



EFFECT OF SALINITY AND POTASSIUM FERTILIZER APPLICATION ON YIELD CONTRIBUTING CHARACTERISTICS OF RICE

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Abstract: Salt tolerant variety BR 41 was grown in *kharif* 2 season by pot experiment to study the effects of salinity and potassium fertilizer on agronomic characteristics of rice (*Oryza sativa* L.). The agronomic parameters increased with increasing salinity up to 12 dSm⁻¹ level but with plant height. The increase in tiller number, panicle number, shoot dry matter and total grain yield was statistically significant at 5% (LSD_{0.05}) level, whereas the increase in 1000 grain weight was significant at 1% (LSD_{0.01}) level. Application of potassium fertilizer at different salinity levels did not produce significant change in agronomic parameters with an exception in shoot dry matter.

Keywords: Salinity, rice, potassium fertilizer, agronomic characteristics

Introduction

Soil problems in relation to salinity in coastal areas of Bangladesh are increased over the last decade (SRDI, 2003). The level of salinity varies widely with location and season, depending on availability of fresh water, intensity of tidal flooding and nature of movement of saline ground water. Salts affect certain soil physical and chemical properties, which may reduce the suitability of the soil as a medium for plant growth. Salinity effect on agronomic characteristics of rice was markedly recognized. Zeng and Shannon (2000) reported that harvest index of rice and tiller number per plant significantly decreased with salinity. Folkard *et al.* (2000) developed a highly predictive screening tool for the vegetative growth stage of rice to estimate salinity-induced yield losses. Excess soil salinity causes poor and spotty stands of crops, uneven and stunted growth and poor yields, the extent depending on the degree of salinity. Apart from the osmotic effect of salts in the soil solution, excessive concentration and absorption of individual ions may prove toxic to the plants and may retard the absorption of other essential plant nutrient. Potassium is the most versatile nutrient in plants, highly mobile and involved in numerous regulation mechanisms, e.g. N metabolism, sugar transport, water utilization, stress resistance and osmotic adjustment. Sodium-potassium relationship may be synergistic or antagonistic depending on the ratio between them. Sodium competes with the essential nutrient ion K⁺ in the process of transport across the cell membrane during uptake, making it difficult for plants to obtain the K⁺. Again high level of Na⁺ can cause imbalance in the uptake and utilization of other cations (Brady and Weil, 2002). Plants usually have high selectivity for potassium uptake over sodium, particularly at low saline condition and at low external potassium concentration. Folkard *et al.* (2000) observed leaf K/Na

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ratio predicts salinity induced yield loss in irrigated rice. However, there are evidences that high sodium levels in the growth medium depress potassium uptake in many plants. Potassium controls water uptake, transport and utilization and have a major role on osmoregulation. Silberbush and Asher (2001) suggested that salinity (by means of Na concentration) suppressed root and leaf growth, which further affect uptake and transpiration of ions. The observed K^+ uptake should be attributed to the salinity tolerance of the plants. The objective of the present research work was to investigate the effect of salinity and K fertilizer application on agronomic characteristics of rice (*Oryza sativa* L.).

Materials and Methods

Non saline soil was collected from Jessore district for simulating 2, 5, 7, 9, 11 and 12 dSm^{-1} levels of salinity by using saline water from *Kazibacha* river during winter season. Two kg soil sample was taken into each earthen pot (20 cm diameter). Potassium was supplied as muriate of potash (KCl) and the treatments were 0, 10, 20, 30, 40 and 60 Kg/ha and the symbol for the potassium treatments were K0, K1, K2, K3, K4 and K5, respectively. Each potassium treatment was applied at each salinity level. All the treatments were replicated three times. Nitrogen, phosphorus, sulphur and zinc were applied at recommended dose (BARC, 1997). The pots were arranged in completely randomized block design. Soil pH was determined electrochemically at 1:2.5 soil : water ratio by using a glass electrode pH meter as described by Jackson (1973). Electrical Conductivity (EC) of soil was measured at a soil: water ratio of 1:5 by EC meter (USSLS, 1954). Available Na^+ , Ca^{2+} and K^+ of soil samples were extracted with 1N NH_4OAc solution (pH-7.0) as described by Piper (1950) and Jackson (1962) and determined with the help of a Flame Photometer. The physico-chemical properties of soil were presented in the Table 1.

