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Response of Rice to Different Salinity Levels during Different Growth Stages

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Abstract: Salt accumulation in irrigated soils is one of the main factors that diminish crop productivity since most of the crops are not halophytic. A greenhouse experiment was conducted in Rasht, North of Iran during May to June 2010 as a complete randomized block design with three replications. The treatments in this study were application of four levels of saline irrigation water (2, 4, 6 and 8 dS/m, respectively) at four growth stages (tillering, panicle initiation, panicle emergence and ripening). The aim of this study was to determine the effect salinity levels on some agronomic characters of rice. The results of this study showed that increase in salinity levels of irrigation water significantly decreased length of filled panicle, number of filled grains per filled panicle, number of spikelets per filled panicle and total number of spikelets per panicles but effect of different salinity levels on percentage of ratio of filled panicle number to tiller number and percentage of ratio of yield to straw weight was not significant. The least of these yield components were observed at the highest salinity level (8 dS/m). In different growth stages of rice, all yield components were different. Final growth stages, i.e., panicle emergence and ripening showed less sensitivity to salinity but primary stages, i.e., tillering and panicle initiation were more sensitive to salinity. Therefore, irrigation with saline water can be used in the final stages of plant growth, i.e. panicle emergence and ripeness.

Keywords: Growth stages, salinity, salinity sensitivity, sodium, yield components

INTRODUCTION

Salt-affected soil is one of the serious abiotic stresses that cause reduced plant growth, development and productivity worldwide (Siringam *et al.*, 2011). In Iran, salinity has already become a major deterrent to crop production, including rice. Addition of salts to water lowers its osmotic potential, resulting in decreased availability of water to root cells. Salt stress thus exposes the plant to secondary osmotic stress, which implies that all the physiological responses, which are invoked by drought stress, can also be observed in salt stress (Sairam *et al.*, 2002). Growth and yield reduction of crops is a serious issue in salinity prone areas of the world (Ashraf, 2009). Water-deficit and salt affected soil are two major abiotic stresses which reduce crop productivity, especially that of rice, by more than 50% world-wide (Mahajan and Tutejan, 2005; Nishimura *et al.*, 2011). Salinity is one of the important abiotic stresses limiting rice productivity. The capacity to tolerate salinity is a key factor in plant productivity (Momayezi *et al.*, 2009).

More than 800 million ha of land throughout the world are salt-affected (FAO, 2008). In many regions of the world and many areas of Iran, salinity stress may occur when crops are exposed to high levels of Na and Ca salts. Specific effects of salt stress on plant metabolism, especially on leaf senescence, have been related to the accumulation of toxic Na^+ and Cl^- ions and to K^+ and Ca^{2+} depletion (Al-Karaki, 2000). Salinity associated with excess NaCl adversely affects the growth and yield of plants by depressing the uptake of water and minerals and normal metabolism (Akhtar *et al.*, 2001; Akram *et al.*, 2001). The intercellular water potential is thereby lowered below the external water potential allowing continued water uptake. However, different species of plants inherently possess different measures and different capacities of coping with exposure to high salinity and salt stress responses and tolerance vary between species (Jampeetong and Brix, 2009; Munns and Tester, 2008).Sodium chloride salts are quickly dissolved in the water and play as ionic effects in higher plant including rice crop (Nishimura *et al.*, 2011). Excess Na^+ in plant cells directly damages membrane systems and organelles, resulting in plant growth reduction and abnormal development prior to plant death (Davenport *et al.*, 2005; Quintero *et al.*, 2007; Siringam *et al.*, 2011). High concentrations of both Na^+ and Cl^- can be toxic to plants resulting in growth inhibition (Caines and Shennan, 1999).

