REMEDIATION OF SALT STRESS ON GROWTH, YIELD AND NUTRIENT CONTENT OF BINA DHAN 10 AND BRRI DHAN 29 BY DIFFERENT FERTILIZATION METHOD OF TSP

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This is to certify that the thesis entitled **REMEDIATION OF SALT STRESS ON GROWTH, YIELD AND NUTRIENT CONTENT OF BINA DHAN 10 AND BRRI DHAN 29 BY DIFFERENT FERTILIZATION METHOD OF TSP"** submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Agricultural Chemistry**, embodies the result of a piece of bona fide research work carried out by **TASLIMA KHATUN**, Registration No. **11-04541** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated:

Dhaka, Bangladesh

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Dedicated To

My Beloved Parents

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REMEDIATION OF SALT STRESS ON GROWTH, YIELD AND NUTRIENT CONTENT OF BINA DHAN 10 AND BRRI DHAN 29 BY DIFFERENT FERTILIZATION METHOD OF TSP

ABSTRACT

An experiment was carried out the net house of Agro-Environmental Chemistry, Department of Agricultural Chemistry, SAU, Dhaka during the period from December 2016 to June 2017 to evaluate the remediation of salt stress on growth, yield and nutrient content of BINA dhan 10 and BRRI dhan 29 by different fertilization method of TSP. This experiment consisted of two variety *viz*. (i) V_1 (BINA dhan 10) and (ii) V_2 (BRRI dhan 29) and five types of TSP application methods *viz*. (i) T_0 (Control; 0 TSP), (ii) T_1 (⅓ foliar and ⅔ soil application of TSP), (iii) T_2 (⅔ foliar and ⅓ soil application of TSP), (iv) T_3 (Total foliar application of TSP) and (v) T_4 (Total soil application of TSP) under four different salinity levels *viz*. S_0 (0 dS m^{-1}), S_1 (3 dS m^{-1}), S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}). The experiment was laid out in a complete Randomized Design (CRD) with three replications. Considering varietal performance, at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively the highest shoot dry weight $plant^{-1}$ (22.36, 20.54, 15.97 and 17.19 g), number of effective tillers $plant^{-1}$ (7.27, 6.87, 6.67 and 7.00), number of filled grains $panicle^{-1}$ (94.40, 62.53, 86.00 and 79.40), grain weight $plant^{-1}$ (12.95, 10.21, 11.37 and 10.97 g) and straw weight $plant^{-1}$ (27.75, 25.39, 23.20 and 22.16 g) were found from the variety, V_1 (BINA dhan 10). Regarding the effect of different fertilization method of TSP, the treatment T_2 (⅔ foliar and ⅓ soil application of TSP) showed the best performance on shoot dry weight $plant^{-1}$ (23.77, 20.68, 22.27 and 21.29 g), number of effective tillers $plant^{-1}$ (7.67, 7.00, 7.00, 7.00 and 7.00), number of filled grains $panicle^{-1}$ (99.00, 96.67, 87.83 and 88.34), grain weight $plant^{-1}$ (14.57, 14.10, 13.26 and 13.93 g) and straw weight $plant^{-1}$ (30.24, 26.74, 24.36 and 23.76 g) at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively. Combinations of variety and different TSP application method the highest shoot dry weight $plant^{-1}$ (26.76, 27.60, 22.81 and 23.81 g), number of effective tillers $plant^{-1}$ (8.33, 7.33, 7.33 and 7.67), number of filled grains $panicle^{-1}$ (81.00, 75.67, 61.67 and 52.67), and grain weight $plant^{-1}$ (14.72, 15.77, 13.42 and 15.08 g) at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively were found from the treatment combination of V_1T_2. Nutrient content in grain and straw affected by different application methods of TSP, significant variation was observed on P and S content in grain and straw but Na, Ca and K content in grain and straw was not significant.

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ABBREVIATIONS AND ACRONYMS

%	=	Percentage
AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
Ca	=	Calcium
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
e.g.	=	exempli gratia (L), for example
et al.,	=	And others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
GM	=	Geometric mean
i.e.	=	id est (L), that is
K	=	Potassium
Kg	=	Kilogram (s)
L	=	Litre
LSD	=	Least Significant Difference
M.S.	=	Master of Science
m^2	=	Meter squares
mg	=	Miligram
ml	=	MiliLitre
NaOH	=	Sodium hydroxide
No.	=	Number
^oC	=	Degree Celceous
P	=	Phosphorus
SAU	=	Sher-e-Bangla Agricultural University
USA	=	United States of America
var.	=	Variety
WHO	=	World Health Organization
µg	=	Microgram

CHAPTER I

INTRODUCTION

Rice is the second most widely grown cereal and primary source of food for more than half of the world population and about 90% of the world rice is grown in Asia which is carrying about 60% of the world population (Haque *et al*., 2015). In Asia, Bangladesh is one of the top most rice producing countries covering an area of about 7.85 million hectares of arable land of which 70% is occupied for rice production (BBS, 2011). Rice is not only the foremost staple food but it also provides nearly 48% of the rural employment about two-third of the total calories supply and about one-half of the protein intake of an average person in the country (Julfiquar *et al*., 2009). In fact, rice production is highly concerned with life style of the people of Bangladesh.

Rice is major grain crop and carbohydrate source, supplying the necessary daily calories for more than half the world's population (Dubey and Singh, 1999 and Khush, 2005). It has been predicted that the demand for rice in the world will increase from 560 million tons to 780 million tons by the year 2020 (Shabbir, *et al*., 2001). However, environmental stress is a serious issue confronting rice production, especially the problem of salinity (Yokoi, *et al*., 2002, Zeng *et al*., 2003).

Soil salinity is a major environmental stress that adversely affects plant growth and metabolism. Salinity occurs in two distinctly different regions: (1) Costal regions where salinity is induced by inundation with seawater containing high amounts of soluble salts and (2) arid and semi-arid regions where evaporation is considerably higher than total precipitation and as a consequence, water movement is upward (capillary movement of water) resulting in the accumulation of salts in the root zone. Several authors summarized that salt stress significantly decreased shoot, root and total dry matter of plants and noticed an increasing degree of reduction in dry matter production with increasing salinity levels (Pessarakli *et al*., 1989, Bar-Tal *et al*., 1991).

Salinity is a major problem in irrigated and rain- fed agriculture. The irrigated farming system provides about a third of the world's food (Munns, 2002) and it is estimated that about 20% of the irrigated area (45 million ha) is affected by salinity (FAO, 2008). Salt stress is also a problem in rain-fed agriculture, especially in coastal areas as salt water enters them during high tide (Walia *et al*., 2005). It is estimated that 2% of the rain-fed agriculture area (32 million ha) is affected by salinity (FAO, 2008). The salinity problem has been addressed through improvements in production practices and the introduction of tolerant varieties. Osmotic stress and ion toxicity are effects caused by salinity. Osmotic stress is the result of the salt in the growth solution reducing the capacity of the plant to absorb water, while ion toxicity is caused by an excessive amount of salts entering the transpiration flow and damaging leaf cells. Reduced growth and photosynthesis are the main effects of salt stress (Munns *et al*., 2006).

The ability of plants to grow under salinity is a feature that determines crop distribution and productivity in many areas; therefore, it is important to understand the mechanisms that confer tolerance in saline environments (Pattanagul; Thitisaksakul, 2008). In general, rice shows variability in its sensitivity to excessive salinity at different stages of growth. It is considered a relatively saline-tolerant species in the germination stage, whereas the vegetative and early reproduction stages are the most sensitive to salinity, directly affecting yield (Zeng, 2004).

Exogenous application of osmoprotectants, plant growth regulators, antioxidants and fertilizers have been reported to successfully mitigate the adverse effects of salinity on plants (Kefeli, 1981; Janda *et al*., 1999; Shalata and Neumann, 2001). Phosphorus (P) in plants is deficient in most of our soils, which reduce crop production (Memon, 1996). Phosphorus deficiency in soil decreases yield

(Wissuwa *et al.*, 1998). Phosphorus is the second major nutrient for plant growth as it is an integral part of different biochemicals like nucleic acids, nucleotides, phospholipids and phosphoproteins. Phosphate compounds act as "energy currency" within plants (Russell, 1981 and Tisdale *et al.*, 1985). Supplementary phosphorus has a role in alleviation of the adverse effects of high salinity on whole plant biomass for a variety of crop plants (Kaya *et al.*, 2003).

Phosphorus nutrition appeared to modify the effects of salinity upon growth of glycophytic plants (Champergnol, 1979). There was a significant increase in the starch content and cob index in maize due to foliar application of P (Leach and Hameleers, 2001). When initial P deficiency symptoms appeared in crops at early stage higher doses of phosphorus as a foliar spray gave the greatest reduction in P deficiency and highest yields (Haloi, 1980). Phosphorus and salinity act antagonistically. Phosphorus lessens the effects of salinity, and induces salt tolerance in plants (Garg *et al.*, 2005). It has been observed that Phosphorus fertilization reduces the concentration of Na^+ in shoots and grains. It results in better survival growth and yield in rice (Qadar, 1998). By increasing the supply of Phosphorus to a saline medium it tended to decrease the concentration of Na^+ in rice (Aslam *et al.*, 1996 and Asch *et al.*, 1999).

With conceiving the above scheme in mind, the present research work has been undertaken in order to fulfilling the following objectives:

1. To study the effect of different levels of salinity on growth, yield and nutrient content of BINA dhan 10 and BRRI dhan 29
2. To find out the optimum doses of and proper methods of TSP application against salinity stress
3. To evaluate the nutrient content (P, Na, S, Ca and K) in rice grain and straw.

CHAPTER II

REVIEW OF LITERATURE

Salinity stress is one of the most deleterious abiotic stresses reducing crop production across the world. It is one of the most important stresses limiting crop production in arid and semiarid region and it is a great problem in the coastal region of Bangladesh, where a vast area remains fallow for long time. Very limited research works have been conducted to adapt rice in the saline area of Bangladesh. An attempt has been made to find out the performance of rice at different levels of salinity and salinity management regarding phosphorus fertilizer application. To facilitate the research works different literatures have been reviewed in this chapter under the following headings.

2.1 Salinity effect on different cultivars

El-Sabagh *et al*. (2015) conducted a pot experiment to study the response of three Egypt soybean cultivars (Giza-111, Giza-82 and Giza-35) to salinity stress (Control, 10 mM NaCl). Salinity is a widespread soil problem limiting productivity of oilseed crops worldwide and soybean cultivars differ in their sensitivity to soil salinity. The results showed that the cultivars had a negative response to salinity stress and most of the measured plant yield traits, oil and protein content. Results indicated that Giza-111 cultivar surpassed other cultivars in all characters under study. The highest value of seed yield, seed oil and protein percent observed in Giza-111 with the compare to other cultivars under salinity conditions. It was concluded that soybean is a sensitive plant to salinity stress but the extent of this sensitivity varies among cultivars. As a result, Giza-111 cultivar showed more capability to survive under salinity condition compared with another cultivars regarding of almost all plant traits examined. Considering, Giza-111 was found more appropriate under salinity condition.

Yasuta and Kokubun (2014) tested that the super-nodulating En-b0-1 genotype is more salinity tolerant than a normal nodulating genotype with a pot experiment. Results showed that under saline conditions imposed during pre-flowering, En-b0-1 formed heavier nodules, resulting in greater N uptake, higher photosynthetic activity, and greater biomass production compared with Enrei. Saline treatment increased the concentrations of sodium (Na) and chlorine (Cl) in all plant parts regardless of genotype; but in En-b0-1, the concentrations of these elements in shoots were significantly lower, while those in roots and nodules were higher than in Enrei. When the salinity treatment was imposed during the reproductive growth stages, En-b0-1 maintained higher N uptake, leading to better alleviation of salinity-induced yield reduction than in Enrei. The super-nodulating genotype En-b0-1 was more tolerant to salinity than its parental normal-nodulating cultivar, due to its superior nodulation and prevention of excessive accumulation of Na and Cl in shoots, which were retained in roots and nodules.

Alaa El-Din Sayed Ewase (2013) conducted a pot experiment to observe the effect of salinity stress on plants growth of Coriander *(Coriandrum sativum* L.). He used four treatments of different concentrations of NaCl namely 0, 1000, 2000, 3000 and 4000 ppm. The obtained results showed that plant length, number of leaves, roots number and length were reduced by increasing the NaCl concentration and Coriander plants were found to resist salinity up to the concentration of 3000 ppm NaCl only.

Milne (2012) studied on the effects of 30 and 60 mM NaCl on Lettuce *(Lactuca sativa* L.), grown in soilless culture, with additions of 0, 1, 2 and 4 mM Si was evaluated. Height, leaf number, weight, chlorophyll content and elemental analysis of plants were examined.

Saberi *et al.* (2011) conducted a pot experiment where two forage sorghum varieties (Speed feed and KFS4) were grown under salinity levels of 0, 5, 10 and 15 dSm^{-1}. Leaf area of plants were also reduced in response to salinity and decreasing soil water availability, while the suppressive effect was magnified under the combined effect of the two factors. Salinity and water stress significantly affected the total leaf area of ratoon crop. The maximum total leaf area was obtained in the control treatment but with increasing salinity and infrequent irrigation, this parameter was found to decrease. Maximum leaf area of 1167 mm^2 $plant^{-1}$ was attained in plants with normal irrigation, without water stress. Under effects of salinity 5, 10 and 15 dSm^{-1} the leaf area was reduced by 7, 12 and 17%, respectively.

Nawaz *et al.* (2010) reported that applications of salt in the growth medium caused reduction in shoot length of sorghum cultivars. Under saline conditions 50 mM proline was more effective to reduce the effect of NaCl than 100 mM proline in both cultivars. Proline level 50 mM showed 26.58% and 11.78% increased shoot length as compared to NaCl stresses plants. However, high concentration of proline (100 mM) was not so much effective as compared to low concentration i.e. 50 mM.

Jafari *et al.* (2009) studied the interactive effects of salinity, calcium and potassium on physio-morphological traits of sorghum *(Sorghum biclolor* L.) in a green-house experiment. Treatments included 4 levels of NaCl (0, 80, 160, and 240 mM NaCl), 2 levels of CaCh (0 and 20 mM), and 2 levels of KCl (0 and 20 mM). Salinity substantially reduced the plant growth as reflected by a decrease in the plant height, shoot and root weight.

Jampeetong and Brix (2009) and Gorai *et al.* (2010) reported that, various plant growths and development processes viz. seed germination, seedling growth, flowering and fruiting are adversely affected by salinity, resulting in reduced yield and quality.

BINA (2008) studied the screening of wheat varieties for growth and yield attributes contributing to salinity tolerance and reported that wheat varieties of high yielding and tolerant group recorded a higher value of number of effective tillers plant^{-1}.

Liu *et al.* (2008) reported significant reduction in the dry biomass of halophyte *Suaeda salsa* when exposed to different concentration of NaCl under different water regimes.

Munns and Tester (2008) observed that osmotic effect, which develops due to increasing salt concentration in the root medium, is a primary contributor in growth reduction in the initial stages of plant growth. This stage can be characterized by reduction in generation of new leaves, leaf expansion, development of lateral buds leading to fewer braches or lateral shoots formation in plants.

Memon *et al.* (2007) conducted a pot experiment on silty clay loam soil at Sindh Agriculture University, in Tando Jam, Pakistan. Sarokartuho variety of Sorghum *(Sorghum bicolor* L.) was continuously irrigated with fresh (control) and marginally to slightly saline EC 2, 3, 4 and 5 (dSm^{-1}) waters. Increasing water salinity progressively decreased plant height and fodder yield (fresh and dry weight) per plant.

Mortazainezhad *et al.* (2006) had observed that tiller number decreased with increasing salinity levels imposed at all growth stages in rice. Soil salinity affects the growth of rice plant. But the degree of deleterious effect may vary on the growth stages of plant. During germination rice is tolerant, but it becomes very sensitive during the early seedling stage. Similar result was also reported by many workers in rice (Islam, 2004; Rashid, 2005; Karim, 2007).

Munns (2005); Munns and Tester (2008) reported that salt-induced osmotic stress is the major reason of growth reduction at initial stage of salt stress, while at later stages accumulation of Na+ occurs in the leaves and reduces plant growth.

Parida and Das (2005) observed salt stress affects some major processes such as root/shoot dry weight and Na^+/K^+ ratio in root and shoot.

Sixto *et al.* (2005) stated that depending on increasing salinity levels, decrease in vegetative growth parameters has been observed in plants. Decrease in root, stem and shoot developments, fresh & dry stem and root weights; leaf area and number and yield have been observed in plants subject to salinity stress.

Ali (2004) conducted a research on Salt tolerance in eighteen advanced rice genotypes was studied under an artificially salinized (EC= 8.5 dSm^{-1}) soil conditions after 90 days of transplanting. The results showed that the yield per plant and number of productive tillers, panicle length and number of primary braches per panicle of all the genotypes were reduced by salinity.

Islam (2004) conducted a pot experiment to study the effect of salinity (3, 6, 9, 12 and 15 dSm^{-1}) on growth and development of rice under induced salinity condition and observed that number of leaves decreased with the increased salinity level. Similar result was also observed by Rashid (2005) in rice.

Javaid *et al.* (2002) investigated the salinity effect (0, 20, 50 and 75 mM NaCl) on plant height in four rice variety and reported that salinity affects the morphological characters of the studied plants and plant height decreased with increased salinity levels.

Javaid *et al.* (2002) investigated the salinity effect (0, 20, 50 and 75 mM NaCl) on plant height, stem diameter, TDM, leaf number and leaf area in four *Brassica* species and reported that salinity affected the morphological characters of the studied plants and leaf number as well as leaf area decreased with increased salinity levels.

Angrish *et al.* (2001) conducted a pot experiment and observed that increasing levels of chloride (0-12 dSm^{-1}) and sulfate salinity decreased leaf number of wheat plants. Similarly, Khan *et al.* (1997) reported that leaf number and leaf area were seriously decreased by salinity in rice.

Chakraborti and Basu (2001) conducted a pot experiment to study the effect of salinity (0, 6 and 9 dSm^{-1}) on growth and development of sesame under induced salinity condition and observed that number of leaves decreased with the increased salinity level.

El-Midaoui *et al.* (1999) conducted a greenhouse experiment with three sunflower cultivars (cv. Oro 9, Flamme pinto and Ludo) under four salinity levels of 0, 50, 75 and 100 mM NaCl. They reported that plant growth was adversely affected by increasing salinity.

Shannon and Grieve (1999) reported that salinity changes the roots structure by reducing their length and mass, therefore roots may become thinner or thicker.

