



## Effects of Salinity on Yield and Yield Components of Some Varieties of Rice (*Oryza sativa* L.)

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### ABSTRACT

Rice (*Oryza sativa* L.) is a monocotyledon spermatophyte crop belonging to the genus *Oryza* of the family Poaceae, it is one of the vital agricultural food crop cultivated globally and a crop grown under extensive irrigation scheme. In semi-arid region of Northern Nigeria, the interplay of climatic, geological and anthropogenic characteristics makes the soil virtually saline, among the monocot crops, rice is salt sensitive and its productivity is severely affected by the accumulation of soluble salts in soils especially in areas where irrigation is an essential aid to agriculture. Field trial experiment under split plot design (SPD) with three replications was carried out to assess the effects of NaCl and CaCl<sub>2</sub> at different concentrations (0.22, 4, 6, 8 10 dSm<sup>-1</sup>) on yield and yield components of some varieties of rice in Phase II Hadejia-Jama'are River Basin Irrigation Land. The result of analysis of variance revealed that yield and yield components of rice were negatively affected among varieties and salinity of both salt types at different concentrations, particularly in the range of 8 to 10dSm<sup>-1</sup>. FARO 52 and FARO 44 produced higher yield thus, appeared to be more tolerant in terms of yield and yield components compared to JAMILA. This could be attributed to the genetic make-up of the varieties. It can be concluded that yield and yield components of rice varieties studied were strongly affected among the varieties and the two salt types at different concentrations. As different rice responds differently to salinity, it is recommended that more rice varieties need to be screened for salinity tolerance and agronomic practices including proper method of irrigation, water management and appropriate use of fertilizer among others should be reviewed to controlled accumulation of salts in the soil.

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### INTRODUCTION

Rice (*Oryza sativa* L.) is a monocotyledon spermatophyte crop belonging to the genus *Oryza* of the family Poaceae, it is an annually growing grass with round hallow and jointed culms, flat leaves and a terminal inflorescence (Tripathi *et al.*, 2011). Rice is one of the most essential agricultural food crop cultivated in every part of the world and a crop grown under extensive irrigation regimes (Yeo and Flowers, 1983; Sahi *et al.*, 2006). However, in Nigeria, rice is one of the major staple foods consumed across all geopolitical zones and

socioeconomic classes (Kamai *et al.*, 2020). Rice has been cultivated as a major crop for many years, and it currently sustains nearly one-half of the world population (Wu *et al.*, 2004; Joseph *et al.*, 2010).

Among the monocot crops, rice is salt sensitive and its productivity is severely affected by the accumulation of soluble salts in soils (Maas and Hoffman, 1997; Ashraf, 2009). Salinity is a pervasive threat to crop yields, especially in countries where irrigation is an essential aid to agriculture (Flowers, 2004). Salt stress results from a number of detrimental processes



including a toxic action of  $\text{Na}^+$ , the impairment of  $\text{K}^+$  nutrition, a modification in the plant water status and secondary stresses such as oxidative stress linked to the production of reactive oxygen species (Zhu, 2002; Ndayiragije and Lutts, 2006). High concentrations of salts in soils impose both ionic and osmotic stresses on plants; hence, salt stress has been a serious threat for crop production in irrigated land (Pitman and Lauchli, 2002).

In addition, Photoinhibition coupled with salinity stress causes serious damage to many cellular and physiological processes including photosynthesis, nutrient uptake, water absorption, root growth and cellular metabolism, which all obviously lead to yield reduction (Darwish *et al.*, 2009; Zeng and Shannon, 2000b; Zhu, 2001). High salt concentration may lead to plant death and no yield. Research have showed that during fertilization, salt stress may cause sterility of panicle, which leads to a decline in grain setting, pollen bearing capacity, and decrease of the stigmatic surface, or both (Abdullah *et al.*, 2001). The main cause of decreased grain yield under salt stress is lack of transformation of carbohydrates to vegetative growth and spiklets development. Zeng and Shannon, (2000) observed negative linear relationships in many yield components with increased salt stress such as number of tillers per plant, number of spiklets per panicle, and percent of sterile florets (Khatun and Flowers, 1995; Zeng and Shannon, 2000).