Salinity reduces the growth of plant through osmotic effects, reduces the ability of plants to take up water and this causes reduction in growth. There may be salt

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specific effects. If excessive amount of salt enter the plant, the concentration of salt will eventually rise to a toxic level in older transpiring leaves causing premature senescence and reduced the photosynthetic leaf area of a plant to a level that can not sustain growth (Munns, 2002; Shereen *et al.*, 2005). Salinity appears to affect two plant processes water relations and ionic relations. During initial exposure to salinity, plants experience water stress, which in turn reduces leaf expansion. During long-term exposure to salinity, plants experience ionic stress, which can lead to premature senescence of adult leaves (Amirjani, 2011). Salinity has three potential effects on plants:

- Lowering of the water potential
- Direct toxicity of any Na and Cl absorbed
- Interference with the uptake of essential nutrients (Flowers and Flowers, 2005)

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). Soil salinity and sodicity limit the potential area of growth of sensitive crops. High salt concentration may lead to plant death and no yield. The effects of salinity on crop yields were indicated with a scale of conductivity with 5 steps of increasing yield restriction (0-2, 2-4, 4-8, 8-16, >16 dS/m, respectively) (Eynard *et al.*, 2005).

Salt tolerance is the ability of plants to grow and complete their life cycle on a substrate that contains high concentrations of soluble salt (Parida and Das, 2005). All plants are sensitive to salts at some concentration. The limiting concentrations change with plant species, variety and stage of development and duration of the salt stress (Eynard *et al.*, 2005). Plants develop a plethora of biochemical and molecular mechanisms to cope with salt stress. Biochemical pathways leading to products and processes that improve salt tolerance are likely to act additively and probably synergistically (Iyengar and Reddy, 1996). Plants subjected to salt stress display complex physiological, biochemical and molecular responses including curling of leaf lamina, loss of chlorophyll, the production of stress inducible proteins involved in the biosynthesis of compatible osmolytes such as proline, glycine betaine, polyamines, polyols and in many other functions (Bohnert *et al.*, 1995). It has been reported that two major physiological traits enable the plant to tolerate salinity:

- Compensatory growth following adjustment to salinity
- Ability to increase both leaf area ratio and net assimilation rate to achieve this increased growth (Alamgir and Yousuf Ali, 2006; Wiynarah, 1990).

Tolerance for salinity-sodicity is not conferred by a single factor, rather the main physiological and biochemical traits contributing to the acquisition of resistance to salinity-sodicity stress at reproductive phase are Na^+ : K^+ levels, photosynthesis in flag leaves (which provide about two thirds of photo-assimilate for grain filling, pollen viability and stigma receptivity (Khan and Abdullah, 2003).

Rice, the main cereal crop of many countries including Iran, is not in general salt tolerant. It is a crop of fresh-water marshy land and is cultivated in Iran for centuries. Rice is the second largest cereal crop in the world and forms the basic diet of more than half of the world's population. Salinity stress triggers the expression of several osmoresponsive genes and proteins in rice tissues (Chourey *et al.*, 2003). The response of rice to salinity varies with growth stage. In the most commonly cultivated rice cultivars, young seedlings were very sensitive to salinity (Lutts *et al.*, 1995; Zeng and Shannon, 2000b). Tillering and booting phases are two physiologically important growth stages contributing to good plant population stand as well as yield (Alamgir and Yousuf Ali, 2006). Rice is considered moderately tolerant to exchangeable Na. The tolerance to sodicity of rice may lead to soil sodication if irrigation is carried out with sodic water. Therefore, in order to maintain long-term soil productivity, rice may be excluded from crop rotations if alkaline water is used for irrigation (Eynard *et al.*, 2005). Zeng and Shannon (2000b) showed that shoot dry weights of main culms were not significantly reduced by salinity until EC was 6.1 dS/m or higher. Asch and Wopereis (2001) studied the effect of field-grown irrigated rice cultivars to varying levels of floodwater salinity and concluded that floodwater EC levels >2 dS/m may lead to losses up to 1 t/ha per unit.

The present study is intended to clear up the effect of saline irrigation water at different growth stage on some agronomic characters of rice.

MATERIALS AND METHODS

This project was conducted at the Rice Research Institute in Rasht, North of Iran, on the rice (*Oryza sativa* L.), Hashemi cultivar, during May to July 2010. The site is located at latitude 37º12′ N and longitude 49º38′ E and 32 m altitude. Its climate is humid. In order to have a better control and preventing from influence of undesirable factors, this experiment conducted in greenhouse (cultivating in pot under shelter).