Mohammad *et al.* (1998) conducted a pot experiment where tomato seedlings (cv. *riogrande)* were grown in 500 ml glass jars containing Hoagland's solutions which were salinized by four levels of NaCl salt (0, 50, 100 and 150 mM NaCl) and/or enriched with three P levels (0.5, 1 and 2 mM P) making nine combination The results indicate that increasing salinity stress was accompanied by significant reductions in shoot weight, plant height, number of leaves per plant.

Maas (1986) and Bolarin *et al.* (1993) reported that all stages of plant development including seed germination, vegetative growth and reproduction show sensitivity to salt stress and economic yield is reduced under salt stress.

2.2 Management of salinity stress through P application

Tian *et al*. (2017) conducted a pot experiment to study if P has any effect on rice (*Oryza sativa* L.) yield, dry matter and P accumulation and translocation in salt-alkaline soils. Plant dry weight and P content at heading and harvest stages of two contrasting saline-alkaline tolerant (Dongdao-4) and sensitive (Tongyu-315) rice varieties were examined under two saline-alkaline (light versus severe) soils and five P supplements (P_0, P_{50}, P_{100}, P_{150} and P_{200} kg ha^{-1}). The results were: in light saline-alkaline soil, the optimal P levels were found for P_{150} for Dongdao-4 and for P_{100} for Tongyu-315 with the greatest grain dry weight and P content. Two rice varieties obtained relatively higher dry weight and P accumulation and translocation in P_0. In severe saline-alkaline soil however, dry weight and P accumulation and translocation, 1000-grain weight, seed-setting rate and grain yield significantly decreased, but effectively increased with P application for Dongdao-4. Tongyu-315 showed lower sensitivity to P nutrition. Thus a more tolerant variety could have a stronger capacity to absorb and translocate P for grain filling, especially in severe salt-alkaline soils. This should be helpful for consideration in rice breeding and deciding a reasonable P application in saline-alkaline soil.

Badar-uz-Zaman *et al*. (2015) carried out a study to observe the growth and Na^+/K^+ ratio in *Brassica juncea* having phosphorus supplied from commercial fertilizers under salt stress. Seeds of *Brassica juncea* (cv. Raya Anmol) were germinated and the seedlings raised in standard nutrient solution under controlled conditions. Phosphorus was applied from three sources of fertilizers i.e. DAP, SSP and TSP @ 2 (as control) and 10 mmol L^{-1}. Salt stress was developed with NaCl

(150 mmol L^{-1}). Under salt stress and elevated P application as SSP and TSP, fresh mass was higher than with DAP source. Dry mass was higher with SSP source than with DAP and TSP. Na^{+}/K^{+} ratio was low using SSP. P-uptake by the plants was highest using TSP. For growth parameters and Na^{+}/K^{+} ratio, phosphate fertilizers contributed differentially under salt stress. It was also observed that under salt-stress conditions available phosphorus may not be in adequate amounts or in accessible forms for timely utilization by plants.

Khan *et al*. (2013) conducted an experiment to determine the effect of different levels of phosphorus (P) on wheat under saline conditions. Data of shoot and root fresh and dry weights, chlorophyll contents, different ion accumulation and yield components of wheat were collected. When different levels of phosphorus were applied on wheat plant under saline conditions phosphorus reduced the effect of salinity. Applications of phosphorus decreased Na^{+} uptake and increased potassium concentrations, chlorophyll contents and enhanced growth of wheat plants under saline and non-saline conditions. This indicated that application of phosphorus stabilized the physiology of the wheat plants as phosphorus activated potassium transport in wheat plants. Therefore, application of phosphorus had a positive effect on yield of the wheat plants. In conclusion, all these investigations showed that phosphorus induced the salt tolerance in wheat plants.

Mohammad *et al*. (1998) conducted this study to evaluate the root and shoot responses of tomato to salt stress conditions under different levels of phosphorus (P) nutrition. Tomato seedlings (cv. Riogrande) were grown in 500 mL glass jars containing Hoagland's solutions which were salinized by four levels of NaCI salt (0,50, 100, and 150 mM NaCl) and/or enriched with three P levels (0.5, 1, and 2 mMP) making nine combination treatments. Plants were harvested at the vegetative growth stage and data were collected for root and shoot characteristics. The results indicate that increasing salinity stress was accompanied by significant reductions in shoot weight, plant height, number of leaves per plant and a significant increase in leaf osmotic potential and peroxidase activity regardless of the level of P supplied. Both root length and root surface area per plant were decreased significantly under higher salinity conditions at all levels of phosphorus. On the other hand, increasing the phosphorus levels enhanced root growth through increasing both root length and root surface area. This phenomenon was observed at all levels of salinity. It can be concluded that root morphology parameters and peroxidase activity are additional sensitive parameters which are affected by salt stress and therefore, can be employed as a criteria for monitoring plant response mechanisms to salt stress conditions.

Siddique *et al*. (2015) conducted a pot experiment to evaluating the effect of exogenous application of proline on the growth and yield of rice under salt stress condition. There were six treatments including T_1 (Control), T_2 (25 mM NaCl), T_3 (50 mM NaCl), T_4 (25 mM NaCl + Proline), T_5 (50 mM NaCl + Proline) and T_6 (Proline). A salt sensitive variety of rice (cv. BRRI dhan29) was used as a test crop. Salinity (NaCl) was induced at vegetative growth stage (35 days after transplanting) of rice. Proline of 25 mL plant^{-1} was applied as foliar on the same day of NaCl treatment. All plants virtually died when they were treated with 50 mM NaCl (T_3). On the other hand, foliar application of proline resulted in a significant increase in plant growth parameters of rice. The grain and straw yields plant^{-1} decreased with increased salinity levels. When the salt treated plants were supplied with exogenous proline they produced significant amount of grain and straw yields. Sodium content and uptake by plants were decreased with foliar application of proline. It can be concluded that salt stress in rice reduce to a significant extent due to the exogenous application of proline.

CHAPTER III

MATERIALS AND METHODS

This experiment was conducted to evaluate the remediation of salt stress on growth, yield and nutrient content of BINA dhan 10 and BRRI dhan 29 by different fertilization method of TSP. This study was conducted during the period from December 2016 to June 2017. The materials and methods those were used and methods followed for conducting the experiment have been presented under the following headings.

3.1 Experimental site

This experiment was conducted under pot-culture at the net house and the laboratory of Agro-Environmental Chemistry Lab. of the Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka during the period from December 2016 to June 2017. Geographically the experimental field is located at 23°46' N latitude and 90°22'E longitude at an elevation of 8.2 m above the sea level belonging to the Agro-ecological Zone “AEZ-28” of Madhupur Tract.

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (Anon., 1988) under AEZ No. 28. The characteristics of the soil under the experiment were analyzed in the Laboratory of Soil science Department, SAU, Dhaka and details of soil characteristics have been presented in Appendix I.

3.3 Test crops

Two boro rice varieties were used for the present study. BINA dhan 10 and BRRI dhan 29 were used as test crops.

3.4 Layout of the experiment

The experiment was set in Randomized Complete Block Design (RCBD) having three factors with 3 replications. The treatment combination of the experiment was assigned at random into 20 pots of each at 3 replications.

3.5 Treatments

Two varieties with five methods of TSP application were considered as treatments of the experiment tested under 5 salinity levels.

Factor A: Variety **-** Two varieties

1. V_1 = BINA dhan 10
2. V_2 = BRRI dhan 29

Factor B: TSP application **-** Five methods of TSP application

1. T_0 = Control (0 TSP)
2. T_1 = ⅓ foliar and ⅔ soil application of TSP
3. T_2 = ⅔ foliar and ⅓ soil application of TSP
4. T_3 = Total foliar application of TSP
5. T_4 = Total soil application of TSP

Factor C: Salinity Level-Four methods of salinity application

S_0= 0 dS m^{-1}

S_1= 3 dS m^{-1}

S_2= 6 dS m^{-1}

S_3= 9 dS m^{-1}

3.6 Preparation of salinity levels

For 3 dS m^{-1} 5.76 g NaCl, for 6 dS m^{-1} 11.52 g NaCl and for 9 dS m^{-1} 17.28 g NaCl is taken in 3 liter of water in each pot.

3.7 Sterilization of seeds

Prior to germination test seeds were surface sterilized with 1% sodium hypochlorite solution. The glass vials containing distilled water for seed rinsing was sterilized for 20 minutes in an auto clave at 121±1°C at 15 bar air pressure.

3.8 Collection of pots

The required number of plastic pots having 24 cm top, 18 cm bottom diameter and 22 cm depth were collected from the local market and cleaned before use.

3.9 Seed collection, sprouting and sowing

Seeds of the rice variety, BRRI dhan 29 were collected from Bangladesh Rice Research Institute, Joydebpur, Gazipur and BINA dhan 10 was collected from BADC, Khamarbari, Dhaka. Initially seed soaking was done in water for 24 hours and after wards they were kept tightly in jute stack air for 2 days. When about 90% of the seeds were sprouted, they were sown uniformly in well prepared wet nursery bed.

3.10 Fertilizer application

Soils of 8 kg/pot were fertilized with 40 g/pot cowdung, 1.72 g urea/pot, 0.8 g MP/pot @ 15 ton ha^{-1} cowdung, 215 kg ha^{-1} Urea and 100 kg ha^{-1} MP. TSP was applied as per treatment. 20 kg P from TSP considered as recommended doses of TSP. The whole amount of all the fertilizers except urea were applied at the time of final land preparation and thoroughly incorporated with soil with the help of a spade. Urea was top dressed in three equal splits on 15, 30 and 45 DAT.

3.11 Preparation of pots and transplanting of seedlings

40 days old seedlings were transplanted in each pot on 3rd February 2017. Two weeks after transplanting the salt solutions were applied in each pot according to the treatments. To avoid osmotic shock the required amount (at the rate of 640 mg

per liter distilled water for 1 dS m^{-1}) of salt solution was added in three equal installments at one week intervals until the expected conductivity was reached. The salinity i.e. Electrical Conductivity (EC) of each pot was measured with a conductivity meter (Model-DiST4 HANNA HI98304) and the necessary adjustments of salinity were made.

3.12 Intercultural operations

Weeds grown in the pots and visible insects were removed by hands when necessary in order to keep the pots neat and clean. The soil was loosening by hand during the period of experiment. Watering was done in each pot to hold the soil water level and salt concentration constant when needed.

3.13 Harvesting

The crop was harvested on maturity on 20th May 2017. The harvested crop of each individual pot was bundled separately. Grain and straw yields were recorded as ton ha^{-1}.

3.14 Collection of data

Data were collected on the following parameters

1. Plant height (cm)
2. Root length (cm)
3. Shoot dry weight $plant^{-1}$ (g)
4. Root dry weight $plant^{-1}$ (g)
5. Number of effective tillers $plant^{-1}$
6. Panicle length (cm)
7. Number of filled grains $panicle^{-1}$
8. Number of unfilled grains $panicle^{-1}$
9. Grain weight $plant^{-1}$ (g)
10. Straw weight $plant^{-1}$ (g)
11. Chemical analysis of rice grain and straw: Na, K, P, S and Ca.

3.15 Procedure of recording data

3.15.1 Plant height (cm)

The plant height of rice plant was considered from the top surface level of the pot to the tip of the longest panicle at maturity stage and expressed in cm.

3.15.2 Root length (cm)

Root length of rice plant was considered from the base of the root to the tip at maturity stage.

3.15.3 Shoot and root dry weight plant^{-1} (g)

Shoot and root dry weight was measured after separating the shoots and roots of tagged plants following by oven-drying

3.15.4 Number of effective tillers plant^{-1}

Number of effective tillers plant^{-1} was counted from selected samples at maturity stage.

3.15.5 Panicle length (cm)

The length of panicle was measured with a meter scale from selected samples and the average value was recorded.

3.15.6 Number of filled grains panicle^{-1}

The total number of filled grains was collected randomly from selected samples and then average number of filled grains panicle^{-1} was recorded.

3.15.7 Number of unfilled grains panicle^{-1}

The total number of unfilled grains was collected randomly from selected samples and then average number of unfilled grains panicle^{-1} was recorded.

3.15.8 Grain weight plant^{-1} (g)

Grain weight plant^{-1} was determined from the selected samples and average data was taken as grain weight plant^{-1} (g) on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

3.15.9 Straw weight plant^{-1} (g)

Grain weight plant^{-1} was determined from the selected samples and average data was taken as straw weight plant^{-1} (g) at proper drying condition.

3.15.10 Chemical analysis

Chemical analysis was in the laboratory following the procedure of nutrient content measurement regarding phosphorus (P), sodium (Na), sulphur (S), calcium (Ca) and potassium (K). Nutrient content was measured in grain and straw.

3.16 Statistical analysis

The data collected on different parameters were statistically analyzed with CRD design using the MSTAT-C computer package program developed by Russel (1986). Least Significant Difference (LSD) technique at 5% level of significance was used by DMRT to compare the mean differences among the treatments (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSIN

The results with the effect of variety and TSP application and their combinations against different levels of salinity obtained from the present study are presented and discussed in this chapter. Data about morpho-physiological parameters, yield contributing characters and grain yield of rice have been presented in both Tables and Figures and analyzes of variance and corresponding degrees of freedom have been shown in Appendices.

4.1 Plant height

Effect of variety under different salinity levels

Different variety had variation on plant height under different salinity stress (Fig. 1). Results revealed that the variety, V_2 (BRRI dhan 29) showed the best performance on plant height under all salinity levels compared to the variety V_1 (BINA dhan 10). Among the different salinity levels, the highest plant height (90.73, 98.46, 99.53 cm and 96.07 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found from the variety, V_2 (BRRI dhan 29) where the lowest plant height (77.63, 79.57, 83.67 and 80.81 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from V_1 (BINA dhan 10) at all salinity levels. Similar results was also observed by Kumar (2017) and Nawaz *et al.* (2010) and found that salinity stress caused by NaCl reduced seedling growth of soybean cultivars.

Effect of different fertilization method of TSP under different salinity levels

Significant variation was recorded on plant height at different salinity levels influenced by different fertilization method of TSP (Fig. 2). Results revealed that the highest plant height (91.00, 92.68, 93.42 and 88.17 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were recorded from T_2 (⅔ foliar and ⅓ soil application of TSP) where the lowest plant height (67.67, 83.00, 88.67 and 87.00 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were observed on T_0 (Control; 0 TSP) with S_0 (0 dS m^{-1}) at all salinity levels.

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP showed significant variation on plant height under different salinity levels (Table 1). It was found that the treatment combination of V_2T_2 gave the best performance on plant height where V_1T_0 showed lowest performance at all salinity levels. Treatment combination of V_2T_2 showed the highest plant height (97.33, 99.33, 102.70 and 98.33 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively). Treatment combination of V_2T_3 showed significantly similar result with V_2T_4. But the treatment combination of V_2T_2, V_2T_3 and V_2T_4 showed non-significant difference with each other at 3 and 6 dS m^{-1} salinity levels. The lowest result on plant height (67.67, 69.00, 82.33 and 79.00 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from control (V_1T_0).

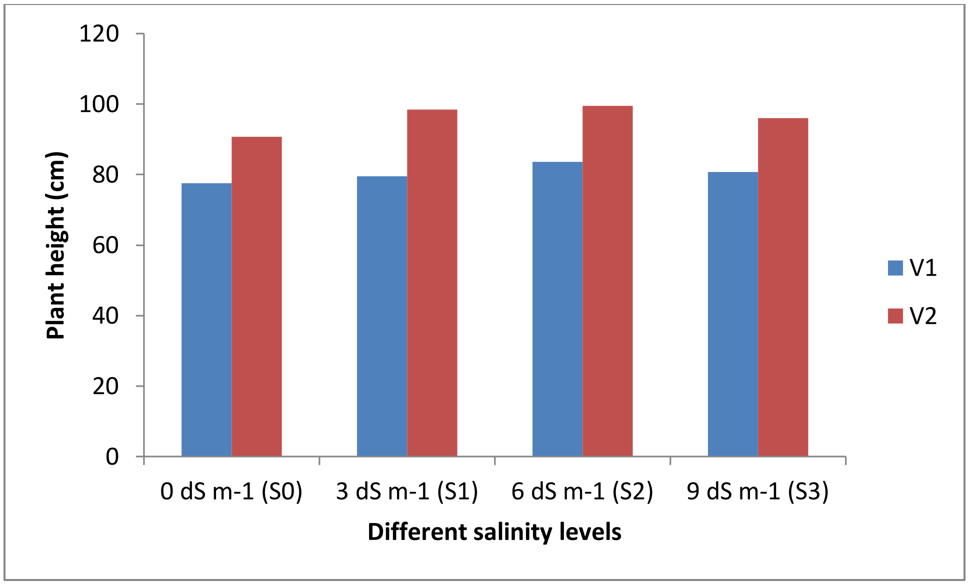

Fig.1. Plant height of BINA dhan 10 and BRRI dhan 29 at harvest under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

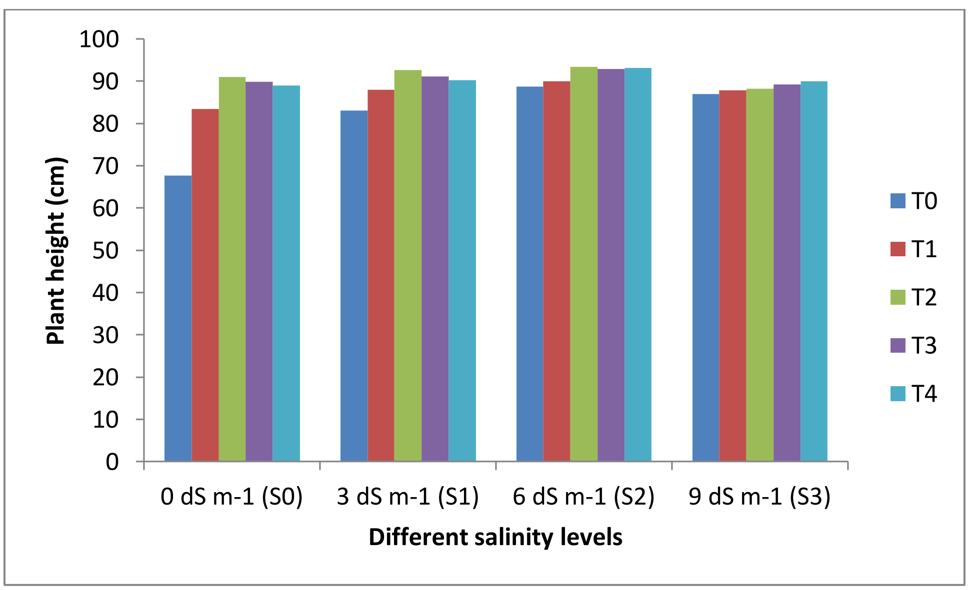

Fig.2. Plant height of rice as influenced by different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Table1. Plant height of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Treatment	Plant height (cm) at different salt concentration			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	67.67 e	69.00 g	82.33 d	79.00 d
V_1T_1	71.10 d	78.67 f	95.00 b	80.67 d
V_1T_2	84.67 b	86.03 c	84.53 c	94.00 c
V_1T_3	83.03 bc	83.00 d	84.67 c	81.67 d
V_1T_4	81.67 c	81.13 e	83.67 c	81.70 d
V_2T_0	68.67 e	97.00 b	83.17 cd	80.00 d
V_2T_1	95.67 a	97.33 b	96.67 b	95.67 bc
V_2T_2	97.33 a	99.67 a	102.7 a	98.33 a
V_2T_3	96.67 a	99.33 a	101.0 a	95.67 bc
V_2T_4	96.33 a	99.33 a	102.3 a	96.67 ab
$LSD_{0.05}$	1.778	1.803	1.779	1.989
CV (%)	8.76	11.40	10.38	12.89

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.2 Root length

Effect of variety under different salinity levels

Variation on root length was observed on varietal performance under different salinity levels (Fig. 3). It was found that variety, V_1 (BINA dhan 10) showed highest root length (33.20, 35.00, 30.88 and 31.60 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) compared to the variety, V_2 (BRRI dhan 29) (28.05, 26.51, 24.36 and 22.65 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively). It was also observed that the highest root length (35.00 cm) was found from V_1 (BINA dhan 10) at S_1 (3 dS m^{-1}) salinity level where the lowest root length (22.65 cm) was found from V_2 (BRRI dhan 29) at S_3 (9 dS m^{-1}) salinity level.