In Nigeria, one of the reasons for the failure of agricultural productivity is underestimating the importance of soil status. In semi-arid region of northern Nigeria where Hadejia-Jama'are River Basin is located, the interplay of climatic, geological and anthropogenic characteristics makes surface water virtually saline, and many farmers have been forced to invest exploitation of the water for cultivation of many agricultural crops (Dammo, *et al.* 2015; Tukur *et al.*, 2016). Furthermore, most of the local farmers depend on the use of inorganic fertilizer and chemical herbicides as well as poor irrigation methods in their farming activities which have deleterious effects on the soil used for cultivation of agricultural crops, predominantly rice. Therefore, extensive

research or information data available is required on abiotic factors; especially salinity which may have significant effects on soil and thus, affecting the yield and yield components of rice plants.

## MATERIALS AND METHODS

**Study Area:** The research was carried out in Phase II Irrigation Project of Hadejia-Jama'are River Basin Development Authority, Jigawa State, Nigeria at Bangeli Irrigation Sector (latitude  $12^{\circ}33'41''$  N and Longitude  $9^{\circ}68'34''$ ), located 3.4 kilometers away from Auyo Town in Auyo Local Government Area, using Irrigation tube well for a period of five Months (March-July, 2020).

**Treatment Combinations:** Field trial experiment under Split plot design (SPD) with three replications was conducted. The research involved three different varieties of rice; FARO 44, JAMILA and FARO 52 obtained from Leventus Foundation Panda, Kano State. The treatment given included four different concentrations (4, 6, 8 and  $10 \text{ dS m}^{-1}$ ) of NaCl and  $\text{CaCl}_2$  each and control of  $0.22 \text{ dS m}^{-1}$ . Each of the two salts, five concentrations including control and the three varieties of rice were combined factorially, giving twenty seven (27) treatment combinations. Varieties served as main plot while salt type and concentrations served as subplot.

**Preparation of Salt Solution:** Four different concentrations of sodium chloride and calcium chloride (4, 6, 8 and  $10 \text{ dSm}^{-1}$ ) were prepared in addition to control using pure salts of NaCl and  $\text{CaCl}_2$  adopting the method described by Auyo *et al.* (2020).  $\text{Na}^+$  in form of NaCl and  $\text{Ca}^{2+}$  in the form of  $\text{CaCl}_2$  were prepared into five electrical conductivities (ECe) values in addition to control i.e.  $0.22 \text{ dSm}^{-1}$ ,  $4 \text{ dSm}^{-1}$ ,  $6 \text{ dSm}^{-1}$ ,  $8 \text{ dSm}^{-1}$  and  $10 \text{ dSm}^{-1}$  to provide the desired levels of salinity as per treatment.

**Agronomic Practices:** A portion of land measuring  $250 \text{ m}^2$  from the experimental area was properly cleared using tractor and other accessory farm tools such as hoe and rake. Soil was well tilled, all trashes of grass were cleaned and clots were broken into fine pieces, then,



treated with *glyphosate* (recommended herbicide). At each replicate, Twenty seven (27) plots of 1m x 1m and 0.5m between each were made using hoe, plots were demarcated so as to minimize excess contamination between neighboring plots (Sangita *et al.*, 2018). Water was allowed to enter each plot with the aid of water hose (2 inch in diameter); connected to the generator from the irrigation tube well, at each plot, pre-germinated seeds of uniform size were sown manually by hand (Pradheeban, 2017) as nursery preparation. Three weeks after germination, seedlings were uprooted manually using hand to remove weak and excess number of seedlings germinated, then washed and transplanted manually at 20cm x 20cm spacing between each and 15cm between the rows, three seedlings were transplanted, as described by Pradheeban, (2017). Weeding activities were carried out manually whenever necessary throughout the experimental period. Fertilizer (N.P.K) at 120:60:60 kg h<sup>-1</sup> and 130 kg h<sup>-1</sup> of urea (46% Nitrogen) were applied at appropriate time to each experimental unit (FAO, 2017).