The experiment was laid out in a randomized complete block design with two factors (salinity levels and time of salinity application) and replicated three times. Factor one included four levels of saline irrigation water (2, 4, 6 and 8 dS/m, respectively) and the time when salinity conducts in different levels of rice growth stages (including tillering, panicle initiation, panicle emergence and ripening stages). Dates of rice cultivation stages in the project were: date of transplanting, May 23, date of impelling salinity in tillering stage, June 6, date of impelling salinity in panicle initiation, June 17, date of impelling salinity in panicle emergence, June 27, date of impelling salinity in ripening stage, July 23.

3 transplants provided in ordinary condition were cultivated in pots with diameter and deepness of 25 cm filled with agricultural soil. 7 days after cultivation, transplants were irrigated by ordinary water. Conducting treatments began with 5 cm height flooded irrigation. When each growth stage was finished, leaching was done with ordinary water and then irrigation with ordinary water was finished. All agricultural stages conducted usually and equally based on the region's custom.

Considered salinities of irrigation water were provided using pure NaCl and $CaSO_4$ in ratio of 2:1 and pots were irrigated by them. To provide different levels of salinity in irrigation water, basic water was provided first so that 425 g NaCl and 215 g $CaSO_4$ was added to 100 L ordinary water ($EC \leq 1$ dS/m). Different levels of salinity made with this basic water so that 10 L basic water with 90 L ordinary water added together to provide 2 dS/m salinity. 35 L basic water with 65 L ordinary water resulted in 4 dS/m salinity. 6 dS/m salinity prepared through mixing 60 L basic water and 40 L ordinary water. 8 dS/m salinity obtained through 86 L basic water and 22 L ordinary water.

All treatments fertilized during 2 stages on the May 26 and June 24. 6 kg urea (with 46% N), 8 kg potassium sulfate (with 50% K_2O) and 6 kg triple super phosphate (with 46% P_2O_5) were mixed together and added to treatments adequately. On the July 21, leaching was done to prevent accumulation of salt. After crop was ripped, some agronomic characters such as total number of filled grains per panicles, total number of spikelets per unfilled panicles, total number of grains per panicles, percentage of emptiness per panicle, total number of panicles and percentage of ratio of total panicle to tiller were measured.

All data were checked for normality before being analysed (Gomez *et al*., 1994). Analysis of variance and regression analysis were performed with SAS (SAS, 2001). Duncan's multiple-ranged test was also performed to identify the homogenous sets of data at the $p<0.05$ levels.

RESULTS AND DISCUSSION

Total number of filled grains per panicles: With regard to the conclusions of variance analysis (Table 1), different growth stages had different sensitivity to salinity. Effect of different growth stages, different levels of salinity and also their interaction effect on total number of filled grains per panicles was significant ($p<0.01$). High effectiveness of salinity on numbers of grains has been reported by many researchers.

Conclusions of comparison between total number of filled grains per panicles in Table 2, showed that control treatment had the most amount (1196) and after that were treatments at 2, 4, 6 and 8 dS/m, respectively. Therefore increasing salinity decreased total number of filled grains per panicles. The least total number of filled grains per panicles was 556.88 at 8 dS/m salinity, so it showed 53% decrease in compare with control treatment. Salinity 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, has been reported by any researchers (Abdullah *et al*., 2001; Khatun and Flowers, 1995a).

In different growth stages of rice total number of filled grains per panicles was different. The most and the least total numbers of filled grains per panicles were 921.50 and 464.25 which belonged to panicle emergence and panicle initiation. The least sensitivity to salinity was in panicle emergence and after that were in ripening, tillering and panicle initiation stages, respectively. Therefore primary growth stages, it means tillering and panicle initiation showed more sensitivity to salinity in compare with final growth stages. It has long been recognized that a crop's sensitivity to salinity varies from one developmental growth stage to the next (Lauchli and Grattan, 2007). Rice has been reported as being salt-susceptible in both its vegetative and reproductive stages (Moradi and Ismail, 2007; Zeng *et al*., 2001), leading to a reduction in productivity of more than 50% when exposed to 6.65 dS/m Electrical Conductivity (EC) of salinity (Cha-um and Kirdmanee, 2010; Zeng and Shannon, 2000b).

With regard to Fig. 1, in a survey of reciprocal effectiveness of different levels of salinity and growth stages, it was found that total number of filled grains per panicles was 1196 in control treatment and the least amount was 190.50 in tillering stage at 8 dS/m salinity.