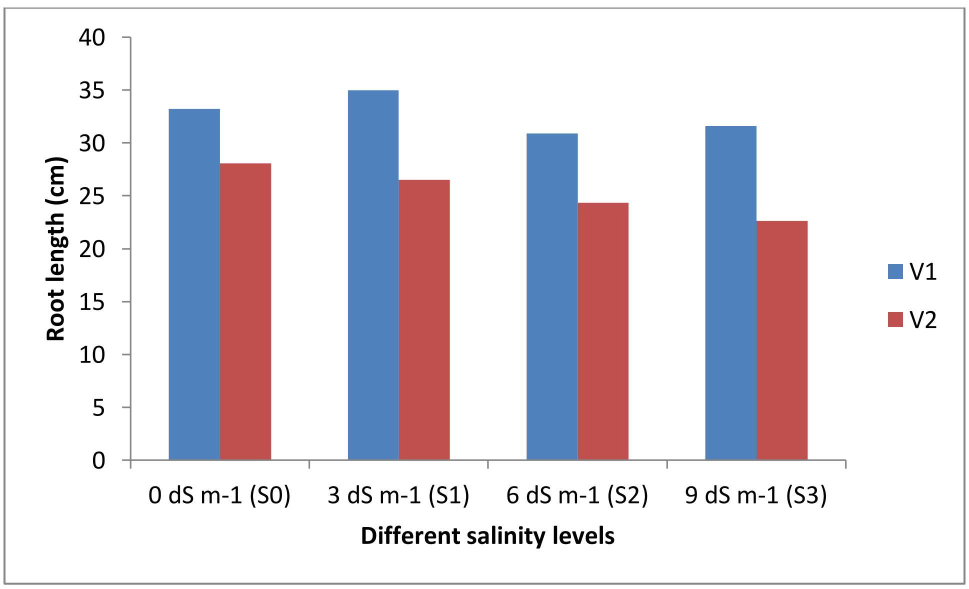

Fig.3. Root length of BINA dhan 10 and BRRI dhan 29 at harvest under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

Effect of different fertilization method of TSP under different salinity levels

Significant variation was recorded on root length at different salinity levels influenced by different fertilization method of TSP at all salinity levels (Fig. 4). Results revealed that at all salinity stress, T_2 (⅔ foliar and ⅓ soil application of TSP) showed highest root length (31.84, 32.70, 31.63 and 29.17 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where treatment T_0 (Control; 0 TSP) showed lowest root length (29.97, 29.50, 25.22 and 25.84 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity level. It was also found that among all the entire considering all salinity levels, the highest root length (32.70 cm) was found from T_2 (⅔ foliar and ⅓ soil application of TSP) under S_1 (3 dS m^{-1}) salinity level where the lowest root length (25.22 cm) was observed from T_0 (Control; 0 TSP) under S_2 (6 dS m^{-1}) salinity level. Treatment T_3 (Total foliar application of TSP) and T_4 (Total soil application of TSP) also showed better performance under different salinity levels.

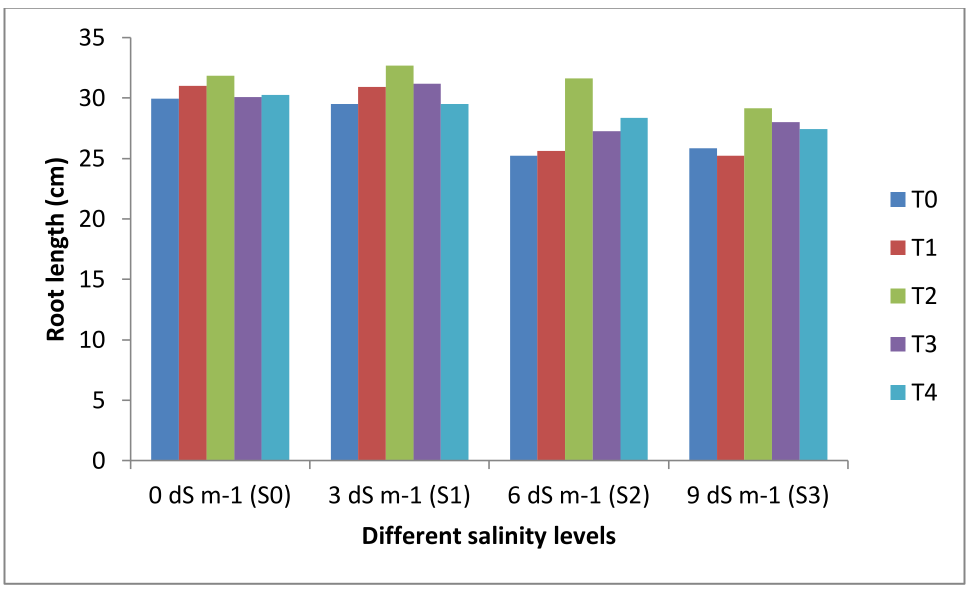

Fig.4. Root length of rice as influenced by different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP showed significant variation on root length under different salinity levels (Table 2). It was found that the treatment combination of V_1T_2 gave the best performance on root length where V_2T_0 showed lowest performance at all salinity levels. Treatment combination of V_1T_2 showed the highest root length (35.17, 38.50, 29.33 and 35.00 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where the lowest root length (26.93, 23.33, 22.10 and 21.67 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found from control (V_2T_0). Considering, all the entire treatment combinations, the highest root length (38.50 cm) was found from V_1T_2 under S_1 (3 dS m^{-1}) salinity level where the lowest root length (21.67 cm) was found from V_2T_0 under S_3 (9 dS m^{-1}) salinity level.

Table2. Root length of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Treatment	Root length (cm) at different salt concentration			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	33.00 b	26.50 c	28.33 c	30.00 c
V_1T_1	33.50 b	31.67 b	28.07 c	28.33 cd
V_1T_2	35.17 a	38.50 a	29.33 a	35.00 a
V_1T_3	32.17 b	37.33 a	36.33 b	33.00 b
V_1T_4	32.17 b	35.00 c	32.33 b	31.67 c
V_2T_0	26.93 d	23.33 bc	22.10 e	21.67 e
V_2T_1	28.50 c	27.33 e	23.17 de	22.10 e
V_2T_2	28.50 c	32.50 b	25.17 d	23.33 e
V_2T_3	28.00 c	28.07 d	26.93 d	23.00 e
V_2T_4	28.33 c	27.33 c	24.43 d	23.17 de
$LSD_{0.05}$	2.354	2.732 c	2.072	1.807
CV (%)	6.32	9.37	8.26	10.55

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.3 Shoot dry weight plant^{-1}

Effect of variety under different salinity levels

Variation on shoot dry weight plant^{-1}was observed on varietal performance under different salinity levels (Fig. 5). It was found that variety, V_1 (BINA dhan 10) showed highest shoot dry weight plant^{-1} (22.36, 20.54, 15.97 and 17.19 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) compared to the variety, V_2 (BRRI dhan 29) (18.75, 12.39, 18.95 and 13.17 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively).

Effect of different fertilization method of TSP under different salinity levels

Significant variation was recorded on shoot dry weight plant^{-1}at different salinity levels influenced by different fertilization method of TSP at all salinity levels (Fig. 6). Results revealed that at all salinity stress, T_2 (⅔ foliar and ⅓ soil application of TSP) showed highest shoot dry weight plant^{-1} (23.77, 20.68, 22.27 and 21.29 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where treatment T_0 (Control; 0 TSP) showed lowest shoot dry weight plant^{-1} (16.22, 11.81, 15.22 and 8.79 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity level. Treatment T_3 (Total foliar application of TSP) also showed identical results with T_2 (⅔ foliar and ⅓ soil application of TSP) at S_0 (0 dS m^{-1}) and S_1 (3 dS m^{-1}) salinity levels.

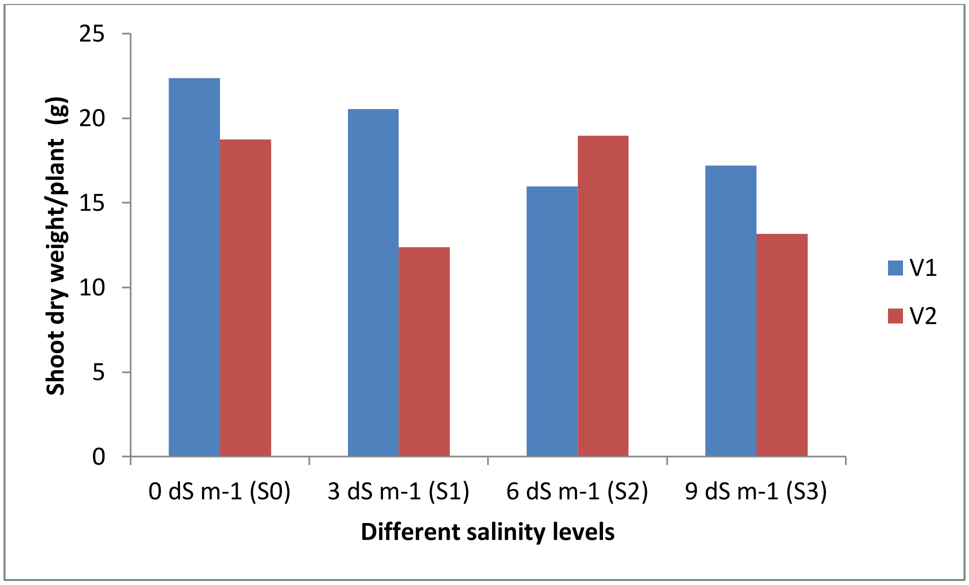

Fig.5. Shoot dry weight plant^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

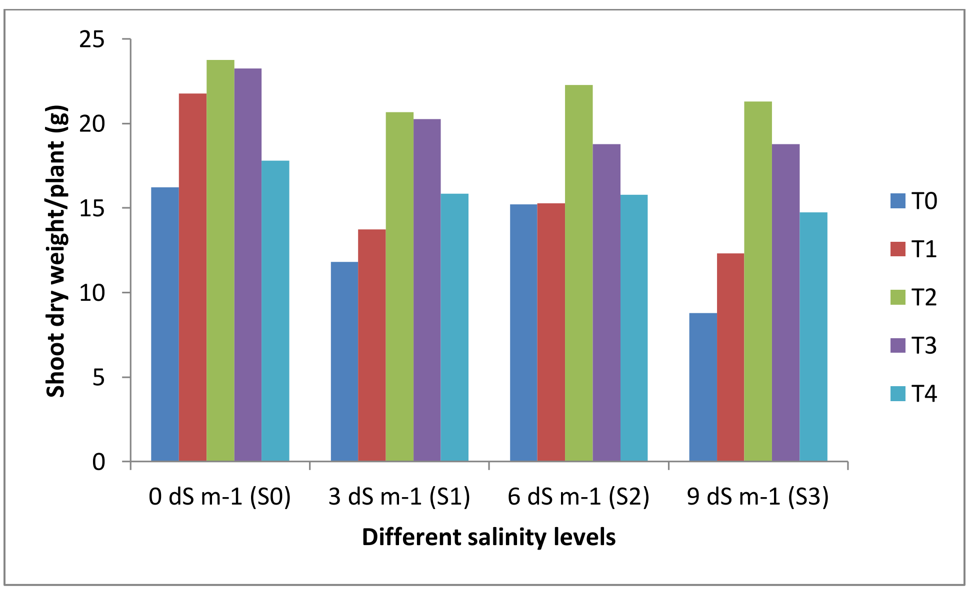

Fig.6. Shoot dry weight plant^{-1} of rice as influenced by different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP showed significant variation on shoot dry weight plant^{-1} under different salinity levels (Table 3). It was found that the plant^{-1} treatment combination of V_1T_2 gave the best performance on shoot dry weight plant^{-1} where V_2T_0 showed lowest performance at all salinity levels. Treatment combination of V_1T_2 showed the highest shoot dry weight plant^{-1} (26.76, 27.60, 22.81 and 23.81 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) which was statistically identical with V_1T_3 at S_3 (9 dS m^{-1}) salinity level where the lowest shoot dry weight plant^{-1} (14.72, 10.84, 12.74 and 6.80 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from V_2T_0 which was close to the treatment combinations of V_1T_0 at all salinity levels.

Table3. Shoot dry weight plant^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Treatment	Shoot dry weight plant^{-1} (g) at different salt concentration			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	17.72 d	12.77 fg	12.76 e	10.78 e
V_1T_1	25.76 b	15.76 d	17.70 d	13.86 de
V_1T_2	26.76 a	27.60 a	22.81 a	23.81 a
V_1T_3	25.78 b	25.76 b	18.76 c	22.81 a
V_1T_4	18.80 d	20.79 c	12.76 e	14.70 d
V_2T_0	14.72 e	10.84 g	12.74 e	6.800 f
V_2T_1	17.77 d	11.68 g	17.78 cd	10.76 e
V_2T_2	20.77 c	14.78 de	21.72 b	18.77 c
V_2T_3	20.70 c	13.76 ef	18.80 c	14.76 d
V_2T_4	16.78 de	10.88 g	18.77 c	14.75 d
$LSD_{0.05}$	2.332	1.907	0.9442	3.406
CV (%)	5.67	7.28	10.36	11.42

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.4 Root dry weight plant^{-1}

Effect of variety under different salinity levels

Varietal performance under different salinity levels showed considerable difference on root dry weight plant^{-1} (Fig. 7). It was found that the variety, V_1 (BINA dhan 10) showed highest root dry weight plant^{-1} (8.74, 9.37, 10.16 and 8.96 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where the lowest root dry weight plant^{-1} (4.19, 4.18, 3.09 and 3.39 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found from the variety, V_2 (BRRI dhan 29).

Effect on different fertilization method of TSP under different salinity levels

At different salinity levels significant variation was recorded on root dry weight plant^{-1} influenced by different fertilization method of TSP (Fig. 8). Results indicated that at all salinity stress, T_2 (⅔ foliar and ⅓ soil application of TSP) showed highest root dry weight plant^{-1} (7.79, 9.29, 8.24 and 8.26 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where treatment T_0 (Control; 0 TSP) showed lowest root dry weight plant^{-1} (4.71, 4.72, 4.46 and 3.96 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity level. Treatment T_3 (Total foliar application of TSP) also showed identical results with T_2 (⅔ foliar and ⅓ soil application of TSP) at S_0 (0 dS m^{-1}) and S_2 (6 dS m^{-1}) salinity levels.