**Treatment Application:** After two weeks of transplanting as described by Hakim *et al.* (2014). Treatments were applied to the water in each plot accordingly, monitoring with electric conductivity meter, to make the desired ECe values, while, the control received no addition of salt. The salt concentrations were raised gradually; until the desired concentration is achieved so as to prevent salt shock to the plant. The treatment application was carried out in the late evening so as to minimize damage.

**Data Collection:** At harvest, when the grains have reached the maturity stage, three stands of plant at the middle of the plot were selected randomly for measurement of yield components. Number of effective tillers per stand, number of spikelet per panicle and number of grains per panicle were determined and recorded through manual counting, length of panicle per plant was measured using 30cm plastic ruler. However, after threshing and winnowing, 1000- grain weight and grain yield per stand were determined in the laboratory using digital weighing balance while grain yield per plot was determined in the

laboratory using digital weighing balance while grain yield per plot was determined after individual plots were harvested, threshed and winnowed then, Weighed and eventually computed into hectare basis to obtain the actual yield per hectare. Data collected were subjected to Genstat Statistical software package (Version 17.1.0.13780) for analysis of variance (ANOVA). The treatment means were compared through employing least significance different test at 5% level of significance.

## RESULTS AND DISCUSSIONS

### *Effects of Varieties on Yield and Yield Components of Rice*

**Panicle length (cm):** In terms of panicle length, there was significant difference observed among the varieties. FARO 44 recorded the highest panicle length (20.6 cm), while FARO 52 recorded the lowest panicle length (19.4 cm). The reduction in panicle length might be as a result of the negative effects of the induced salinity during seedling growth, especially at panicle initiation stage. This result was in agreement with findings of Hakim *et al.*, (2013), who reported that panicle length were different in different rice varieties. It was also reported that yield components such as spikelets per panicle, panicle length, number of tillers per plant, number of florets per panicle, and 1000-grain weight are all severely affected due to increasing salt stress (Khatun and Flowers, 1995; Farshid and Hassan, 2012). Similarly, differential behavior of panicle length under salt stress in different varieties of rice has been reported by Marassi *et al.*, (1989). In contrary, Ali *et al.*, (2004) reported that there is an increase in percentage for number of primary branches per panicle, panicle length and fertility percentage in six genotypes tested.

**Number of spiklets per panicle:** When compared base on number of spiklets per panicle, FARO 44 and FARO 52 recorded the maximum number (10.9 and 10.6), while the minimum number of spiklets per panicle (10.4) was recorded by JAMILA. This indicated that FARO 44 and FARO52 showed more resistance to the induced salinity compared to JAMILA; this



could be due to the fact that, different rice varieties were identified to retained stress tolerance alleles in their genetic composition when they are facing harsh environmental conditions. This confirmed the findings of Makihar *et al.*, (1999) who revealed that, the yield component most responsible for the yield decrease under salinity varied among the varieties, the number of spikelets per plant was most responsible in IR28 and Pokkali. Several researchers also reported that there was significant reduction of number spikelets per panicle in rice (Khan *et al.*, 1997; Cui *et al.*, 1995 and Rad *et al.*, 2012).

**Number of grains per panicle:** With regard to number of grains per panicle, there was no significance difference recorded amongst the three rice varieties studied in the research. This could be due to the genetic makeup of the varieties and efficient assimilation of photosynthetic product. Chamely *et al.*, (2015) also observed the same criteria for the grain production per panicle. This result was in contradiction with findings of Islam and Hossain, (2020) who stated that, different rice varieties respond differently to salinity of different concentrations in terms of grains per panicle.