Total number of spikelets per unfilled panicles: With regard to conclusions of variance analysis (Table 1), different growth stages showed different sensitivity to salinity considering effect on total number of spikelets per unfilled panicles. Effect of different growth stage on total number of spikelets per unfilled panicles was significant ($p<0.01$) but effect of different levels of salinity was not significant on it ($p<0.05$). High effectiveness of salinity on the number of spikelet has been reported by many researchers (Cui *et al*., 1995; Khan *et al*., 1997). Final yield of grain is depended on yield components and are severely affected by salinity, so spikelet decreases in panicle due to salinity (Cui *et al*., 1995; Khan *et al.*, 1997).

Conclusions of mean comparison of total number of spikelets per unfilled panicles (Table 2) showed that control treatment had the least total number of spikelets per unfilled panicles (6.50). Treatments of 2, 4, 6 and 8

Table 1: Analysis of variance for yield components as affected by salinity levels at different growth stages

Sources of variation	df	Total number of filled grains per panicles	Total number of spikelets per unfilled panicles	Total number of grains per panicles	Percentage of emptiness per panicle	Total number of panicles	Percentage of ratio of total panicle to tiller
	df	Mean squares					
Replication (R)	2	15071.67^{ns}	471.25^{ns}	13070.72^{ns}	72.93^{ns}	24.19^{ns}	58.88^{ns}
Growth stages (GS)	3	590006.55**	910.96**	466056.70**	2485.22**	27.80^{ns}	321.10^{ns}
Salinity levels (SL)	3	252775.69**	128.48^{ns}	252817.03**	307.87^{ns}	38.74^{ns}	189.60^{ns}
GS×SL	9	57063.72*	232.89^{ns}	67980.88^{ns}	369.47^{ns}	14.08^{ns}	189.65^{ns}
Error	3	23913.77 ^{ns}	196.84^{ns}	44873.26^{ns}	232.81^{ns}	19.43^{ns}	366.29 ^{ns}
CV%		22.30	77.50	21.91	48.19	21.83	22.27

*: significant at 5%; **: significant at 1%; ns: non significant

Table 2: Mean comparison of salinity levels at different growth stages affected on yield components of rice

	Total number of filled grains per panicles	Total number of spikelets per unfilled panicles	Total number of grains per panicles	Percentage of emptiness per panicle	Total number of panicles	Percentage of ratio of total panicle to tiller
Salinity levels (dS/m)						
2	847.00a	15.46a	1155.08a	26.25a	22.58a	90.87a
4	787.17a	22.33a	1004.00ab	28.95a	20.17a	85.96a
6	583.08b	19.09a	878.33b	33.75a	18.25a	81.13a
8	556.88b	15.58a	830.63b	37.68a	19.75a	85.77a
Growth stages						
Tillering	547.63b	15.00ab	744.96b	30.92b	18.42a	86.31a
Panicle initiation	462.25b	30.83a	857.08b	51.97a	19.67a	79.15a
Panicle emergence	921.50a	15.50ab	1136.00a	18.95b	22.00a	91.74a
Ripening	840.75a	11.08b	1130.00a	24.79b	20.67a	86.54a
Control	1196.00	6.50	1475.00	19.06	21.67	103.97

The same letters are not significantly different in each column (p<0.05) by Duncan's test

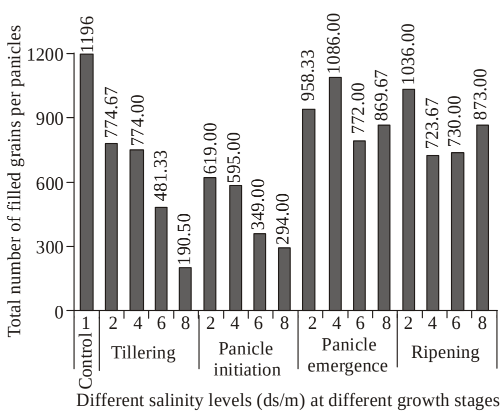

Fig. 1: Effect of salinity levels at different growing stages on the total number of filled grains per panicles

dS/m salinity with total number of spikelets per unfilled panicles of 15.46, 22.33, 19.09 and 15.58, respectively placed in class a, after control treatment. Therefore increasing salinity did not show negative effect on total number of spikelets per unfilled panicles. In different growth stages of rice, total number of spikelets per unfilled panicles was different; the most amount was 30.83 in panicle initiation and the least amount was 11.08 in ripening stage.