Table 1. The physico-chemical properties of soil

Salinity levels	EC (dSm^{-1})	pH	Calcareousness	Available nutrients c mol (+) kg^{-1}		
				K	Na	Ca
S ₁	2	7.95		0.18	0.24	3.84
S ₂	5	8.29		0.23	0.64	4.87
S ₃	7	8.26	Violent	0.26	0.62	6.67
S ₄	9	8.26		0.27	1.36	6.67
S ₅	11	8.21		0.29	1.64	3.04
S ₆	12	8.25		0.31	2.18	9.74

The experimental rice variety, BR-41 is salt tolerant. The experiment was conducted in Kharif-2 season. Plant height and tiller number were measured at maximum tillering stage, and panicle number was recorded at anthesis (heading) stage. The grain yield, shoot dry matter and 1000 grain weight were recorded after harvest. To compare the effect of K, Na and Ca uptake by the rice plant on agronomic parameters at different salinity levels and potassium treatments, data were taken and calculated from Rabbi *et al.* (2005).

Results

Salt tolerant rice variety (BR-41) was grown at different salinity levels treated with different potassium doses. The highest plant height (87cm) was observed at S3 and the lowest was (67.67

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cm) at S1 (Table-2). The plant height responded to potassium dose of K3 at S3 was higher than other K doses, while the response was minimal at S1. But the changes in plant height due to K fertilizer application were different at different salinity levels. Tillering, panicle initiation and dry matter production of rice plant was minimum at lowest salinity level (S1), whereas agronomic performance was better at higher salinity levels. The highest tiller number was observed at S6 salinity level (15 cm) with K5 and the lowest was at S1 salinity level (4 cm) with K3. Among all the salinity treatments tiller number was significantly higher at S3 and S6. At S4, 8 panicle per pot was recorded which was the highest among salinity levels. The higher potassium application rate at different salinity levels did not significantly increase number of panicle per plant. The highest shoot dry matter was recorded 11.73 gm at S3 salinity level with K1, whereas the lowest was 3.73 gm was observed at S1 salinity level with K3 (Table-2). The change in shoot dry weight was statistically significant at different salinity levels. The maximum reduction of grain yield was observed at S2 and higher yield at higher soil salinity. The highest grain yield 12.81 g pot⁻¹ was recorded at S3 salinity level with K3 and the lowest grain yield 5.06 g pot⁻¹ was at S2 level of salinity with K2. The 1000 grain weight showed similar pattern at all the salinity level as grain weight. The highest weight (26.67gm) was at S3 with K3 and K4 and the lowest was (20.00gm) at S4 and S5 at K1 and K0.

Table 2. Effects of Salinity and potassium fertilizer application on yield contributing characteristics of rice

Salinity (dSm ⁻¹)	Doses of Potassium Fertilizer (Kg ha ⁻¹)					
	0	10	20	30	40	50
	Plant Height (cm)					
2	75.67±1.34	71±1.42	70.00±1.16	67.67±0.71	67.67±0.84	76.00±1.41
5	67.33±0.86	71.33±1.22	70.00±1.80	70.00±1.39	72.33±0.86	68.67±0.33
7	82.00±1.60	81.67±0.68	81.00±0.90	87.00±0.90	81.33±0.55	79.66±1.03
9	85.33±0.36	77.00±2.27	79.66±0.71	77.33±0.75	77.66±0.72	77.33±1.03
11	70.67±1.13	71.00±0.41	69.00±0.77	72.67±1.06	71.33±0.91	73.67±0.49
12	76.00±1.53	74.67±0.82	75.33±0.61	73.33±1.05	79.33±0.43	69.67±0.33
	Tiller No.					
2	5±1.0	7±1.0	7±1.73	4±1.0	5±1.0	5±1.0
5	6±1.0	5±1.0	6±1.0	5±2.0	5±2.65	6±1.73
7	12±1.0	12±1.0	12±2.0	11±0.0	13±1.0	13±1.0
9	10±1.0	10±1.0	9±1.0	10±2.08	9±1.0	9±2.0
11	9±1.0	10±1.0	10±2.08	9±2.0	8±1.0	8±1.0
12	14±1.0	12±1.0	10±1.0	14±2.65	10±3.47	15±2.65
	Panicle No.					
2	5±1.0	7±0.0	7±1.0	4±1.0	5±1.0	5±1.0
5	6±0.0	5±1.0	6±0.0	5±0.0	5±0.0	6±1.0
7	6±1.0	5±0.58	6±1.73	5±2.0	5±1.73	6±1.53
9	7±1.0	8±1.0	6±1.73	8±1.0	8±1.0	8±1.0
11	6±0.58	7±0.58	6±1.0	6±3.0	6±1.0	7±0.0
12	6±1.0	7±0.58	6±1.53	6±1.0	6±1.15	7±0.58