**Number of effective tillers per stand:** In terms of number of effective tillers per stand, there was significance difference amongst the varieties. FARO 44 recorded the maximum number of effective tillers (26.3) while FARO 52 and JAMILA which recorded the minimum number of effective tillers. The number of tillers per plant is an important yield parameter under salinity because it determines the number of grain-bearing panicles of the rice plants which eventually reflects on the total yield of the plant (Tanveer *et al.*, 2009). This result also indicates the tolerance behavior of FARO 44 to salinity conditions and the sensitivity of FARO 52 and JAMILA. This reduction could be as a result of salinity stress imposed at tillering stage resulted in reduction in photosynthesis. The present result confirmed the findings of Uyoh *et al.*, (2020) who reported that, Salinity treatment caused a highly significant reduction in number of tillers in the treated genotypes. Similar result was also revealed by Hassanuzzaman *et al.*, (2016); there

was a significant variation in number of tillers per hill amongst the varieties. It was also stated by Abhilash and Mohanan, (2013) that number of total tillers produced showed significant reduction in three cultivars due to salt stress. Other researchers also reported the reduction of tiller number in different rice cultivars (Linghe *et al.*, 2000; Weon *et al.*, 2003 and Akram *et al.*, 2013).

**1000 – Grains weight (g):** Base on 1000 grains weight (g), there was significant difference recorded between the three rice varieties, JAMILA and FARO 44 recorded the highest value (19.0g and 18.3g respectively), while the lowest value (17.5g) was recorded by FARO 52. This reduction in 1000- grain weight amongst might be due to the negative effect of the salinity stress that decreases the translocation of the food materials to the grain or lower accumulation of carbohydrates and other food materials that result in lowering of grain weight. This was in accordance with findings of Pradheeban (2017) who reported that among the varieties studied, significant differences were observed in 1000 grain weight due to salinity stress; compared with other varieties.

**Actual yield (Kg):** However, in terms of yield per stand (g), yield per plot (kg) and yield per hectare (kg), there was no significance difference amongst all the three rice varieties studied. This equal tolerance observed amongst the rice varieties might be due to the presence of large number of genetic resources, genes and quantitative trait loci (QTLs) for abiotic stress tolerance in rice which were identified by rice breeders or the genes involved in Na<sup>+</sup>/ K<sup>-</sup> transport, ABA dependent and independent pathways, signaling and some miRNAs have been implicated in governing salinity tolerance, these could better the viability of pollens and eventually result in high yield. The present result was in agreement with findings of Pradheeban *et al.*, (2017) who stated that there was no significant difference in yield between Adakari, At 353, Bg 352 and Pokkali rice varieties. However, in contrast to this findings, Ali *et al.*, (2004) revealed that, yield per plant decreased significantly in response to salinity in all rice genotypes studied.



### Effects of Salt Type and Concentrations on Yield and Yield Components

Amongst the salinity levels; in terms of panicle length and number of spiklets per panicle, highest concentration of both salt types ( $\text{CaCl}_2$  10  $\text{dSm}^{-1}$  and  $\text{NaCl}$  10  $\text{dSm}^{-1}$ ) recorded the minimum value compared with control condition (0.22  $\text{dSm}^{-1}$ ). This result confirmed the findings of Farshid, (2012). Based on number of grains per panicle, number of effective tillers per stand and 1000 grains weight (g), the highest values were recorded in the control condition (0.22  $\text{dSm}^{-1}$ ), while the least values were recorded at  $\text{CaCl}_2$  10  $\text{dSm}^{-1}$  and  $\text{NaCl}$  10  $\text{dSm}^{-1}$ . High effectiveness of salinity on numbers of grains has been reported by many researchers. The research carried out by Hassan, (2012), reported that control treatment had the most amounts (1475); increased salinity resulted in decreased total number of grains per panicles. Punendu, *et al.*, (2004) also stated that there was significant effect of salinity on number of tillers per hill, and the number increased from control to 7.81  $\text{dSm}^{-1}$  salinity levels. Furthermore, Karami *et al.*, (2010) reported that by increasing salinity levels, total number of tiller, number of fruitful tiller, number of full grain per cluster and kernel weight decreased.