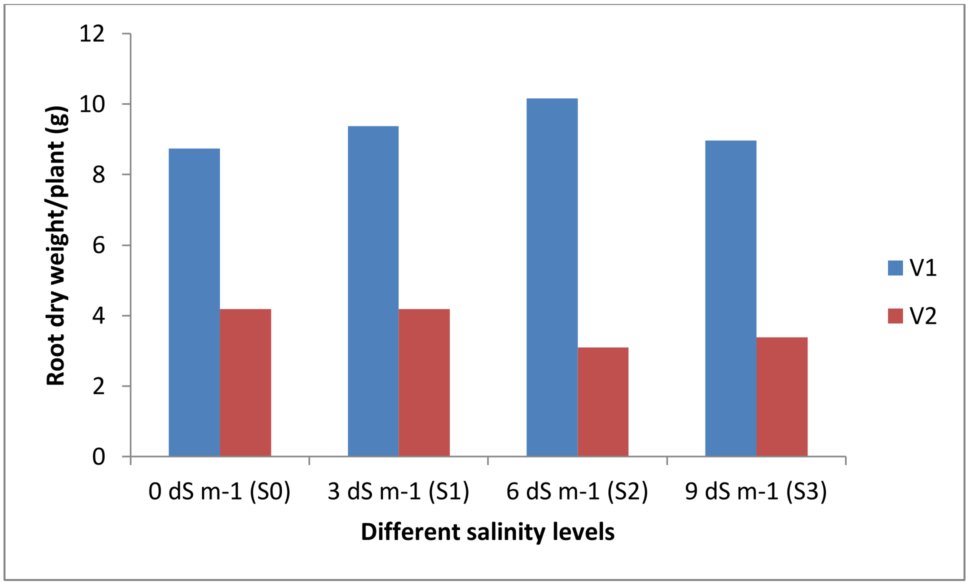

Fig.7. Root dry weight plant^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest with under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

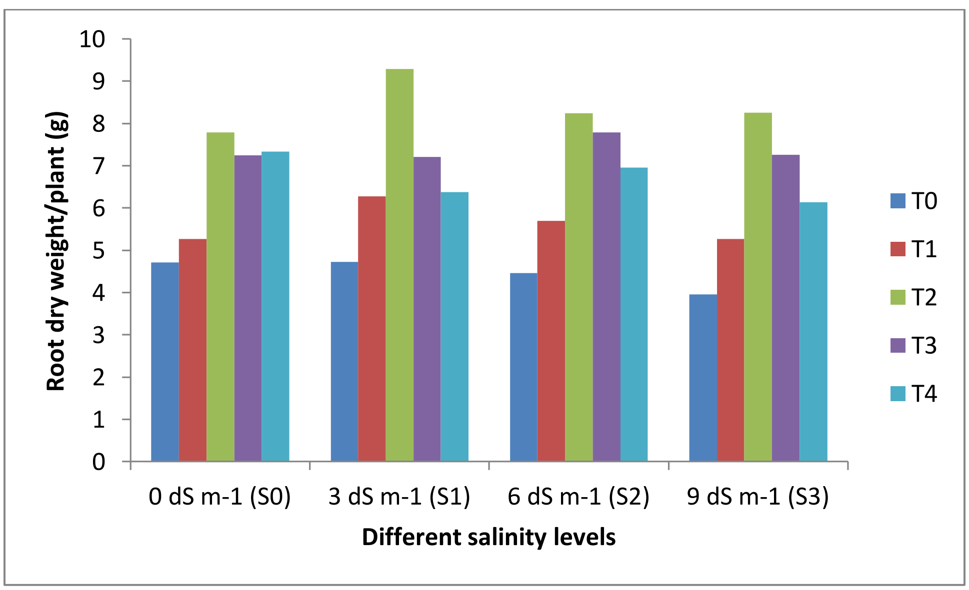

Fig.8. Root dry weight plant^{-1} of rice as influenced by different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed significant influence on root dry weight plant^{-1} under different salinity levels (Table 4). The best performance on root dry weight plant^{-1} was obtained from V_1T_2 where V_2T_0 showed lowest performance at all salinity levels. It was noted that the treatment combination of V_1T_2 showed highest root dry weight plant^{-1} (10.77, 12.80, 12.70 and 11.74 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) which was statistically identical with V_1T_3 at S_3 (9 dS m^{-1}) salinity level. At S_0 (0 dS m^{-1}) and S_2 (6 dS m^{-1}) salinity levels, V_1T_3 and V_1T_4 showed statistically identical results with V_1T_2 and at S_2 (6 dS m^{-1}) salinity levels only V_1T_3 was statistically identical with V_1T_2. Significantly the lowest root dry weight plant^{-1} (3.70, 2.68, 2.10 and 2.14 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found from V_2T_0 which was statistically identical with the treatment combinations of V_2T_4 at all salinity levels but significantly different S_3 (9 dS m^{-1}) salinity level.

Table4. Root dry weight plant^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Treatment	Root dry weight plant^{-1} (g) at different salt concentration			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	5.720 bc	6.75 c	6.820 c	5.78 c
V_1T_1	6.760 b	8.76 b	7.680 b	7.80 b
V_1T_2	10.77 a	12.80 a	12.70 a	11.74 a
V_1T_3	9.760 a	9.75 b	11.80 a	10.80 a
V_1T_4	10.70 a	8.78 b	11.80 a	8.68 b
V_2T_0	3.700 d	2.68 f	2.100 e	2.14 e
V_2T_1	3.750 d	3.80 ef	3.700 d	2.71 e
V_2T_2	4.800 cd	5.78 cd	3.780 d	4.78 d
V_2T_3	4.740 cd	4.66 de	3.770 d	3.72 e
V_2T_4	3.950 d	3.98 ef	2.120 e	3.58 e
$LSD_{0.05}$	1.657	1.374	1.162	0.9673
CV (%)	4.93	6.22	5.74	5.36

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.5 Number of effective tillers plant^{-1}

Effect of variety under different salinity levels

Considerable variation on number of effective tillers plant^{-1} was not found on varietal difference under different salinity levels (Fig. 9). But it was found that variety, V_1 (BINA dhan 10) showed highest number of effective tillers plant^{-1} (7.27, 6.87, 6.67 and 7.00 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where the lowest number of effective tillers plant^{-1} (6.20, 6.20, 6.27 and 5.80 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found from the variety, V_2 (BRRI dhan 29). Mortazainezhad *et al.* (2006) observed that tiller number decreased with increasing salinity levels imposed at all growth stages in rice.

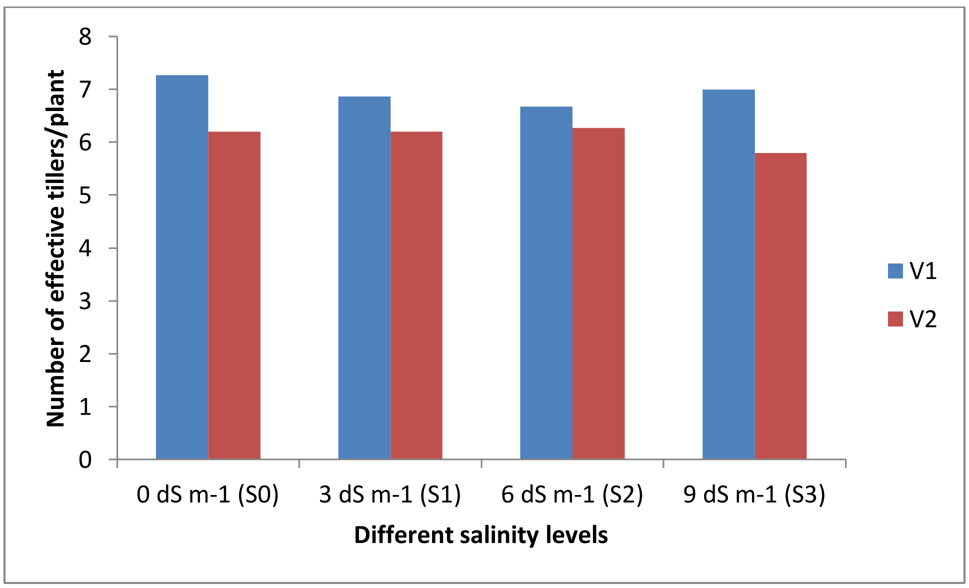

Fig.9. Number of effective tillers hill^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

Effect of different fertilization method of TSP under different salinity levels

Number of effective tillers plant^{-1} was not significantly varied due to different fertilization method of TSP under different salinity levels (Fig. 10). Results revealed that at all salinity stress, T_2 (⅔ foliar and ⅓ soil application of TSP) showed highest number of effective tillers plant^{-1} (7.67, 7.00, 7.00, 7.00 and 7.00 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where treatment T_0 (Control; 0 TSP) showed lowest number of effective tillers plant^{-1} (5.67, 6.17, 5.50 and 5.50 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity level.

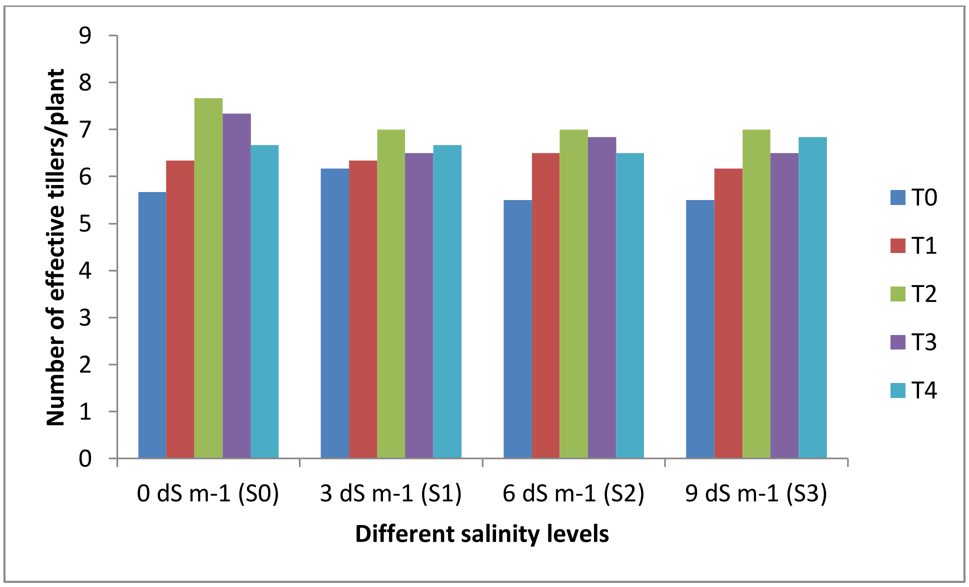

Fig.10. Number of effective tillers plant^{-1} of rice as influenced by different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP showed significant variation on number of effective tillers plant^{-1} under different salinity levels (Table 5). It was found that the treatment combination of V_1T_2 gave the best performance on number of effective tillers plant^{-1} where V_2T_0 showed lowest performance at all salinity levels. Treatment combination of V_1T_2 showed the highest number of effective tillers plant^{-1} (8.33, 7.33, 7.33 and 7.67 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) which was statistically identical with V_1T_3 at S_3 (9 dS m^{-1}) salinity level which was statistically identical with the treatment combination of V_1T_3 at S_0 (0 dS m^{-1}), S_1 (3 dS m^{-1}) and S_2 (6 dS m^{-1}) salinity levels. The lowest number of effective tillers plant^{-1} (5.33, 5.67, 5.33 and 5.00 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found from the treatment combinations of V_2T_0 which was close to the treatment combinations of V_1T_0 at all salinity levels but significantly different.

Table5. Number of effective tillers hill^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Treatment	Number of effective tillers plant^{-1} at different salt concentration			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	6.00 d	6.67 c	5.67 e	6.00 e
V_1T_1	6.67 c	6.67 c	6.33 c	6.67 c
V_1T_2	8.33 a	7.33 a	7.33 a	7.67 a
V_1T_3	8.00 a	7.00 a	7.00 a	7.00 b
V_1T_4	7.33 b	6.67 c	7.00 b	7.00 c
V_2T_0	5.33 e	5.67 f	5.33 f	5.00 f
V_2T_1	6.00 d	6.00 e	6.67 c	5.67 e
V_2T_2	7.00 bc	6.67 c	6.67 bc	6.33 d
V_2T_3	6.67 c	6.33 d	6.67 bc	6.00 e
V_2T_4	6.00 d	6.33 d	6.00 d	6.00 e
$LSD_{0.05}$	0.523	0.2819	0.3116	0.3255
CV (%)	4.76	6.88	5.93	7.68

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.6 Panicle length

Effect of variety under different salinity levels

Considerable variation on panicle length was not found on varietal difference under different salinity levels (Fig. 11). But it was found that variety, V_1 (BINA dhan 10) showed highest panicle length (24.40, 23.87, 24.00 and 22.93 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where the lowest panicle length (23.87, 23.60, 22.73 and 21.92 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was observed from the variety, V_2 (BRRI dhan 29). Ali (2004) also found similar result on panicle length which supported the present study.

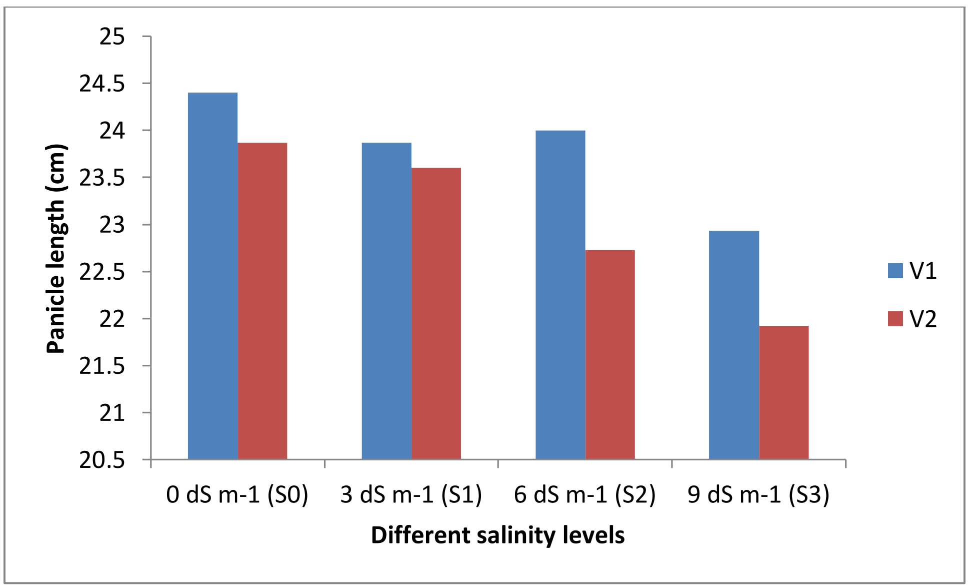

Fig.11. Panicle length of BINA dhan 10 and BRRI dhan 29 at harvest under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

Effect of different fertilization method of TSP under different salinity levels

Significant variation was recorded on panicle length at different salinity levels influenced by different fertilization method of TSP (Fig. 12). Results revealed that at all salinity stress, T_2 (⅔ foliar and ⅓ soil application of TSP) showed highest panicle length (25.84, 24.67, 24.67 and 24.33 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) which was statistically identical with T_3 (Total foliar application of TSP) at all salinity level. The treatment T_0 (Control; 0 TSP) showed lowest panicle length (22.00, 22.34, 21.33 and 21.00 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity level which was closely followed by T_1 (⅓ foliar and ⅔ soil application of TSP) at all salinity levels.

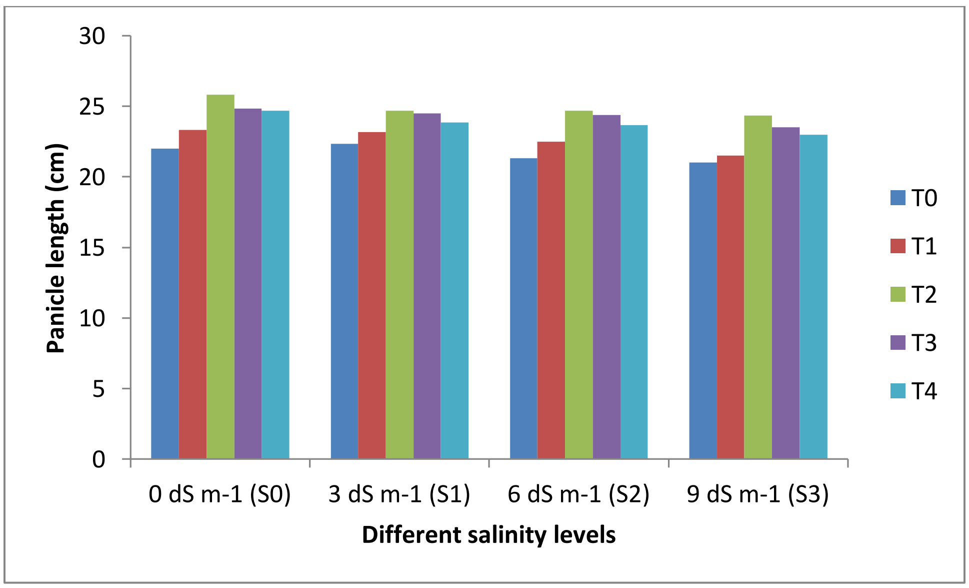

Fig.12. Panicle length of rice as influenced by different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP showed significant variation on panicle length under different salinity levels (Table 6). It was found that the treatment combination of V_1T_2 gave the best performance on panicle length where V_2T_0 showed lowest performance at all salinity levels. Treatment combination of V_1T_2 showed the highest panicle length (26.00, 25.00, 25.00 and 24.33 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively). At the salinity level of S_2 (6 dS m^{-1}), the treatment combination of V_1T_3 showed identical result with V_1T_2. The lowest panicle length (22.00, 22.00, 20.33 and 20.33 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from V_2T_0 which was statistically identical with the treatment combinations of V_1T_0 at all salinity levels.

Table 6. Panicle length of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Treatment	Panicle length (cm) at different salt concentration			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	22.33 g	22.67 f	20.67 f	20.67 f
V_1T_1	24.33 e	24.00 cd	23.33 cd	21.67 e
V_1T_2	26.00 a	25.00 a	25.00 a	24.33 a
V_1T_3	25.00 c	24.33 bc	25.00 a	23.33 c
V_1T_4	24.67 d	23.67 d	24.33 b	23.00 c
V_2T_0	22.00 g	22.00 f	20.33 f	20.33 f
V_2T_1	22.33 f	22.33 ef	21.67 e	22.00 d
V_2T_2	25.67 b	24.67 ab	24.33 b	23.33 bc
V_2T_3	24.67 d	24.67 ab	24.33 b	23.67 b
V_2T_4	24.67 d	24.00 cd	23.00 c	23.00 b
$LSD_{0.05}$	0.2301	0.3758	0.4407	0.3255
CV (%)	10.68	8.39	7.46	9.77

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.7 Number of filled grains panicle^{-1}

Effect of variety under different salinity levels

Varietal performance under different salinity levels showed considerable difference on number of filled grains panicle^{-1} (Fig. 13). It was found that the variety, V_1 (BINA dhan 10) showed highest number of filled grains panicle^{-1} (94.40, 62.53, 86.00 and 79.40 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where the lowest number of filled grains panicle^{-1} (91.47, 81.27, 72.67 and 72.47 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found from the variety, V_2 (BRRI dhan 29).

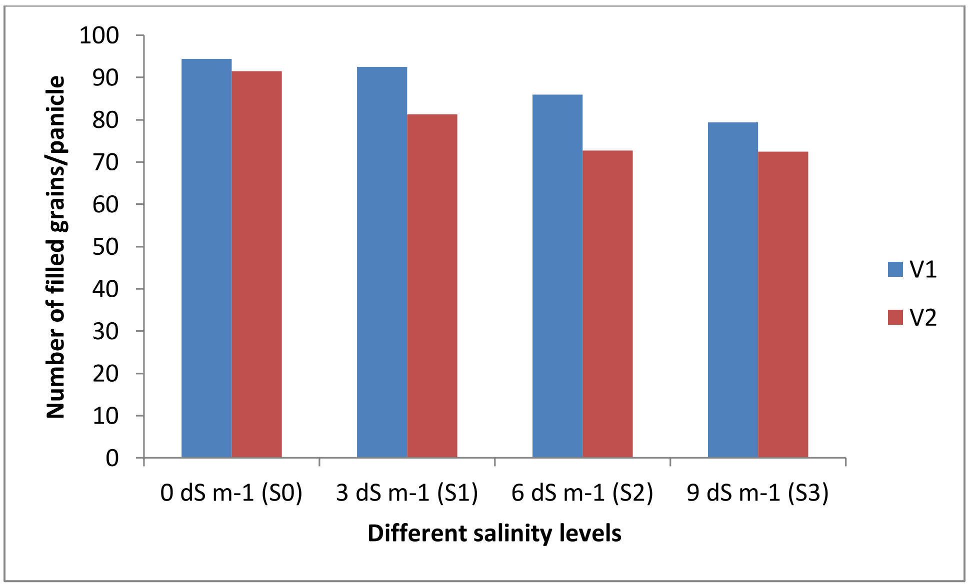

Fig.13. Number of filled grains panicle^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

Effect of different fertilization method of TSP under different salinity levels

Significant variation was recorded on number of filled grains panicle^{-1} at different salinity levels influenced by different fertilization method of TSP at all salinity levels (Fig. 14). Results revealed that at all salinity stress, T_2 (⅔ foliar and ⅓ soil application of TSP) showed highest number of filled grains panicle^{-1} (99.00, 96.67, 87.83 and 88.34 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively). At S_2 (6 dS m^{-1}) salinity level, T_2 (⅔ foliar and ⅓ soil application of TSP) and T_3 (Total foliar application of TSP) showed statistically identical result. The treatment T_0 (Control; 0 TSP) showed lowest number of filled grains panicle^{-1} (82.17, 79.84, 61.84 and 54.17 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity level.