Shoot Dry matter (gm)						
2	4.26±1.19	4.66±1.25	3.85±0.59	3.73±0.45	4.13±0.19	4.18±0.31
5	4.57±0.69	4.83±1.15	5.75±0.61	3.85±0.22	4.16±0.26	3.19±0.34
7	11.16±1.03	11.73±0.68	10.14±0.89	10.92±0.20	10.35±0.80	10.02±1.30
9	11.36±0.70	9.09±1.47	7.24±0.86	8.34±0.68	8.86±0.17	8.86±0.95
11	6.92±0.42	6.90±0.30	6.51±1.37	5.78±0.83	6.60±0.49	5.66±0.28
12	8.65±0.74	8.44±0.31	8.59±0.53	8.29±0.54	9.45±0.62	9.37±0.60
Total Grain weight (gm)						
2	5.71±0.27	5.31±1.0	5.28±0.69	5.43±0.60	5.80±0.12	5.43±0.16
5	6.04±0.23	5.44±0.14	5.06±0.23	5.63±1.42	5.84±0.71	5.21±0.32
7	10.77±0.33	11.07±1.53	11.10±0.13	12.81±0.40	11.34±0.22	10.52±0.50
9	7.75±0.70	9.36±0.82	8.66±0.39	10.22±0.95	9.74±0.23	9.62±1.15
11	5.34±1.22	5.89±0.28	6.42±1.09	6.76±1.08	5.35±0.12	6.07±0.48
12	8.75±0.29	9.65±0.62	9.00±0.17	9.56±0.68	6.48±0.59	7.60±0.60
Weight of 1000 Grain (gm)						
2	25.00±1.08	25.00±0.51	26.67±0.26	25.00±0.73	26.67±0.13	25.00±1.58
5	25.00±0.60	26.67±0.38	25.00±1.34	25.00±0.60	23.34±0.36	23.34±0.93
7	25.00±0.72	25.00±1.54	25.00±0.07	26.67±0.34	26.67±0.44	21.67±0.36
9	25.00±0.71	20.00±1.16	25.00±0.26	21.67±0.40	21.67±0.31	23.34±0.82
11	20.00±0.16	21.67±0.40	20.00±0.35	23.34±0.16	25.00±1.16	23.34±1.85
12	23.34±0.34	25.00±0.29	23.34±0.19	25.00±0.16	20.00±1.25	21.67±0.39

Discussion

It was evident that salinity levels had significant effects on tiller number, panicle number, shoot dry weight, grain yield and 1000 grain weight. Application of potassium did not produce any significance on agronomic parameters of the rice variety. Rabbi *et al.* (2005) reported higher K, Na and Ca uptake by BR-41 at salinity level S3 and S4. In the present study the authors also stated that a further increase of K, Na and Ca uptake was observed at S6 (Fig.1 and 2). It is clearly shown in the Fig.3 that in shoot K uptake was increased with similar pattern of Ca uptake. Although the Ca uptake was higher than the K uptake in case of shoot. The grain K uptake did not behave as shoot K uptake. The grain Ca uptake was lower than K uptake but remained more or less similar over the salinity range. Sodium uptake by shoot and grain showed similar pattern which indicated unhindered transfer of Na through the plant vascular bundle. So, pattern of Na, K and Ca uptake by plants largely controls its agronomic performances. Mehdi *et al.* (2007) reported that in saline-sodic soils the higher K uptake increased tiller number, plant height and yield. However, Aich *et al.* (1998) showed that application of saline water decreased K and Ca uptake by rice. Generally, salt resistance varieties give better performance in saline condition than non resistant varieties. Khan *et al.* (1997) reported that the salt resistant rice variety maintains higher K/Na ratio. Calculated K/Na, Ca/Na ratio from Rabbi *et al.* (2005) indicates that at K/Na was the highest at S1 in shoot and root (Fig.3). The ratio decreased gradually with increasing salinity with the exception at S6. It is obvious that at non saline condition the rate of K uptake must exceed