However, in contrary to the findings of Kaddah (1963), who reported that salinity has

less adverse effects on number of tillers than on grain and panicle production. Another results reported by Mahmood *et al.*, (2009) also revealed the effect of salinity on rice and reported that 1000 grain weight of rice was least affected by high concentration of salinities. With regard to yield per stand, yield per plot and yield per hectare, control condition with 0.22  $\text{dSm}^{-1}$  recorded the highest value (119.9g, 1.1kg and 8641kg respectively), compared with higher levels of both salt types. This significant reduction in yield at high concentrations of salinity could be as a result of reduction in translocation of soluble sugar contents to superior and inferior spiklets and inhibition of starch synthetase activity during grain development. These results confirmed the findings of Hakim *et al.* (2014) who reported that rice yield was significantly varied due to different salinity levels, it ranged from 0.57 to 14.45  $\text{g hill}^{-1}$  having the highest (14.45  $\text{g hill}^{-1}$ ) in the control condition. Similarly, Pradheeban *et al.*, (2017) stated that different salinity levels showed significant effects on yield of rice as the salinity levels increased. According to Young *et al.*, 2003 and Gain *et al.*, 2004, grain yield decreased with raising salinity levels. In addition, Farshid, (2013), stated that control treatment irrigated by fresh water (at 1  $\text{dSm}^{-1}$  salinity) had the most yields.

**Table 4.3.1:** Effect of Varieties, Salt type and Concentrations and the Interactions on Yield and Yield Components of Rice at Harvest in Field Trial at Bangeli Irrigation Land

Treatment	Yield and Yield Components							
	Length of Panicle (cm)	Number of Spiklets/panicle	Number of Grain/panicle	Number of effective tillers	1000 Grain weight (g)	Yield per stand (g)	Yield per plot (Kg)	Yield per hectare (Kg)
<b>Varieties</b>								
FARO 44	20.6 <sup>a</sup>	10.9 <sup>a</sup>	105.4 <sup>a</sup>	26.3 <sup>a</sup>	18.3 <sup>a</sup>	56.0 <sup>a</sup>	0.5 <sup>a</sup>	4665 <sup>a</sup>
JAMILA	20.0 <sup>b</sup>	10.4 <sup>b</sup>	104.5 <sup>a</sup>	22.8 <sup>b</sup>	19.0 <sup>a</sup>	58.7 <sup>a</sup>	0.5 <sup>a</sup>	4812 <sup>a</sup>
FARO 52	19.4 <sup>c</sup>	10.6 <sup>a</sup>	106.3 <sup>a</sup>	23.4 <sup>b</sup>	17.5 <sup>b</sup>	58.0 <sup>a</sup>	0.5 <sup>a</sup>	5164 <sup>a</sup>
<b>LSD</b>	<b>0.46</b>	<b>0.34</b>	<b>1.88</b>	<b>1.74</b>	<b>0.78</b>	<b>2.86</b>	<b>0.04</b>	<b>642.3</b>
<b>Salt type and concentrations</b>								
$\text{NaCl}$ 4 $\text{dSm}^{-1}$	21.7 <sup>b</sup>	12.3 <sup>b</sup>	119.2 <sup>b</sup>	34.2 <sup>c</sup>	19.6 <sup>c</sup>	92.9 <sup>c</sup>	0.8 <sup>b</sup>	8287 <sup>b</sup>
$\text{NaCl}$ 6 $\text{dSm}^{-1}$	19.6 <sup>c</sup>	10.7 <sup>d</sup>	103.2 <sup>d</sup>	22.6 <sup>d</sup>	18.4 <sup>e</sup>	51.2 <sup>d</sup>	0.4 <sup>d</sup>	4478 <sup>c</sup>
$\text{NaCl}$ 8 $\text{dSm}^{-1}$	18.2 <sup>d</sup>	8.9 <sup>e</sup>	93.6 <sup>e</sup>	16.7 <sup>e</sup>	16.8 <sup>g</sup>	29.4 <sup>e</sup>	0.3 <sup>e</sup>	2630 <sup>d</sup>
$\text{NaCl}$ 10 $\text{dSm}^{-1}$	17.3	8.6	88.1	13.6	16.2	21.9	0.20	1957
$\text{CaCl}_2$ 4 $\text{dSm}^{-1}$	21.9 <sup>b</sup>	12.6 <sup>b</sup>	122.0 <sup>b</sup>	35.6 <sup>b</sup>	20.1 <sup>b</sup>	95.9 <sup>b</sup>	0.8 <sup>b</sup>	8427 <sup>b</sup>
$\text{CaCl}_2$ 6 $\text{dSm}^{-1}$	20.0 <sup>c</sup>	11.4 <sup>c</sup>	106.7 <sup>c</sup>	23.4 <sup>d</sup>	18.8 <sup>d</sup>	52.9 <sup>d</sup>	0.5 <sup>c</sup>	4613 <sup>c</sup>