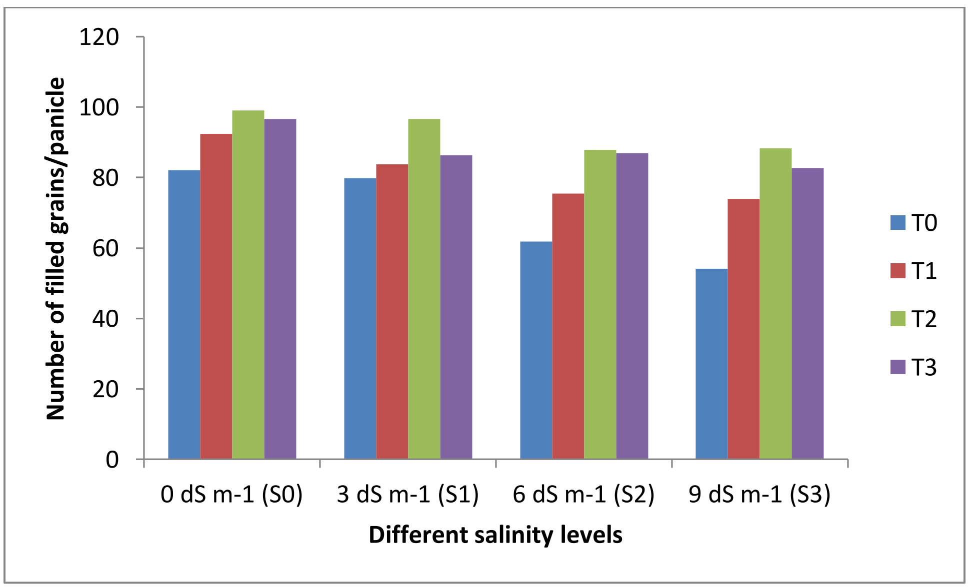

Fig.14. Number of filled grains panicle^{-1} of rice as influenced by different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP showed significant variation on number of filled grains panicle^{-1} under different salinity levels (Table 7). It was found that the treatment combination of V_1T_2 gave the best performance on number of filled grains panicle^{-1} where V_2T_0 showed lowest performance at all salinity levels. Treatment combination of V_1T_2 showed the highest number of filled grains panicle^{-1} (81.00, 75.67, 61.67 and 52.67 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively). At S_0 (0 dS m^{-1}) and S_2 (6 dS m^{-1}) salinity levels, treatment combination of V_1T_3 showed statistically same results with V_1T_2. The lowest number of filled grains panicle^{-1} (81.00, 75.67, 61.67 and 52.67 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found from V_2T_0 which was close to the treatment combinations of V_1T_0 at all salinity levels.

Table 7. Number of filled grains panicle^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Treatment	Number of filled grains panicle^{-1} at different salt concentration			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	83.33 e	84.00 d	62.00 g	55.67 f
V_1T_1	94.00 c	91.67 c	87.00 c	79.67 c
V_1T_2	99.33 a	98.00 a	95.33 a	92.00 a
V_1T_3	99.00 a	92.33 c	94.33 a	87.33 b
V_1T_4	96.33 b	96.67 ab	91.00 b	85.33 b
V_2T_0	81.00 f	75.67 f	61.67 g	52.67 g
V_2T_1	90.67 d	76.00 f	64.00 f	68.33 e
V_2T_2	99.00 a	95.33 b	81.33 d	84.67 b
V_2T_3	94.00 c	80.33 e	78.33 e	78.00 d
V_2T_4	92.67 c	79.00 e	78.00 e	75.67 d
$LSD_{0.05}$	1.804	1.882	1.919	2.608
CV (%)	11.67	10.88	12.74	8.37

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.8 Number of unfilled grains panicle^{-1}

Effect of variety under different salinity levels

Remarkable variation was not found on number of unfilled grains panicle^{-1} under different salinity levels affected by different variety (Fig. 15). But it was found that variety, V_2 (BRRI dhan 29) showed highest number of unfilled grains panicle^{-1} (4.27, 4.67, 5.00 and 5.27 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where the lowest number of unfilled grains panicle^{-1} (4.00, 4.34, 4.87 and 5.24 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was observed from the variety, V_1 (BINA dhan 10).

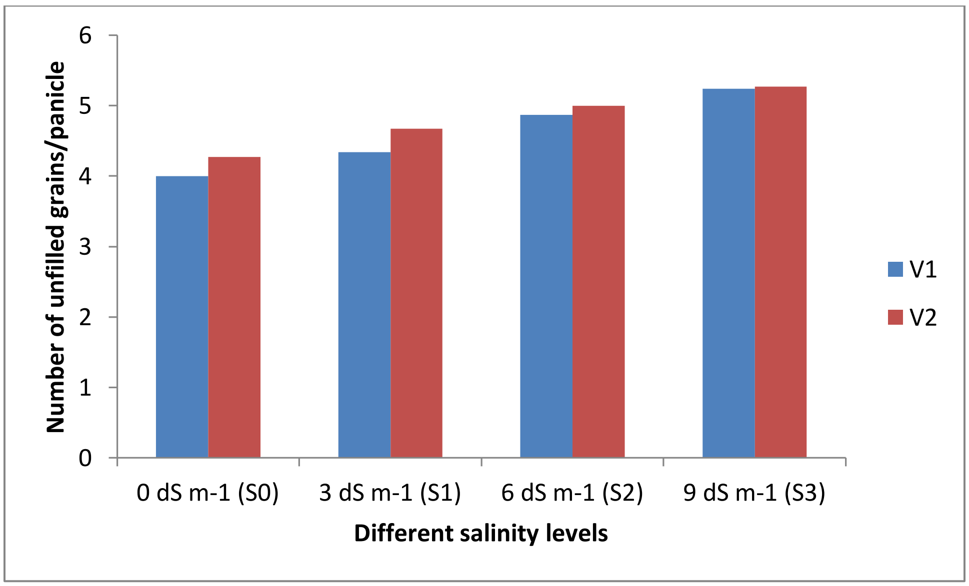

Fig.15. Number of unfilled grains panicle^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

Effect of different fertilization method of TSP under different salinity levels

Non-significant variation was observed on number of unfilled grains panicle^{-1} at different salinity levels influenced by different fertilization method of TSP (Fig. 16). But it was found that all salinity stress, T_1 (⅓ foliar and ⅔ soil application of TSP) showed highest number of unfilled grains panicle^{-1} (5.33, 5.50, 6.17 and 6.60 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where treatment T_0 (Control; 0 TSP) showed lowest number of unfilled grains panicle^{-1} (2.50, 2.67, 3.84 and 4.67 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity level.

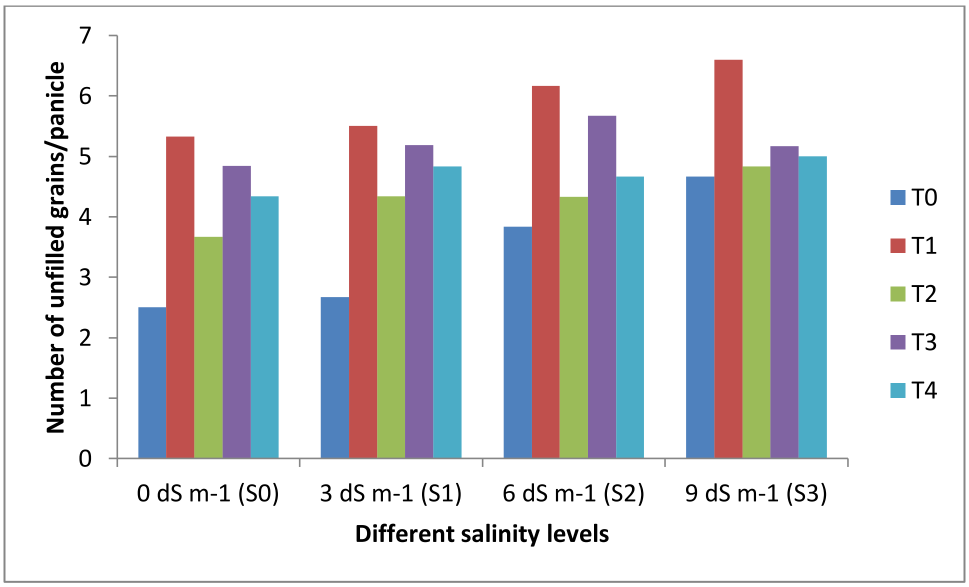

Fig.16. Number of unfilled grains panicle^{-1} of rice as influenced by different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed significant variation on number of unfilled grains panicle^{-1} under different salinity levels (Table 8). It was found that the treatment combination of V_1T_2 showed the highest number of unfilled grains panicle^{-1} (5.67, 5.67, 6.67 and 7.33 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) which was which was significantly different from all other treatment combination under all salinity stress. The lowest number of unfilled grains panicle^{-1} (2.00, 2.00, 3.67 and 4.33 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from V_1T_0 which was closely followed by the treatment combinations of V_2T_0 at all salinity levels.

Table 8. Number of unfilled grains panicle^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Treatment	Number of unfilled grains panicle^{-1} at different salt concentration			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	2.00 g	2.00 g	3.67 e	4.33 c
V_1T_1	5.33 b	5.33 b	5.67 b	5.86 b
V_1T_2	4.33 d	4.67 d	4.33 cd	5.33 b
V_1T_3	4.00 e	4.67 d	5.67 b	5.67 b
V_1T_4	4.67 c	5.00 c	4.67 c	5.00 b
V_2T_0	3.00 f	3.33 f	4.00 de	5.00 b
V_2T_1	5.67 a	5.67 a	6.67 a	7.33 a
V_2T_2	3.00 f	4.00 e	4.33 cd	4.33 c
V_2T_3	5.33 b	5.33 b	5.67 b	4.67 bc
V_2T_4	4.00 e	4.33 e	4.67 c	5.00 b
$LSD_{0.05}$	0.188	0.196	0.359	0.352
CV (%)	5.26	4.78	6.69	5.24

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.9 Grain weight plant^{-1}

Effect of variety under different salinity levels

Considerable variation was not found on grain weight plant^{-1} under different salinity levels affected by different variety (Fig. 17). But it was found that the variety, V_1 (BINA dhan 10) showed highest grain weight plant^{-1} (12.95, 10.21, 11.37 and 10.97 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where the lowest grain weight plant^{-1} (11.35, 13.03, 11.55 and 9.36 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were observed from the variety, V_2 (BRRI dhan 29).

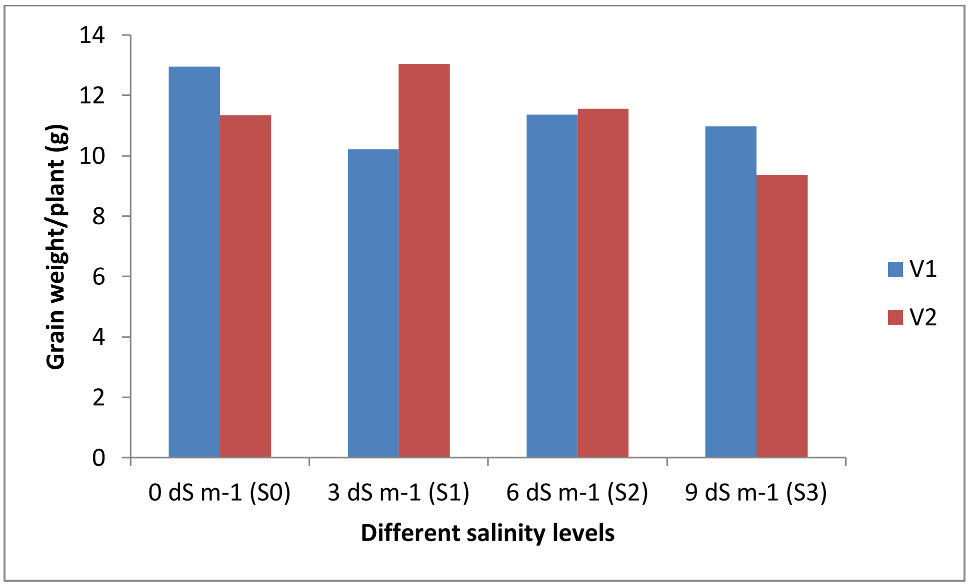

Fig.17. Grain weight hill^{-1} of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

Effect of different fertilization method of TSP under different salinity levels

Significant variation was recorded on grain weight plant^{-1} at different salinity levels influenced by different fertilization method of TSP (Fig. 18). It was found that among all the salinity stress, T_2 (⅔ foliar and ⅓ soil application of TSP) showed highest grain weight plant^{-1} (14.57, 14.10, 13.26 and 13.93 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) which was statistically identical with T_3 (Total foliar application of TSP) at 0, 3 and 6 dS m^{-1} salinity levels but at 9 dS m^{-1} salinity level, it was significantly similar. Again, the treatment T_0 (Control; 0 TSP) showed lowest grain weight plant^{-1} (9.42, 7.92, 8.28 and 7.76 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity level followed by T_1 (⅓ foliar and ⅔ soil application of TSP). Similar results was also observed by Tian *et al*. (2017), Khan *et al*. (2015) and Mohammad *et al*. (1998) with the present study.

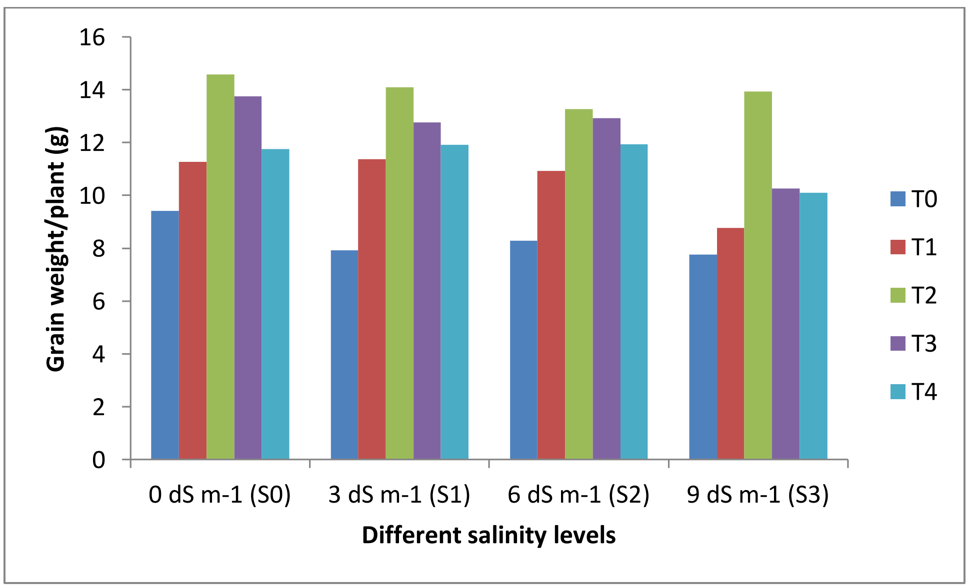

Fig.18. Grain weight hill^{-1} of rice as influenced by different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed significant variation on grain weight plant^{-1} under different salinity levels (Table 9). It was found that the treatment combination of V_1T_2 showed the highest grain weight plant^{-1} (14.72, 15.77, 13.42 and 15.08 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) which was which was statistically identical with V_2T_2 at 0, 3 and 6 dS m^{-1} salinity levels but at 9 dS m^{-1} salinity levels it was significantly similar. At 0 and 3 dS m^{-1} salinity levels, treatment combination of V_1T_3 also showed statistically identical results with V_1T_2 where V_2T_3 was statistically similar with V_1T_2 at 3 dS m^{-1} salinity level. The lowest grain weight plant^{-1} (6.77, 7.10, 7.78 and 7.42 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from V_1T_0 which was closely followed by the treatment combinations of V_2T_0 at all salinity levels.

Table 9. Grain weight hill^{-1} of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Treatment	Grain weight plant^{-1} (g) at different salt concentration			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	6.77 f	7.10 g	7.78 g	7.42 e
V_1T_1	10.41 e	12.42 bc	10.76 e	7.77 e
V_1T_2	14.72 a	15.77 a	13.42 a	15.08 a
V_1T_3	14.42 a	12.43 bc	13.05 a	8.42 d
V_1T_4	10.75 e	13.10 b	11.74 cd	8.11 d
V_2T_0	12.07 d	8.74 f	8.77 f	8.10 d
V_2T_1	12.12 cd	10.34 de	11.08 de	9.75 c
V_2T_2	14.42 a	15.10 a	13.10 a	12.77 b
V_2T_3	13.10 b	10.43 de	12.78 ab	12.10 b
V_2T_4	12.76 bc	10.74 cd	12.11 bc	12.10 b
$LSD_{0.05}$	0.6577	1.644	0.795 4	1.727
CV (%)	8.37	6.52	10.14	9.38

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.10 Straw weight plant^{-1}

Effect of variety under different salinity levels

Considerable variation was not found on straw weight plant^{-1} under different salinity levels affected by different variety (Fig. 19). But it was found that variety, V_1 (BINA dhan 10) showed highest straw weight plant^{-1} (27.75, 25.39, 23.20 and 22.16 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where the lowest straw weight plant^{-1} (26.58, 24.75, 23.36 and 22.57 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were observed from the variety, V_2 (BRRI dhan 29).

