant effects of drought are seen in changes in morphological physiological and biochemical process of the plant.

Result on Days to 50% heading showed that rice accession that received necessary water requirement happened to flower earlier than those under different drought levels. Days to 50% heading increased with increasing drought stress. This finding is in line with the findings of pascual and Wang (2016) and Abdulrahman (2020) who observed that heading was first observed in continuous water relatively to water stress treatment regimes. The result of this finding also revealed that different rice accessions responded differently to different levels of drought episodes and days to 50% flowering from 98-115 days. This result is in line with the work of Sikuku et al. (2010), who observed that rice genotypes showed differences in days to flowering.

Result on days to maturity showed that accession under group watered twice a week and watered once a week motioned earlier than those watered once a week. This finding is in line with work of kuvahs (2018) who studied the effect of different planting dates on panicle growth trend and performance or rice varieties and observed that maturity duration was delayed under water stressed condition then under irrigated condition.

Result on number of panicles showed that different watering regimes affects the number of panicles produced by different rice accessions. Those watered everyday (W0) produced more panicles relative to those subject to different levels of drought. Also different rice accession responded differently in different levels of drought stress. This result support the work of Abdulrahaman (2020), who reported that moisture stress prior to panicle initiation or after panicle initiation affected number of panicle produced it is also in line with the work of Chandra *et al.* (2012) who observed that there was increase in number of panicles under well irrigated condition and reduction under drought conditions.

Also the increase in the length of panicles as observed in this study could be attributed to different watering regimes. Those rice accessions that were watered daily (W0) produced longer panicles than those t subjected to drought stress with panicle length decreasing with increasing drought stress. The differences in an panicle length is in line with the work of Rahman *et al.* (2002) who observed that varietal differences existed in panicle length under different moisture stress regimes. Also this result is in line with the findings of Chandra *et al*., (2012) who stated that there was increase in panicle length under well irrigated condition and reduction in panicle length under drought conditions.

Result on number of spikelets showed that different levels of different watering regimes stress affected the number of spikelet's produced by different rice accession. The control group and those watered twice a week (W2) produced higher number of spikelet's than those watered once a week (W1) this finding is in line with work of Singh *et al* (2018) who reported that the values for number of spikelet's per panicle reduced under drought stress conditions and increased under irrigated conditions.

Results on number of rice seeds showed that number of rice seeds were also affected by different watering regimes the result revealed that rice plants watered everyday (W0) produced more grains per panicle compared to drought stressed plants. The increase is the number of rice seeds should be attributed to different watering regimes. This finding is in line with the work of Rahman *et al*. (2002) who reported that were watered plants have more rice seeds compared to those subjected to water deficit. That reduction in the number of seeds is due to the disruption in translocation of nutrients to the sink which increased the emptiness of the seeds it could also be due limited photosynthetic activities.

Result on proline and glycine betaine content showed that there was in increase in levels of proline and glycinebetaine content in the stressed group that was watered once a week than in the control group. These findings are inline with the work of Debabrata *et al.,* (2021), who reported that wonder drought stress, plants try to maintain the cell turgor by accumulation of proline and glycine betaine that lower osmotic potential. The result is also in lien with the work of Ghulam (2016), who reported that concentration of proline and glycinebetaine has been shown to be higher in stressed plants than well watered plants.

CONCLUSION

In this study, overall drought stress impacted significantly on the vegetative growth parameters and yield attributes of the selected rice accessions and some of them such as FARO 21, 26, 27, 45 and 66 showed tolerance to drought, suggesting the genetic variability for drought tolerance.

RECOMMENDATIONS

From this study, the following recommendations can be made.

i. The use of early maturing rice accessions such as Faro 26, 27, 45, 66 to escape drought.
ii. The use of drought resistance accessions that perform better under drought stress conditions.

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