Survey on reciprocal effect of different levels of salinity and growth stages showed that the most total number of spikelets per unfilled panicles was 4.00 in panicle initiation at 4 dS/m salinity and the least amount was 5.00 in panicle emergence at 8 dS/m salinity.

Total number of grains per panicles: Different growth stages showed different sensitivity to salinity considering effect on total number of grains per panicles (Table 1 and 2). Effect of different growth stages and also different levels of salinity on total number of grains per panicles was significant (p<0.01). High effectiveness of salinity on numbers of grains has been reported by many researchers. Salinity causes a yield reduction by affecting the number and weight of grains, tubers and fruits (Katerjia *et al.*, 2003).

With regard to mean comparison of total number of grains per panicles (Table 2), control treatment had the most amount (1475). Increased salinity resulted in decreased total number of grains per panicles, so that at 2 and 4 dS/m salinity total number of grains per panicles were 1155.08 and 1004.00 respectively both of which placed in class a. Increasing salinity at 6 and 8 dS/m, decreased total number of grains per panicles to 878.33 and 830.63 respectively in compare with control treatment. The least amount of total number of grains per panicles was at 8 dS/m salinity which showed 44% decrease in compare with control treatment. Total number of grains per panicle has a high effect on yield increase; therefore salinity decreases yield through decreasing total number of grains per panicle.

Effect of different growth stages of rice on total number of grains per panicles was different. The most total number of grains per panicles, amounted 1136, observed in panicle emergence and the least numbers, amounted 744.96, observed in tillering stage. Final growth stages, i.e., panicle emergence and ripening

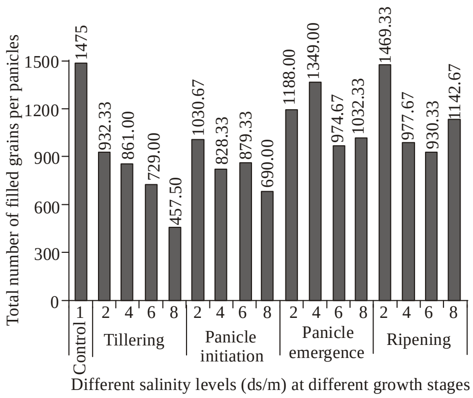

Fig. 2: Effect of salinity levels at different growing stages on the total number of grains per panicles

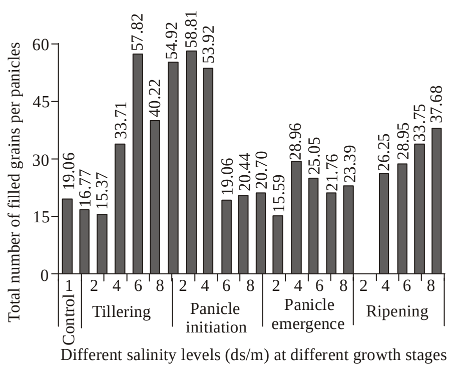

Fig. 3: Effect of salinity levels at different growing stages on the percentage of emptiness per panicle

showed less sensitivity to salinity, so that total number of grains per panicles in these stages were 1136 and 1130, respectively; but primary stages, i.e. tillering and panicle initiation were more sensitive to salinity so that total number of grains per panicles were 744.96 and 857.08 respectively both of which placed in the same statistical class. The tolerance of rice to salinity varies with its stage of development. The stages of seedling and flowering are critical for the salinity of irrigation water (Fraga *et al.*, 2010). In most commonly cultivated rice cultivars, young seedlings were very sensitive to root-zone salinity (Zeng and Shannon, 2000a). Significant differences between cultivars have been observed in rice tolerance to salinity both at vegetative and at reproductive stages (Eynard *et al.*, 2005).