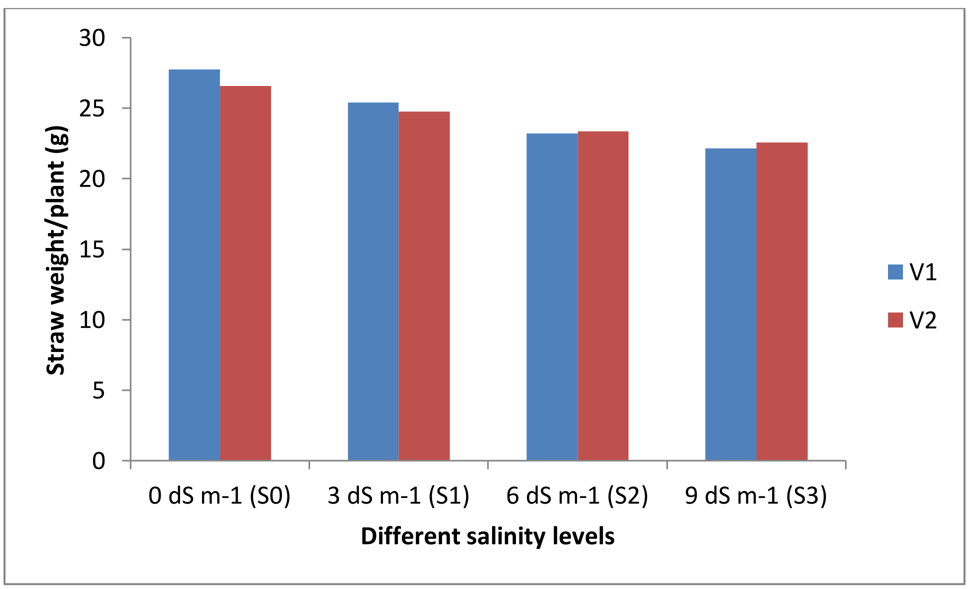

Fig.19. Straw weight hill^{-1} of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

Effect of different fertilization method of TSP under different salinity levels

Significant variation was not found on straw weight plant^{-1} at different salinity levels influenced by different fertilization method of TSP (Fig. 20). It was found that among all the salinity stress, T_2 (⅔ foliar and ⅓ soil application of TSP) showed highest straw weight plant^{-1} (30.24, 26.74, 24.36 and 23.76 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where the treatment T_0 (Control; 0 TSP) showed lowest straw weight plant^{-1} (9.24.86, 23.28, 22.75 and 21.77 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity levels.

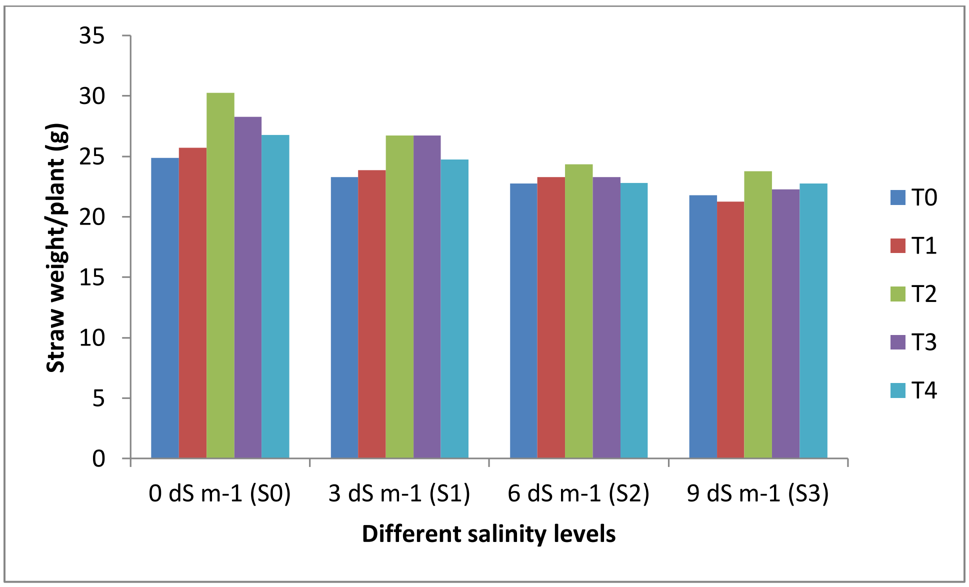

Fig.20. Straw weight hill^{-1} of rice as influenced by different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

At the salinity levels of S_0 (0 dS m^{-1}) and S_1 (3 dS m^{-1}) showed significant variation but at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels showed non-significant variation on straw weight $plant^{-1}$ among the treatment combinations of variety and TSP application methods (Table 10). It was found that the treatment combination of V_1T_2 showed the highest straw weight $plant^{-1}$ (31.72, 27.76, 24.96 and 23.77 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity stress which was which was statistically identical with V_1T_2 at S_1 (3 dS m^{-1}) salinity level. The lowest straw weight $plant^{-1}$ (24.75, 22.74, 21.75 and 20.75 g at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from V_2T_0 which was statistically identical with the treatment combinations of V_2T_0 at S_0 (0 dS m^{-1}) and S_1 (3 dS m^{-1}) salinity levels.

Table 10. Straw weight $hill^{-1}$ of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Treatment	Straw weight $plant^{-1}$ (g) at different salt concentration			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	24.96 e	22.78 e	22.76	20.77
V_1T_1	25.72 d	25.72 b	22.78	21.77
V_1T_2	31.72 a	27.76 a	24.96	23.77
V_1T_3	28.76 b	25.72 b	23.75	23.70
V_1T_4	25.72 d	24.96 c	23.72	21.77
V_2T_0	24.75 e	22.74 e	21.75	20.75
V_2T_1	27.76 c	23.77 d	22.78	22.78
V_2T_2	28.76 b	27.70 a	23.77	23.74
V_2T_3	27.78 c	23.74 d	23.74	22.78
V_2T_4	25.72 d	25.67 b	22.78	21.77
$LSD_{0.05}$	1.102	0.706	NS	NS
CV (%)	9.58	10.60	12.36	10.12

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.11 Nutrient concentration in grain and straw

4.11.1 Phosphorus (P) content (%) in grain

Effect of variety under different salinity levels

Considerable variation on phosphorus (P) content (%) in grain was not found at different salinity levels influenced by different variety (Fig. 21). It was observed that the highest P content in grain (0.94, 1.04, 1.01 and 1.07 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_2 (BRRI dhan 29) where the lowest P content in grain (0.70, 0.84, 0.96 and 0.95 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_1 (BINA dhan 10).

Effect of different fertilization method of TSP under different salinity levels

Significant influence was observed on phosphorus (P) content (%) in grain under different salinity levels affected by different application methods of TSP (Fig. 22). At no salinity level S_0 (0 dS m^{-1}), the treatment, T_1 (⅓ foliar and ⅔ soil application of TSP) showed highest P content in grain (1.05%) which was statistically identical with T_3 (Total foliar application of TSP) and T_2 (⅔ foliar and ⅓ soil application of TSP) where the lowest P content in grain (0.21%) was in T_0 (Control; 0 TSP). Again, the highest P content in grain at S_1 (3 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels (1.12 and 1.19 % respectively) were achieved from the treatment T_3 (Total foliar application of TSP) which was statistically identical with T_1 (⅓ foliar and ⅔ soil application of TSP) under both salinity levels. But at S_2 (6 dS m^{-1}) salinity level, the highest P content in grain (1.20%) was achieved from T_2 (⅔ foliar and ⅓ soil application of TSP) which was also statistically identical with T_1 (⅓ foliar and ⅔ soil application of TSP). At all salinity levels, treatment, T_0 (Control; 0 TSP) demonstrated lowest P content in grain (0.42, 0.47 and 0.49 % at 3, 6 and 9 dS m^{-1} salinity levels respectively).

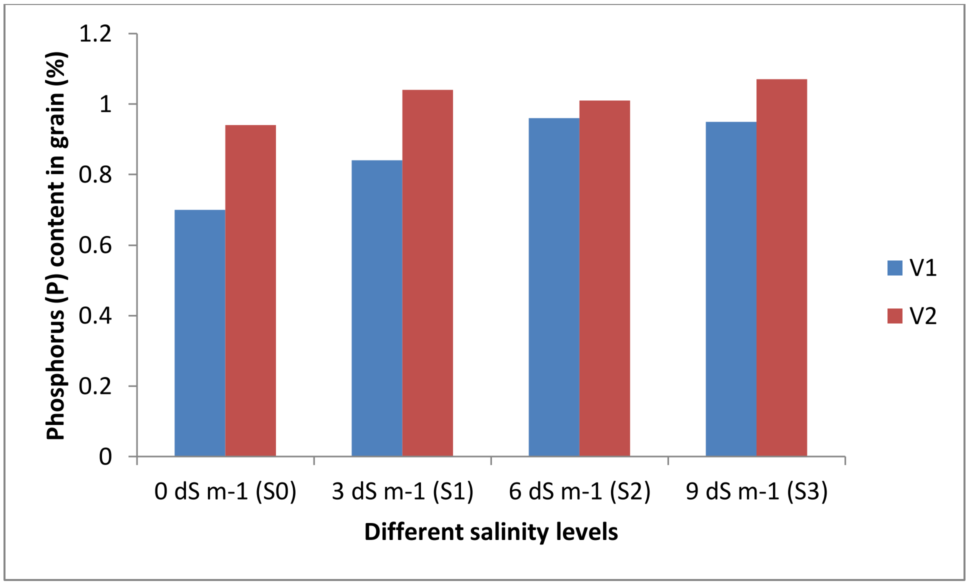

Fig.21. Phosphorus (P) content in grain of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

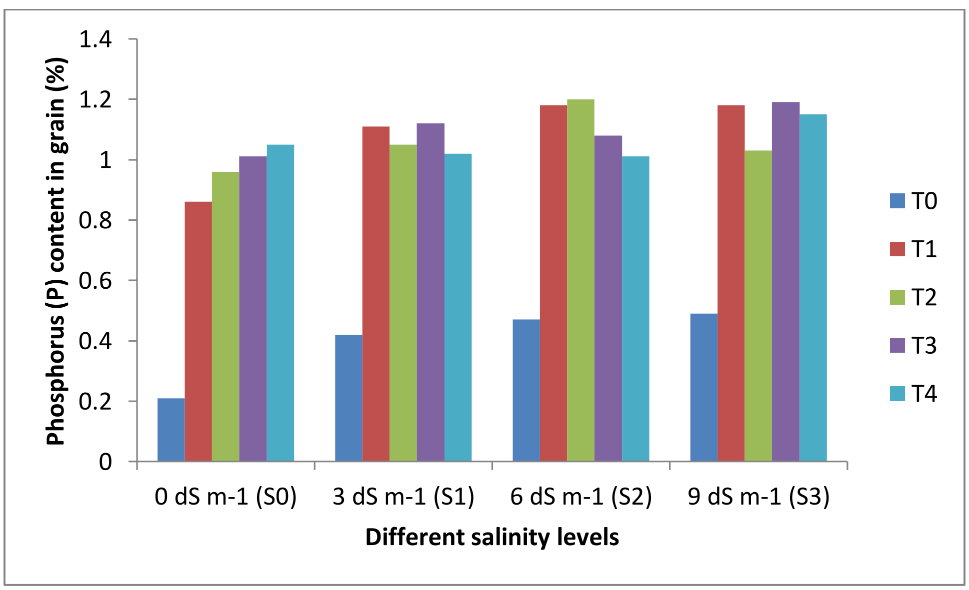

Fig.22. Phosphorus (P) content in grain with different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed significant variation on phosphorus (P) content in grain under different salinity levels (Table 11). Results revealed that at no salinity level S_0 (0 dS m^{-1}), the treatment combination of V_2T_4 gave highest P content in grain (1.27 %) which was statistically identical with V_2T_3. At the salinity level of S_1 (3 dS m^{-1}), the highest P content in grain (1.26 %) was obtained from V_2T_3 which was statistically identical with V_2T_4 and V_2T_1 and statistically similar with V_1T_1, V_1T_2, V_1T_3 and V_2T_2. At S_2 (6 dS m^{-1}) salinity level, V_1T_2 showed highest P content in grain (1.33 %) which was statistically identical with V_2T_1. At the salinity level of S_3 (9 dS m^{-1}), the highest P content in grain (1.26 %) was obtained from V_2T_2 which was statistically identical with V_2T_1, V_2T_3 and V_2T_4 and statistically similar with V_1T_1, V_1T_3 and V_1T_4. At all salinity levels, the lowest P content in grain (0.20, 0.36, 0.46 and 0.45 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were achieved from the treatment combination of V_2T_0 which was statistically identical with V_1T_0.

4.11.2 Phosphorus (P) content (%) in straw

Effect of variety under different salinity levels

Remarkable variation was not found on phosphorus (P) content (%) in straw at different salinity levels influenced by different variety (Fig. 23). But it was observed that the highest P content in grain (0.47, 0.40, 0.44 and 0.48 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_1 (BINA dhan 10) where the lowest P content in grain 0.37, 0.38, 0.42 and 0.46 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found in the variety, V_2 (BRRI dhan 29).

Effect of different fertilization method of TSP under different salinity levels

Significant influence was found on phosphorus (P) content in straw under different salinity levels affected by different application methods of TSP (Fig. 24). It was found that at S_0 (0 dS m^{-1}) and S_1 (3 dS m^{-1}) salinity levels, the treatment, T_2 (⅔ foliar and ⅓ soil application of TSP) showed highest P content in straw (0.56 and 0.45 % respectively) and at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels, the highest P content in straw (0.59 and 0.59 % respectively) were obtained from the treatment, T_1 (⅓ foliar and ⅔ soil application of TSP). Again, the lowest P content in straw (0.29, 0.27, 0.30 and 0.30 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found from T_0 (Control; 0 TSP).

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed non-significant variation on phosphorus (P) content in straw under different salinity levels (Table 11). But the results showed that at S_0 (0 dS m^{-1}) and S_1 (3 dS m^{-1}) salinity levels, the highest P content in straw (0.81 and 0.50 % respectively) were observed from V_1T_2 but at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels, the highest P content in straw (0.65 and 0.61 % respectively) were observed from V_2T_1 where the lowest P content in straw at all salinity levels (0.28, 0.23, 0.28 and 0.29 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from the treatment combination of V_2T_0.

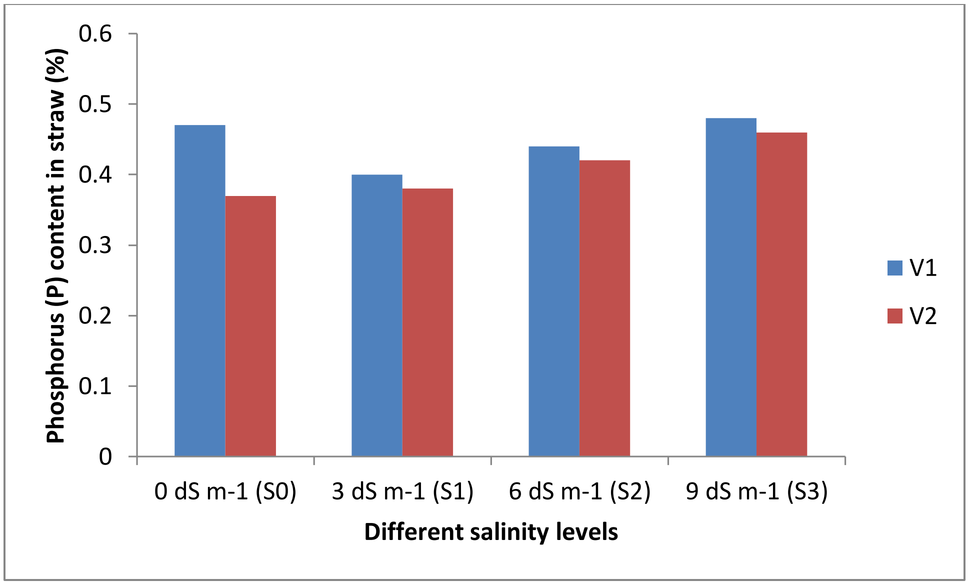

Fig.23. Phosphorus (P) content in straw of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

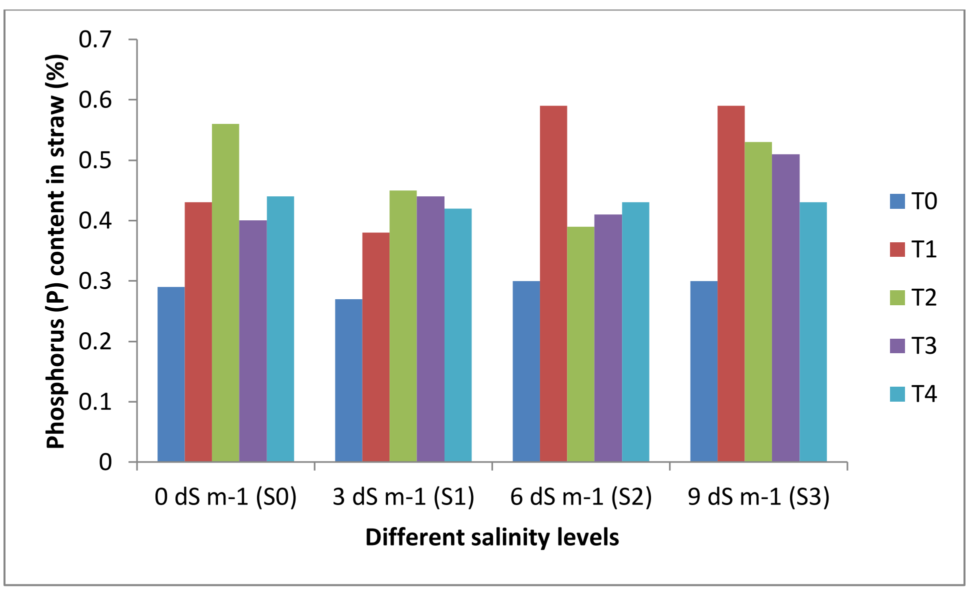

Fig.24. Phosphorus (P) content in straw with different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Table 11. Phosphorus (P) content of BINA dhan 10 and BRRI dhan 29 after harvest with different fertilization method of TSP under different salt concentration

Treatment	Phosphorus (P) content (%) at different salt concentration							
	Phosphorus content in grain				Phosphorus content in straw			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	0.22 d	0.48 c	0.47 d	0.53 d	0.29	0.30	0.31	0.30
V_1T_1	0.75 c	0.99 ab	1.11 b	1.15 ab	0.44	0.40	0.52	0.57
V_1T_2	0.85 c	1.01 ab	1.33 a	0.80 c	0.81	0.50	0.40	0.45
V_1T_3	0.84 c	0.97 ab	1.05 b	1.15 ab	0.41	0.38	0.41	0.54
V_1T_4	0.83 c	0.87 b	0.86 c	1.10 ab	0.41	0.44	0.47	0.44
V_2T_0	0.20 d	0.36 c	0.46 d	0.45 d	0.28	0.23	0.28	0.29
V_2T_1	0.96 b	1.23 a	1.25 a	1.21 a	0.41	0.35	0.65	0.61
V_2T_2	1.07 b	1.09 ab	1.07 b	1.26 a	0.31	0.41	0.38	0.60
V_2T_3	1.18 a	1.26 a	1.11 b	1.23 a	0.39	0.49	0.41	0.48
V_2T_4	1.27 a	1.16 a	1.15 b	1.20 a	0.47	0.40	0.39	0.41
$LSD_{0.05}$	0.094	0.051	0.042	0.078	NS	NS	NS	NS
CV (%)	4.26	3.59	3.42	4.06	2.12	1.73	2.68	3.12

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.11.3 Sodium (Na) content (%) in grain

Effect of variety under different salinity levels

Considerable variation on sodium (Na) content (%) in grain was not found at different salinity levels influenced by different variety (Fig. 25). But it was observed that the highest Na content in grain (0.0039, 0.0287, 0.0410 and 0.0459 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_1 (BINA dhan 10) where the lowest Na content in grain (0.0026, 0.0242, 0.0408 and 0.0438 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_2 (BRRI dhan 29).