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Treatment	Yield and Yield Components							
	Length of Panicle (cm)	Number of Spiklets/panicle	Number of Grain/panicle	Number of effective tillers	1000 Grain weight (g)	Yield per stand (g)	Yield per plot (Kg)	Yield per hectare (Kg)
CaCl <sub>2</sub> 8 dSm <sup>-1</sup>	18.2 <sup>d</sup>	9.3 <sup>e</sup>	95.0 <sup>e</sup>	17.0 <sup>e</sup>	17.2 <sup>f</sup>	31.1 <sup>e</sup>	0.3 <sup>e</sup>	2706 <sup>d</sup>
CaCl <sub>2</sub> 10 dSm <sup>-1</sup>	17.4 <sup>e</sup>	8.3 <sup>f</sup>	89.6 <sup>f</sup>	14.1 <sup>f</sup>	16.3 <sup>h</sup>	22.8 <sup>f</sup>	0.2 <sup>f</sup>	2183 <sup>d</sup>
Control	25.5 <sup>a</sup>	13.4 <sup>a</sup>	131.3 <sup>a</sup>	40.6 <sup>a</sup>	20.9 <sup>a</sup>	119.9 <sup>a</sup>	1.1 <sup>a</sup>	8641 <sup>a</sup>
<b>LSD</b>	<b>0.39</b>	<b>0.55</b>	<b>2.04</b>	<b>1.23</b>	<b>0.29</b>	<b>1.65</b>	<b>0.01</b>	<b>1405.3</b>
<b>Interactions</b>								
Variety*Salt types and conc.	**	NS	**	*	**	**	**	NS

\* Values in a column followed by the same superscript do not differ significantly at 5% level of significance

#### Interactions of Varieties, Salt Type and Concentrations on Yield and Yield Components

The result of interaction of rice varieties and salt type at different concentration on yield and yield components revealed that, in terms of 1000-grains weight, JAMILA recorded the highest grain weight (22.4g) at 0.22 dSm<sup>-1</sup> (control), while the lowest grain weight (15.9g and 15.7g) were recorded by FARO 52 at CaCl<sub>2</sub> 10 dSm<sup>-1</sup> and NaCl 10 dSm<sup>-1</sup> respectively. The result was in agreement with Hakim, *et al.*, (2014) who stated that, the average weight of 1000 grains of different rice varieties grown under control and three different salinity conditions. Furthermore, Pradheeban, *et al.*, (2017) also stated that, there was a significant difference between Pachaperumal, Pokkali and Adakari at 4 dSm<sup>-1</sup> and 6 dSm<sup>-1</sup>.

The result also revealed that, FARO 44 recorded maximum number of effective tillers at CaCl<sub>2</sub> 4 dSm<sup>-1</sup> and NaCl 4 dSm<sup>-1</sup> respectively, while minimum number of effective tillers was recorded by JAMILA at NaCl 10 dSm<sup>-1</sup> and CaCl<sub>2</sub> 10 dSm<sup>-1</sup>. This confirmed the findings of Mahmood (2009), who stated that Basmati Pak produced the highest number of tillers per plant in control and 5.2 dSm<sup>-1</sup>, while PK 4048 produced maximum tillers at 10.5 dSm<sup>-1</sup>. A significant decrease in number of tiller at 15.62 dSm<sup>-1</sup> salinity levels in BR11 rice has been reported by Gain, *et al.*, (2004).