With regard to Fig. 2, in survey on reciprocal effect of different levels of salinity and growth stages, it was observed that the most total number of grains per panicles, amounted 1475, observed in control treatment and the least (457.50) observed in tillering at 8 dS/m salinity.

Percentage of emptiness per panicle: Conclusions of variance analysis showed that different growth stages showed different sensitivity to salinity considering effect on percentage of emptiness per panicle (Table 1). Effect of different growth stages on percentage of emptiness per panicle was significant ($p<0.01$) but effect of different levels of salinity was not significant ($p<0.05$). Salinity of water or soil results in infertility (Zeng *et al*., 2003; Zeng and Shannon, 2000b). As far as grain production is concerned, successful pollination is not the only important process (Abdullah *et al.*, 2001), it was found that a reduction in seed set was due to failure of stigma receptivity (Khatun and Flowers, 1995a,b).

With regard to the conclusion of mean comparison of percentage of emptiness per panicle (Table 2), the least percentage of emptiness per panicle was 19.06 in control treatment and the most percentage was 37.68 at 8 dS/m. Of course there were not any significant differences between different levels of salinity, so all placed in the same statistical class. Treatment of 8 dS/m increased emptiness per panicle up to 98% in compare with control treatment. Increased salinity resulted in increased emptiness per panicle, as a therefore yield decreased. Salinity stress during the vegetative stage and at panicle initiation of rice was found to delay flowering and prolong the crop growth duration by five to ten days (Phap, 2006).

Effectiveness of different growth stages on percentage of emptiness per panicle was different. The most percentage of emptiness per panicle amounted to 51.97, observed in panicle initiation stage and the least amount of it (18.95) observed in panicle emergence stage. Therefore salinity more effect on percentage of emptiness per panicle in primary growth stages, i.e., tillering and panicle initiation but in final stages, i.e., panicle emergence and ripening, salinity less effect on it. The most sensitive stage to salinity, considering percentage of emptiness, was panicle initiation and then were tillering, ripening and panicle emergence stages. In fact primary stages showed more sensitivity to salinity than final stages. Rhoades (1990) reported that some plants are relatively tolerant during germination, but become more sensitive during emergence and early seedling stages. Salinity during the reproductive stage depresses grain yield much more than salinity during the vegetative growth stage (Phap, 2006).

Reciprocal effect of different levels of salinity and growth stages (Fig. 3) showed that the most percentage of emptiness per panicle (58.81) was in panicle initiation at 6 dS/m salinity and the least percentage of emptiness per panicle (15.37) was in tillering at 4 dS/m.

Total number of panicles: With regard to the conclusions of variance analysis (Table 1), effect of different levels of salinity and also effect of growth stages on total number of panicles was not significant ($p<0.05$). The final grain yield can be described as the product of the number of panicles per unit area and panicle weight. The number of panicles per unit area depends on plant

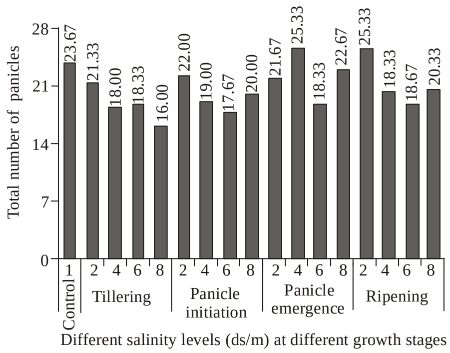

Fig. 4: Effect of salinity levels at different growing stages on the total number of panicles

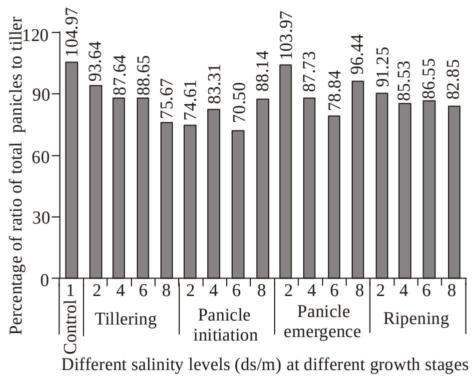

Fig. 5: Effect of salinity levels at different growing stages on the percentage of ratio of total panicle to tiller

density and tillering ability of plants (Zeng and Shannon, 2000b). Rice panicles consist of primary ranchi-branches, secondary branches differentiated from primary branches and flower primordia that develop into spikelets on these branches (Hoshikawa, 1989). High effectiveness of salinity on rice an rice sensitivity to salinity of irrigation water has been reported by many researchers (Asch and Wopereis, 2001; Beatriz *et al.*, 2001). Salinity of water or soil decreases number of panicles (Beatriz *et al.*, 2001).