Effect of different fertilization method of TSP under different salinity levels

Significant influence was not found on sodium (Na) content in grain under different salinity levels affected by different application methods of TSP (Fig. 26). But it was found that at S_0 (0 dS m^{-1}) salinity level, treatment T_1 (⅓ foliar and ⅔ soil application of TSP) (0.0037 %); at S_1 (3 dS m^{-1}) salinity level, treatment T_2 (⅔ foliar and ⅓ soil application of TSP) (0.035 %); and at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels, treatment T_0 (Control; 0 TSP) (0.0425 and 0.0470% respectively) gave highest Na content in grain. But the lowest Na content in grain at S_0 (0 dS m^{-1}) (0.0028 %), S_1 (3 dS m^{-1}) (0.0258 %), S_2 (6 dS m^{-1}) (0.0395 %) and S_3 (9 dS m^{-1}) (0.0429 %) salinity levels were found from T_4 (Total soil application of TSP), T_0 (Control; 0 TSP), T_2 (⅔ foliar and ⅓ soil application of TSP) and T_3 (Total foliar application of TSP) respectively.

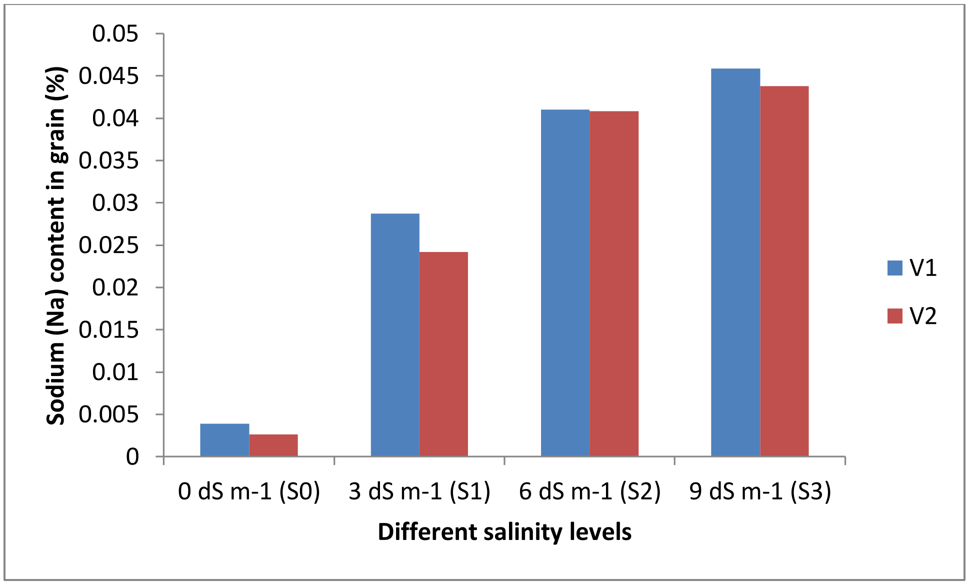

Fig.25. Sodium (Na) content in grain of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

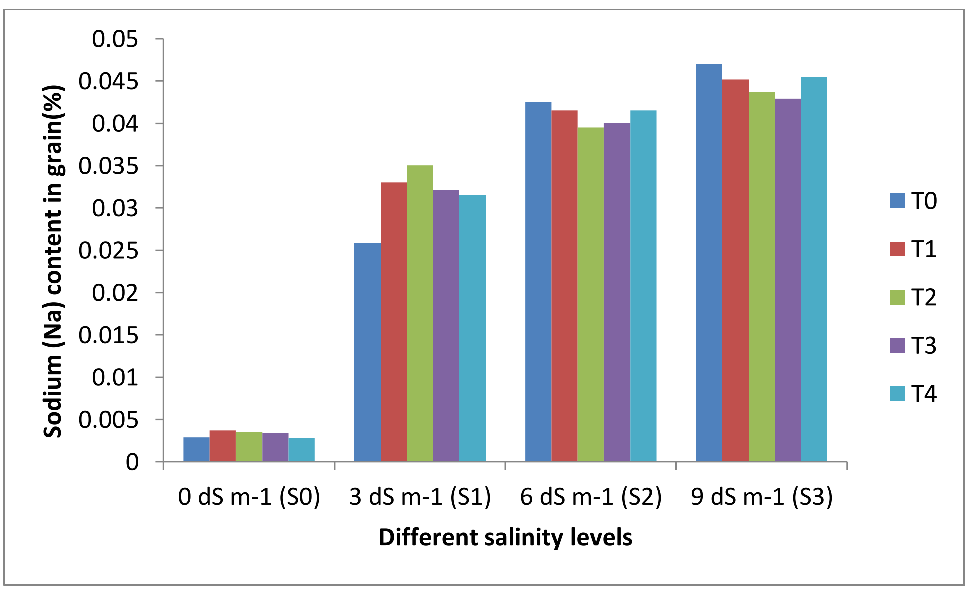

Fig.26. Sodium (Na) content in grain with different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed non-significant variation on sodium (Na) content in grain under different salinity levels (Table 12). But it was observed that at S_0 (0 dS m^{-1}) salinity level, treatment combination of V_1T_1 and at S_1 (3 dS m^{-1}) salinity level, treatment combination of V_2T_2 showed highest sodium (Na) content in grain (0.0048 and 0.0380 % respectively) where the treatment T_0 (Control; 0 TSP) showed highest sodium (Na) content in grain (0.0430 and 0.0491 % respectively) at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels. Again, the lowest sodium (Na) content in grain at S_0 (0 dS m^{-1}) and S_1 (3 dS m^{-1}) salinity levels (0.0024 and 0.0175 % respectively) were found from the treatment combination of V_2T_4 and V_1T_0 respectively but at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels, V_1T_3 gave the lowest sodium (Na) content in grain (0.0388 and 0.0414 % respectively).

4.11.4 Sodium (Na) content (%) in straw

Effect of variety under different salinity levels

Remarkable variation was not found on sodium (Na) content (%) in straw at different salinity levels influenced by different variety (Fig. 27). But it was observed that the highest Na content in grain (00.0029, 0.0387, 0.0468 and 0.0508 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_1 (BINA dhan 10) where the lowest Na content in grain (0.0028, 0.0373, 0.0471 and 0.0512 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_2 (BRRI dhan 29).

Effect of different fertilization method of TSP under different salinity levels

Significant influence was not found on sodium (Na) content in straw under different salinity levels affected by different application methods of TSP (Fig. 28). But it was found that at all salinity levels, the treatment, T_0 (Control; 0 TSP) showed highest Na content in straw (0.0031, 0.0385, 0.0477 and 0.0515 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) where the lowest Na content in straw at 0, 3 and 9 dS m^{-1} salinity levels (0.0026, 0.0374 and 0.0504 % respectively) were found from T_3 (Total foliar application of TSP) but at S_2 (6 dS m^{-1}) salinity level, treatment T_4 (Total soil application of TSP) showed lowest Na content in straw (0.0463 %).

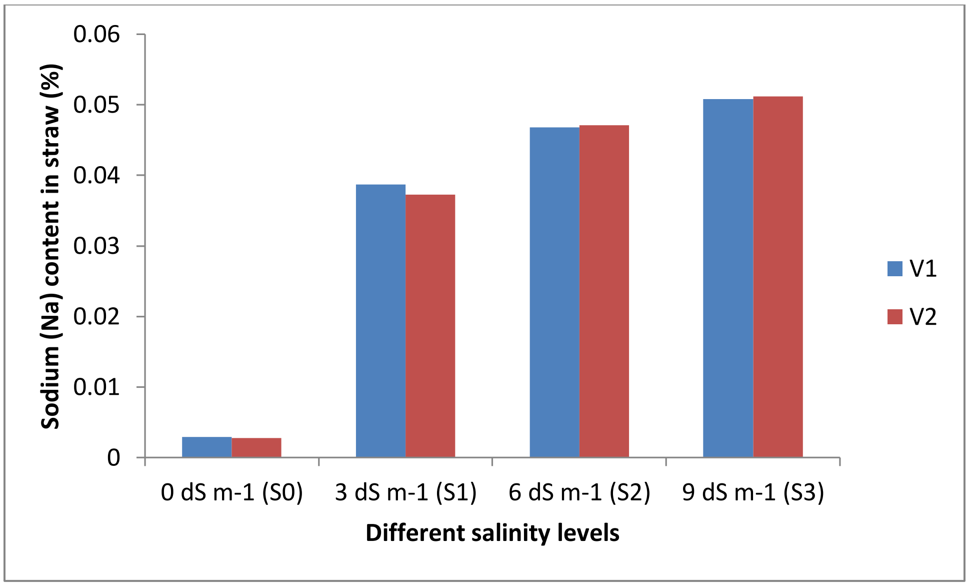

Fig.27. Sodium (Na) content in straw of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

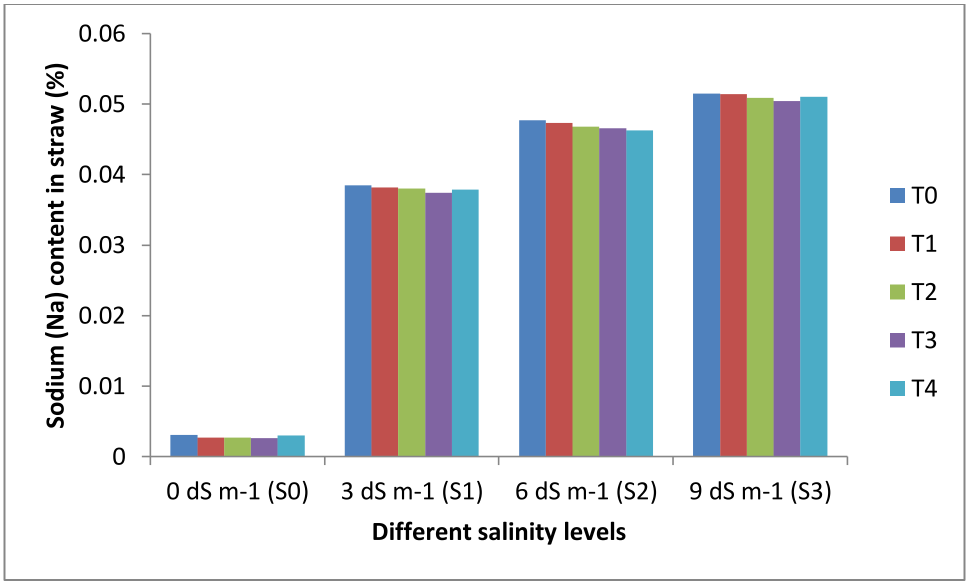

Fig.28. Sodium (Na) content in straw with different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed non-significant variation on sodium (Na) content in straw under different salinity levels (Table 12). But the results showed that the highest Na content in straw (0.0033, 0.0391, 0.0477 and 0.0519 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively was found from S_0 (0 dS m^{-1}) where the lowest Na content in straw (0.0025, 0.0369, 0.0461 and 0.0498 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from the treatment combination of V_1T_3, V_2T_4, V_1T_4 and V_1T_3 respectively.

Table 12. Sodium (Na) content of BINA dhan 10 and BRRI dhan 29 after harvest with different fertilization method of TSP under different salt concentration

Treatment	Sodium (Na) content (%) at different salt concentration							
	Grain				Straw			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	0.0030	0.0175	0.0430	0.0491	0.0033	0.0391	0.0477	0.0519
V_1T_1	0.0048	0.0320	0.0420	0.0488	0.0027	0.0387	0.0470	0.0511
V_1T_2	0.0044	0.0320	0.0390	0.0430	0.0026	0.0390	0.0466	0.0508
V_1T_3	0.0041	0.0302	0.0388	0.0414	0.0025	0.0376	0.0464	0.0498
V_1T_4	0.0030	0.0320	0.0420	0.0470	0.0032	0.0389	0.0461	0.0510
V_2T_0	0.0027	0.0340	0.0420	0.0448	0.0030	0.0378	0.0476	0.0513
V_2T_1	0.0025	0.0340	0.0410	0.0415	0.0026	0.0377	0.0475	0.0514
V_2T_2	0.0026	0.0380	0.0400	0.0443	0.0027	0.0370	0.0469	0.0510
V_2T_3	0.0026	0.0340	0.0410	0.0442	0.0028	0.0371	0.0468	0.0509
V_2T_4	0.0024	0.0310	0.0409	0.0440	0.0027	0.0369	0.0464	0.0510
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	2.89	2.54	3.76	4.28	4.19	3.85	3.74	3.39

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.11.5 Calcium (Ca) content (%) in grain

Effect of variety under different salinity levels

Considerable variation on calcium (Ca) content (%) in grain was not found at different salinity levels influenced by different variety (Fig. 29). But it was observed that the highest Ca content in grain (0.0103 and 0.0120 % respectively) at S_0 0 dS m^{-1}) and S_1 (3 dS m^{-1}) salinity levels was found in the variety, V_2 (BRRI dhan 29) and (0.0151 and 0.0149 % respectively) at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels was found in the variety, V_1 (BINA dhan 10). where the lowest Ca content in grain (0.0030 and 0.0101 % at S_0 (0 dS m^{-1}) and S_1 (3 dS m^{-1}) salinity levels respectively) were found in the variety, V_1 (BINA dhan 10) and at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels, the lowest Ca content in grain (0.0144 and 0.0143 % respectively) were found in the variety, V_2 (BRRI dhan 29).

Effect of different fertilization method of TSP under different salinity levels

Significant influence was not found on calcium (Ca) content (%) in grain under different salinity levels affected by different application methods of TSP (Fig. 30). But it was found that the highest Ca content in grain at S_0 (0 dS m^{-1}) (0.0088 %), S_1 (3 dS m^{-1}) (0.0146 %), S_2 (6 dS m^{-1}) (0.0189 %) and S_3 (9 dS m^{-1}) (0.0185 %) were obtained from the treatment T_4 (Total soil application of TSP), T_2 (⅔ foliar and ⅓ soil application of TSP), T_1 (⅓ foliar and ⅔ soil application of TSP) and T_2 (⅔ foliar and ⅓ soil application of TSP) respectively. Again, at all salinity levels, T_0 (Control; 0 TSP) showed lowest Ca content (0.0018, 0.0019, 0.0019 and 0.0019 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively.

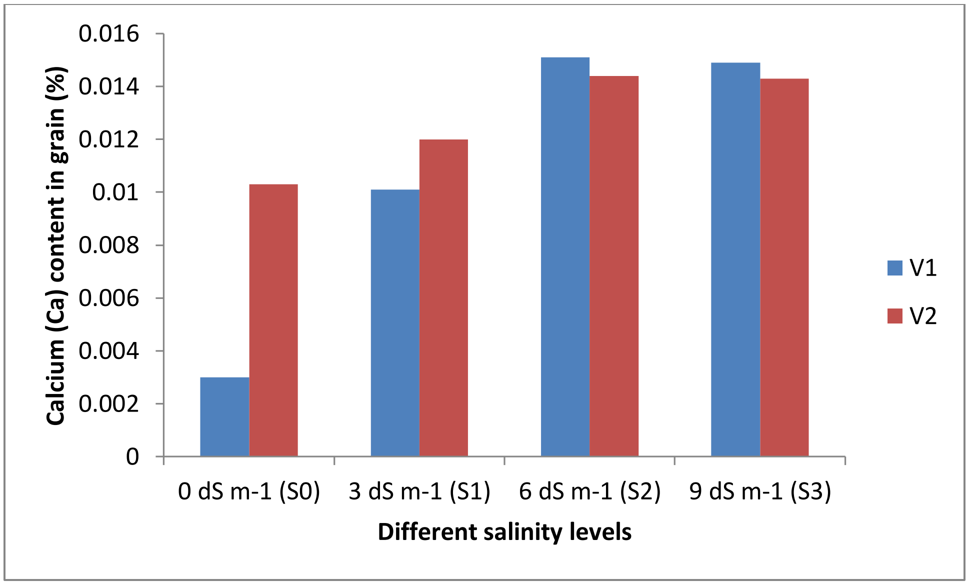

Fig.29. Calcium (Ca) content in grain of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

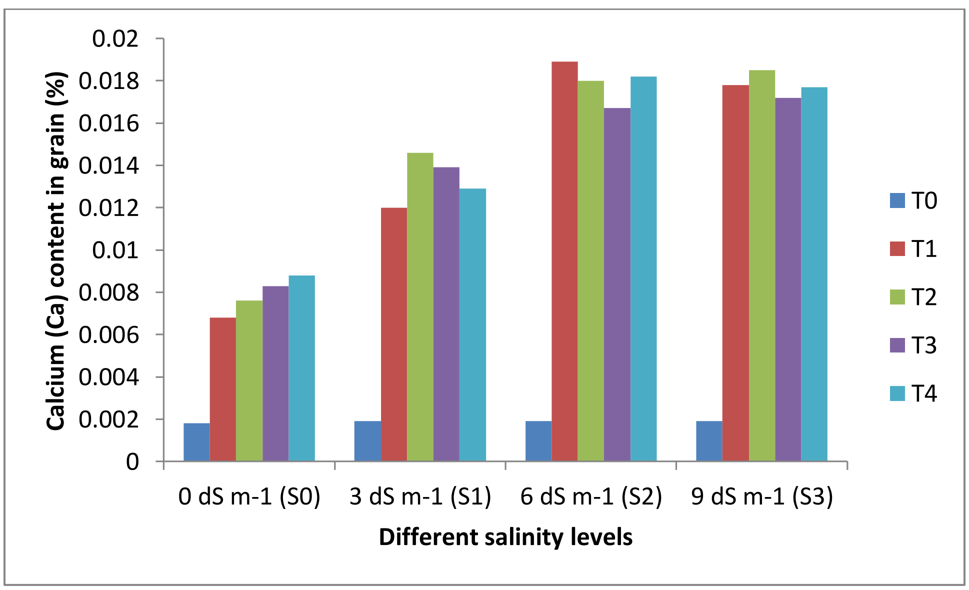

Fig.30. Calcium (Ca) content in grain with different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed non-significant variation on calcium (Ca) content in grain under different salinity levels (Table 13). But it was observed that the highest Ca content in grain at S_0 (0 dS m^{-1}) salinity level (0.0141 %), at S_1 (3 dS m^{-1}) salinity level (0.0170 %), at S_2 (6 dS m^{-1}) salinity level (0.0194 %) and at S_3 (9 dS m^{-1}) salinity level (0.0185 %) was obtained from the treatment combination of V_2T_4, V_2T_3, V_2T_1 and V_1T_2 where the lowest Ca content in grain at different salinity levels was found from the treatment combination of V_1T_0 (0.0018, 0.0015, 0.0017 and 0.0018 % at 0, 3, 6 and 9) dS m^{-1} salinity levels respectively).