that of Na. At higher salinity level e.g. S3, S4 and S6 the experimental rice variety maintained K/Na ratio near 1:2 which decreased to 1:4 at S5. The Ca played an important role in maintaining relatively higher K/Na ratio at higher salinity level. Ross *et al.* (2001) concluded that in absence of Ca^{2+} the plant uptake of K^+ can be inhibited by low concentration of Na^+ . Therefore, Na/Ca ratio plays a significant role in alleviating the adverse effect of high salinity (Huq and Larher, 1983). The potassium is the principal osmoregulator of plant (Maathius and Automann, 1999) and in several cases the presence of third cation, such as Ca^{2+} improves Na-K interaction. In the recent investigation it was revealed that Ca/Na ratio decreased with increase in salinity. However, Ca/K ratio improved with salinity up to certain level, which indicated that at higher salinity plant preferentially uptake more calcium to counterbalance the adverse effect of Na ion. The uptake rate of K, Na and Ca by the experimental rice variety may also be controlled by the concentration of these nutrient elements in soil (Fig.4). The K/Na ratio was higher in soil at low salinity but plant maintained higher K/Na ratio at a salinity level compared with soil ratio at that salinity. The Ca/Na ratio of soil was higher than plant Ca/Na ratio at all salinity levels. Under non saline condition (at high soil Ca/Na) plant maintained lower Ca/K ratio but the ratio was higher in higher salinity levels which indicated high Ca uptake selectivity. Such a high K uptake in presence of Ca may be the reason of better agronomic performance at saline condition. Stephens *et al.* (1998) concluded that the K uptake by salt tolerant rice variety was inhibited by Na but Ca tend to reduce Na induced K uptake reduction. The high K/Na ratio in the tissue is considered to be a good marker for salt tolerance in a crop plant (Wei *et al.*, 2003). Plant uptake of salt ions from soil depends on their concentration in soil solution (Murtaza *et al.*, 2009). The growth both vegetative and grain yield of plant is associated with high K^+ relative to Na^+ . Moreover, other agronomic parameters such as number of tillers are also paralleled the effects of K^+ selectivity on the grain yield (Murtaza *et al.*, 2009).