Conclusions of mean comparison of total number of panicles (Table 2) showed that treatment of 2 dS/m had the most total number of panicles (22.58). Increasing salinity decreased total number of panicles but there were not any significant differences between different levels of salinity so that all 4 levels of salinity placed in the same statistical class. The least total number of panicles was 19.75 at 8 dS/m salinity which showed 9% decrease in compare with control treatment. Salinity decreased total number of panicles which resulted in yield reduction. Fraga *et al*. (2010) studied the effect of salinity water on rice and stated that the number of panicles per pot, number of grains per panicle and 1000-kernel weight decreased and spikelet sterility increased with increasing salinity.

Different growth stages of rice showed different effectiveness on total number of panicles. The most total number of panicles amounted to 22 observed in panicle emergence and the least amount of it (18.42) observed in tillering; however there were not any significant differences between different growth stages. Therefore, different growth stages of rice affected less by salinity in terms of total number of panicles. Salinity affects all stages of the growth and development of rice plant and the crop responses to salinity varies with growth stages, concentration and duration of exposure to salt (Joseph *et al.*, 2010).

In survey of reciprocal effects of different salinities and growth stages (Fig. 4), it was found that the most total number of panicles (25.33) was in panicle emergence at 4 dS/m and in ripening at 2 dS/m salinity. Also the least total number of panicles (16) was in tillering at 8 dS/m salinity.

Percentage of ratio of total panicle to tiller: Conclusions of variance analysis (Table 1) showed that effect of different levels of salinity and also different growth stages on percentage of ratio of total panicle to tiller was not significant ($p<0.05$). High effectiveness of salinity on rice and rice sensitivity to irrigation water has been reported by many researchers (Beatriz *et al.*, 2001; Zeng *et al.*, 2003). Salinity of water or soil decreases number of panicles and increases number of tillers (Beatriz *et al.*, 2001).

With regard to the conclusions of mean comparison percentage of ratio of total panicle to tiller (Table 2), control treatment observed the most amount (103.97). Increasing salinity decreased percentage of ratio of total panicle to tiller but there were not any significant differences between these levels. The changes in the ratios with the increase of salinity were mainly caused by the different sensitivity of these yield components to salinity (Zeng and Shannon, 2000b).

Effect of different growth stages of rice on percentage of ratio of total panicle to tiller was different. The most percentage of ratio of total panicle to tiller was 91.74 in panicle emergence and the least amount was 79.15 in panicle initiation. Of course there were not any significant differences between different growth stages and all placed in the same statistical class. Therefore effect of salinity on yield reduction is less affected by percentage of total panicles to the number of tillers. Although there are exceptions, the majority of the research indicates that most annual crops are tolerant at germination but are sensitive during emergence and early vegetative development (Lauchli and Grattan, 2007; Maas and Grattan, 1999). During the reproductive period of rice, salinity caused morphological changes similar to other environmental stresses that cause growth inhibition of plant structures, such as degeneration of primary and second aryrachis and of panicle spikelets (Cui *et al.*, 1995).

With survey on reciprocal effect of different levels of salinity and growth stages (Fig. 5), it was found that the most percentage of ratio of total panicle to tiller (104.97) observed in control treatment and the least amount (70.50) observed in panicle initiation at 6 dS/m salinity.

CONCLUSION

The use of saline water had no significant effect on the percentage of ratio of filled panicle number to tiller number and percentage of ratio of yield to straw weight but decreased length of filled panicle, number of filled grains per filled panicle, number of spikelets per filled panicle and total number of spikelets per panicles. The least of these yield components were observed at the highest salinity level (8 dS/m). Primary growth stages, i.e. tillering and panicle initiation were more sensitive to salinity but final growth stages, i.e., panicle emergence and ripening showed resistance to salinity. Therefore, irrigation with saline water can be applied at final growth stages.

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