The result of interaction of rice varieties and salt levels on length of panicle presented that, the highest panicle length (26.4cm and

25.9cm) was recorded by JAMILA and FARO 52 at the lowest salinity level (0.22 dSm<sup>-1</sup>), while JAMILA and FARO 52 at CaCl<sub>2</sub> 10 dSm<sup>-1</sup> and NaCl 10 dSm<sup>-1</sup> recorded the lowest panicle length (17.0cm, 17.0cm and 16.9cm respectively). This was in lined with findings of Abhilash and Mohanan, (2013) who reported that Panicle length showed significant reduction in one of the cultivars starting from 50mM salt concentration onwards. Hakim, *et al.*, (2014) stated that, panicle length were different in different rice varieties but the highest was produced in Pokkali and the shortest in IR20.

The result of interaction of rice varieties and salts levels on number of grains per panicle showed that at normal condition, JAMILA and FARO 52 recorded the highest number of grains per panicle (137.7 and 134.3), while, at higher levels of salinity lowest number of grain per panicle were also recorded by JAMILA and FARO 52. Hence, FARO 44 which recorded 92.3 at higher levels of salinity showed less susceptibility to salinity than other two varieties. It was reported by Mahmood, *et al.*, (2009) that increased salinity significantly reduced the grain number per panicle in PK 49951 and PK 33892.

Significant interaction between the rice varieties and salts levels on yield per stand (g) revealed that, at control, JAMILA produced the highest yield per stand (128.4g), while the lowest yield per stand was produced by JAMILA and FARO 52 at the highest levels of salinity. However, interaction of rice varieties and salt levels on yield per plot (Kg) presented on Table 4.3.7 showed that, at control condition (0.22

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dSm<sup>-1</sup>), JAMILA recorded the highest yield (1.156kg), and the lowest yield per plot was recorded by all the three varieties study at highest levels of salinity. The reduction in yield observed amongst the rice varieties could be as a result of ion toxicity of the imposed salinity at high concentrations that decreases yield through decreasing filled grains per rice panicle. Reducing seed set in the panicle, possibly as a consequence of decreased pollen viability or decreased receptivity of the stigmatic surface, or both, due to high salinity levels has been reported by many researchers (Abdullah *et al.*, 2001; Khatun and Flowers, 1995a). The result of the present research was in accordance with that of Mahmood *et al.* (2009) who revealed that, Basmati 370 and Basmati 385 were least affected by the salinity while PK 49626 was most affected in respect of grain yield. Furthermore, Hakim *et al.*, (2014) also revealed that high salinity treatment led to the significance reduction in the grain yield in all varieties with the most drastic reduction being observed at 12 dSm<sup>-1</sup> salinity level.

## CONCLUSION

The research established that varietal characteristics and salinity of different salt type (NaCl and CaCl<sub>2</sub>) at different concentrations have negative effects on yield and yield components of all rice varieties studied in the research, particularly number of effective tiller, 1000-grains weight and panicle length, especially in the range of 8 to 10 dSm<sup>-1</sup>. It has been observed that among the three varieties of rice studied, FARO 44 and FARO 52 were the best varieties that can withstand salinity

## RECOMMENDATIONS

It can be seen from the research work that salinity is a serious problem that require urgent attention looking by the way it affects yield and yield components especially at high concentrations, as observed in previous studies and also in this research; varieties of rice were seen to respond differently to salinity of different salt types, as such it is advisable that agronomic practices responsible for soil salinity such as excessive use of inorganic fertilizers and chemical herbicides, improper method of

irrigation, mono cropping among others should be reviewed to control excess accumulation of salt in the soil and their negative effects on agricultural crops as it can be a threat to food security.

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