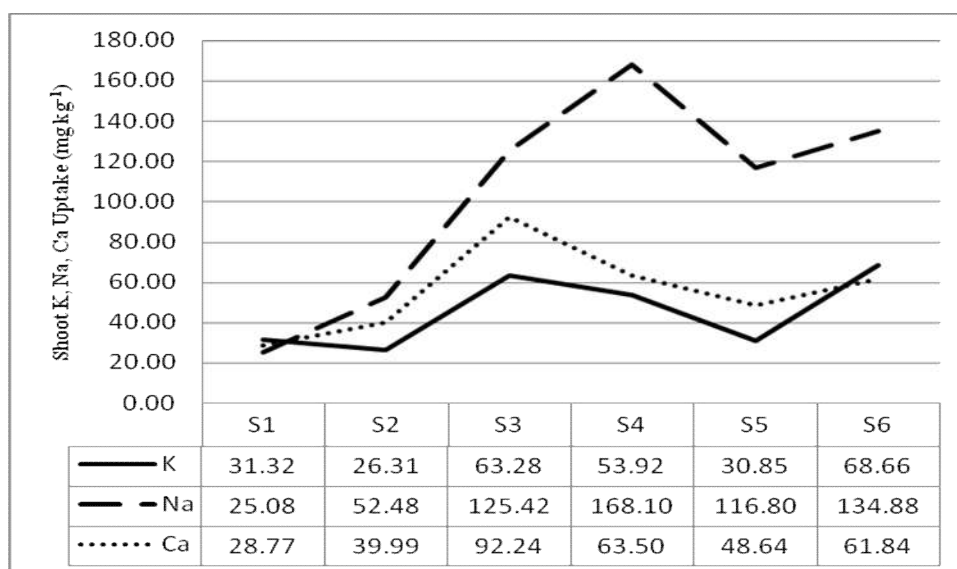


Fig.1. Uptake of K, Na and Ca by shoot of rice

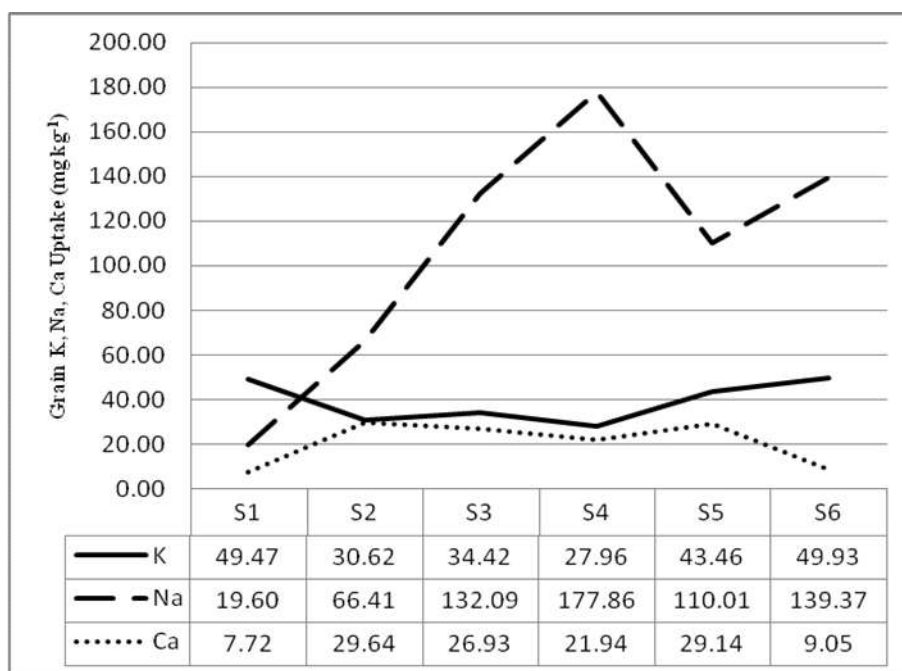


Fig.2. Uptake of K, Na and Ca by grain of rice

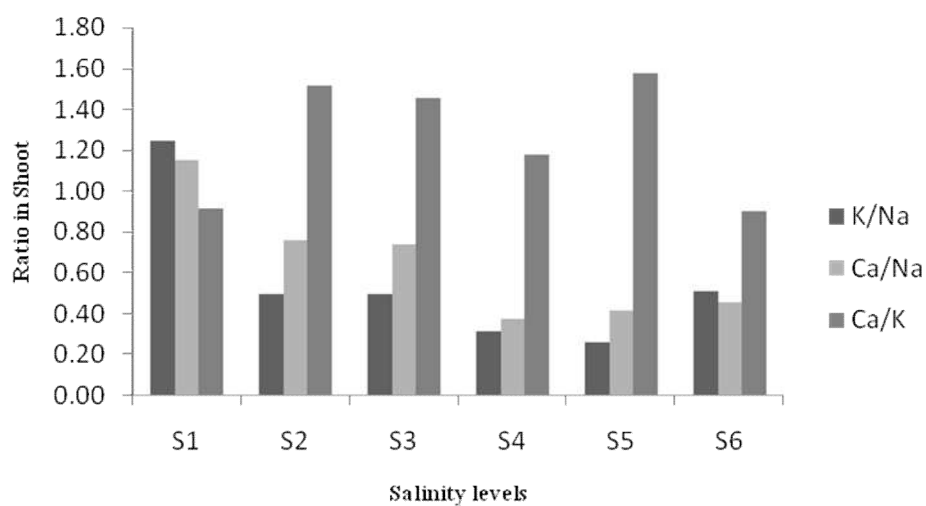


Fig. 3. Ratios of K, Na and Ca in shoot of rice

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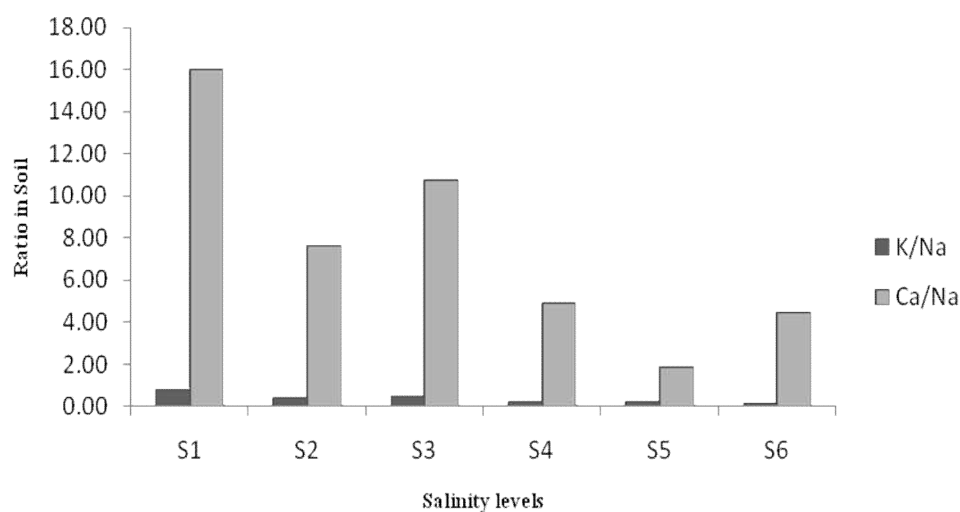


Fig. 4. Ratios of K, Na and Ca in soil

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