4.11.6 Calcium (Ca) content (%) in straw

Effect of variety under different salinity levels

Considerable variation on calcium (Ca) content in straw was not found at different salinity levels influenced by different variety (Fig. 31). But it was observed that the highest Ca content in straw (0.0101 and 0.0123 % respectively at 0 and 3 dS m^{-1} salinity levels was found in the variety, V_2 (BRRI dhan 29) and (0.0154 and 0.0155 % respectively at 6 and 9 dS m^{-1} salinity levels was found in the variety, V_1 (BINA dhan 10). where the lowest Ca content in straw (0.0033 and 0.0108 % at 0 and 3 dS m^{-1} salinity levels respectively) was found in the variety, V_1 (BINA dhan 10) and at (6 and 9 dS m^{-1} salinity levels, the lowest Ca content in straw 0.0148 and 0.0149 % respectively) was found in the variety, V_2 (BRRI dhan 29).

Effect of different fertilization method of TSP under different salinity levels

Significant influence was not found on calcium (Ca) content in straw under different salinity levels affected by different application methods of TSP (Fig. 32). But it was found that the highest Ca content in straw at S_0 (0 dS m^{-1}) and S_2 (6 dS

m^{-1}) salinity levels (0.0084 and 0.0185 % respectively) were found from T_4 (Total soil application of TSP) but at S_1 (3 dS m^{-1}) salinity level, treatment T_3 (Total foliar application of TSP) and at S_3 (9 dS m^{-1}) salinity level, T_2 (⅔ foliar and ⅓ soil application of TSP) showed highest Ca content in straw (0.0160 and 0.0191 % respectively) where at all salinity levels the treatment, T_0 (Control; 0 TSP) showed lowest Ca content in straw (0.0019, 0.0025, 0.0025 and 0.0022 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively).

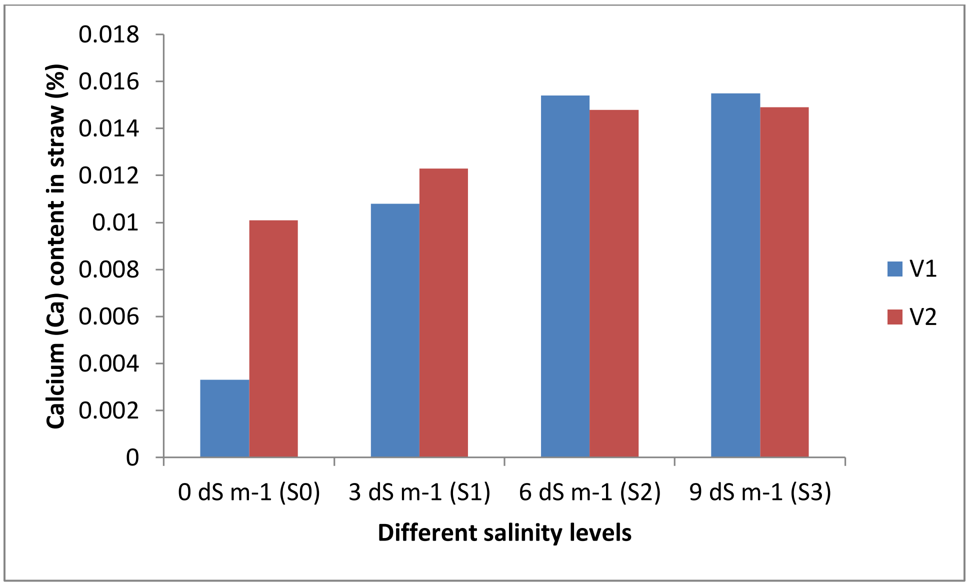

Fig.31. Calcium (Ca) content in straw of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

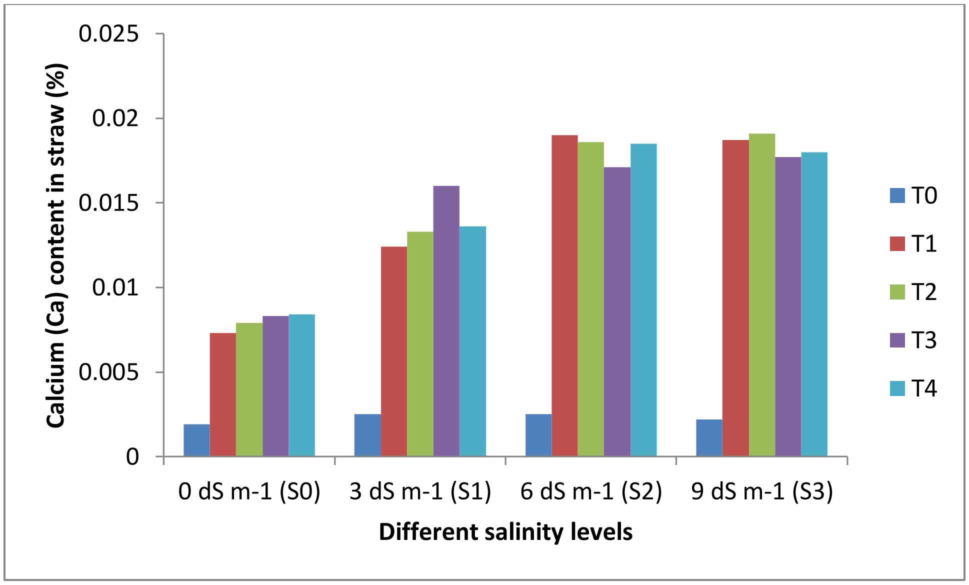

Fig.32. Calcium (Ca) content in straw with different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed non-significant variation on calcium (Ca) content in straw under different salinity levels (Table 13). But the results showed that the highest Ca content in straw at S_0 (0 dS m^{-1}) salinity level (0.0039 %), at S_1 (3 dS m^{-1}) salinity level (0.0177 %) and at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels (0.0196 and 0.0198 % respectively) were found from the treatment combination of V_1T_3, V_2T_3 and V_1T_2 respectively, where the lowest Ca content in straw at S_0 (0 dS m^{-1}) and S_1 (3 dS m^{-1}) salinity levels (0.0019 and 0.0026 % respectively) were found from the treatment combination of V_1T_0 and at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels (0.0030 and 0.0022 % respectively) were found from the treatment combination of V_2T_0.

Table 13. Calcium (Ca) content of BINA dhan 10 and BRRI dhan 29 after harvest with different fertilization method of TSP under different salt concentration

Treatment	Calcium (Ca) content (%) at different salt concentration							
	Grain				Straw			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	0.0018	0.0015	0.0017	0.0018	0.0019	0.0026	0.0019	0.0021
V_1T_1	0.0034	0.0102	0.0184	0.0184	0.0035	0.0106	0.0186	0.0189
V_1T_2	0.0034	0.0141	0.0190	0.0185	0.0037	0.0114	0.0196	0.0198
V_1T_3	0.0032	0.0107	0.0184	0.0170	0.0039	0.0143	0.0186	0.0172
V_1T_4	0.0034	0.0138	0.0178	0.0184	0.0036	0.0150	0.0183	0.0188
V_2T_0	0.0019	0.0022	0.0020	0.0019	0.0018	0.0024	0.0030	0.0022
V_2T_1	0.0102	0.0138	0.0194	0.0170	0.0110	0.0141	0.0194	0.0184
V_2T_2	0.0118	0.0150	0.0170	0.0184	0.0120	0.0152	0.0176	0.0184
V_2T_3	0.0134	0.0170	0.0150	0.0173	0.0127	0.0177	0.0156	0.0181
V_2T_4	0.0141	0.0120	0.0185	0.0170	0.0131	0.0122	0.0186	0.0172
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	1.32	1.66	2.04	2.19	1.58	2.17	1.36	1.71

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.11.7 Sulphur (S) content (%) in grain

Effect of variety under different salinity levels

Considerable variation on sulphur (S) content in grain was not found at different salinity levels influenced by different variety (Fig. 33). But it was observed that at all salinity levels, the highest S content in grain (0.86, 1.04, 1.14 and 1.34 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_2 (BRRI dhan 29 where the lowest S content in grain (0.71, 1.02, 1.13 and 1.26 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from the variety, V_1 (BINA dhan 10).

Effect of different fertilization method of TSP under different salinity levels

Significant influence was observed on sulphur (S) content in grain under different salinity levels affected by different application methods of TSP (Fig. 34). Results revealed that the highest S content at S_0 (0 dS m^{-1}) and S_2 (6 dS m^{-1}) salinity levels (1.06 and 1.25 % respectively) were found from T_2 (⅔ foliar and ⅓ soil application of TSP) and the highest S content at S_1 (3 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels (1.24 and 1.48 % respectively) were found from T_1 (⅓ foliar and ⅔ soil application of TSP). Again, the lowest S content at all salinity levels (0.51, 0.79, 0.90 and 1.00 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from T_0 (Control; 0 TSP) treatment.

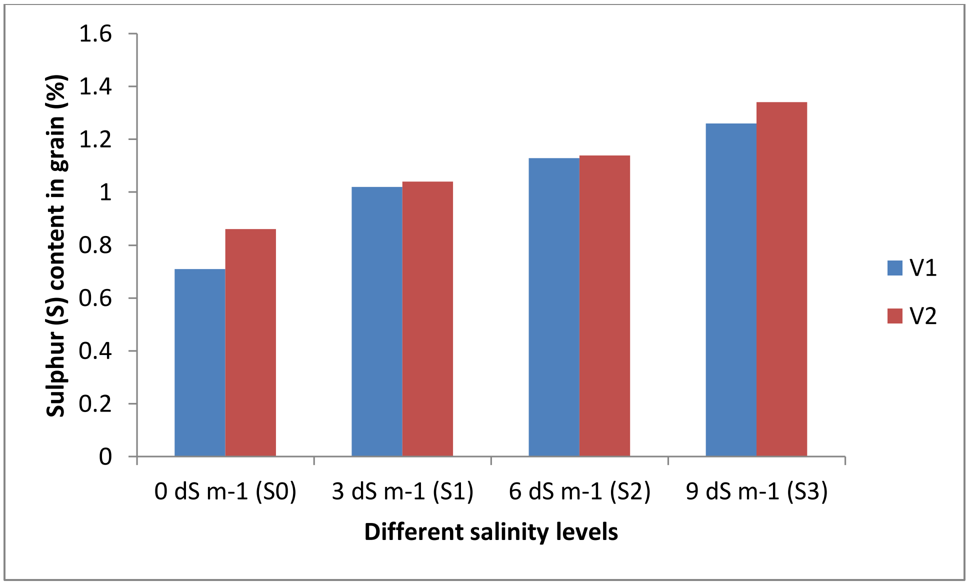

Fig.33. Sulphur (S) content in grain of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

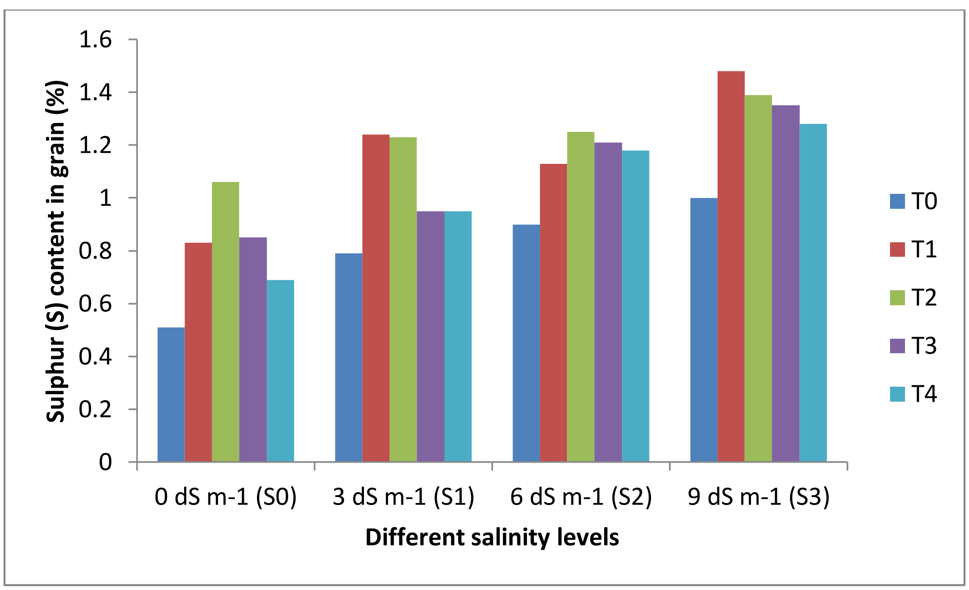

Fig.34. Sulphur (S) content in grain with different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed significant variation on sulphur (S) content in grain under different salinity levels (Table 14). Results revealed that at no salinity level S_0 (0 dS m^{-1}), the treatment combination of V_2T_2 gave highest S content in grain (1.30 %) followed by V_2T_3. At the salinity level of S_1 (3 dS m^{-1}), the highest S content in grain (1.40 %) was obtained from V_2T_1 which was statistically identical with V_2T_2. At S_2 (6 dS m^{-1}) salinity level, V_2T_3 showed highest S content in grain (1.45 %) which was statistically identical with V_1T_0, V_2T_2 and V_2T_4. At the salinity level of S_3 (9 dS m^{-1}), the highest S content in grain (1.67 %) was obtained from V_2T_3 which was statistically identical with V_1T_0, V_2T_1 and V_2T_4. At all salinity levels, the lowest S content in grain (0.36, 0.38, 0.39 and 0.42 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were achieved from the treatment combination of V_2T_0.

4.11.8 Sulphur (S) content (%) in straw

Effect of variety under different salinity levels

Considerable variation on sulphur (S) content in straw was not found at different salinity levels influenced by different variety (Fig. 35). But it was observed that at all salinity levels, the highest S content in straw (1.02, 1.27, 1.36 and 1.36 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_1 (BINA dhan 10) where the lowest S content in straw (1.01, 1.18, 1.17 and 1.28 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from the variety, V_2 (BRRI dhan 29).

Effect of different fertilization method of TSP under different salinity levels

Significant influence was observed on sulphur (S) content in straw under different salinity levels affected by different application methods of TSP (Fig. 36). Results revealed that the highest S content at S_0 (0 dS m^{-1}) and S_2 (6 dS m^{-1}) salinity levels (1.39 and 1.58 % respectively) were found from T_2 (⅔ foliar and ⅓ soil application of TSP) and T_3 (Total foliar application of TSP) respectively. But the highest S content at S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity levels (1.70 and 1.69 % respectively) were found from T_4 (Total soil application of TSP) which was statistically identical with T_2 (⅔ foliar and ⅓ soil application of TSP) at S_1 (3 dS m^{-1}) salinity level and T_3 (Total foliar application of TSP) at S_3 (9 dS m^{-1}) salinity level. Again, the lowest S content at all salinity levels (0.37, 0.42, 0.43 and 0.45 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from T_0 (Control; 0 TSP) treatment.

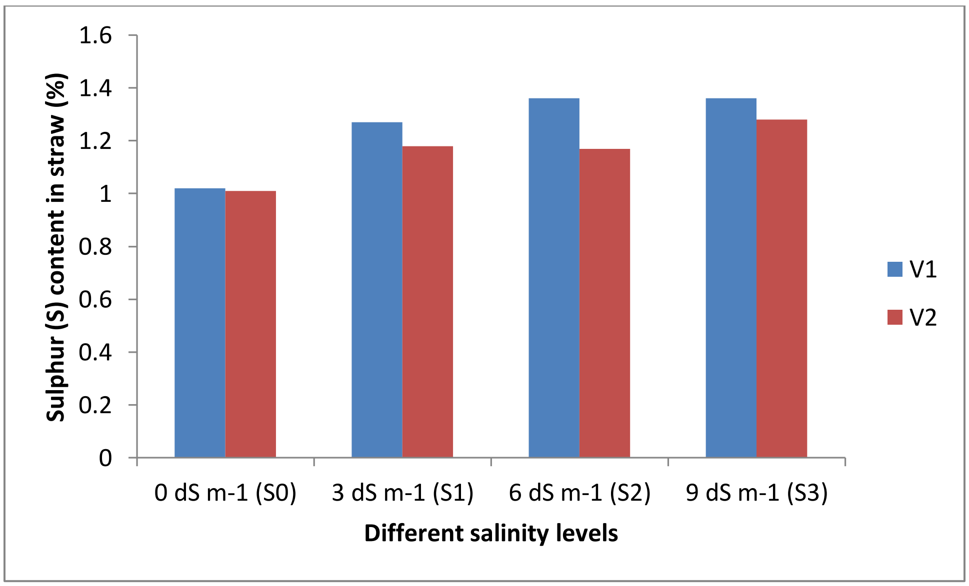

Fig.35. Sulphur (S) content in straw of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

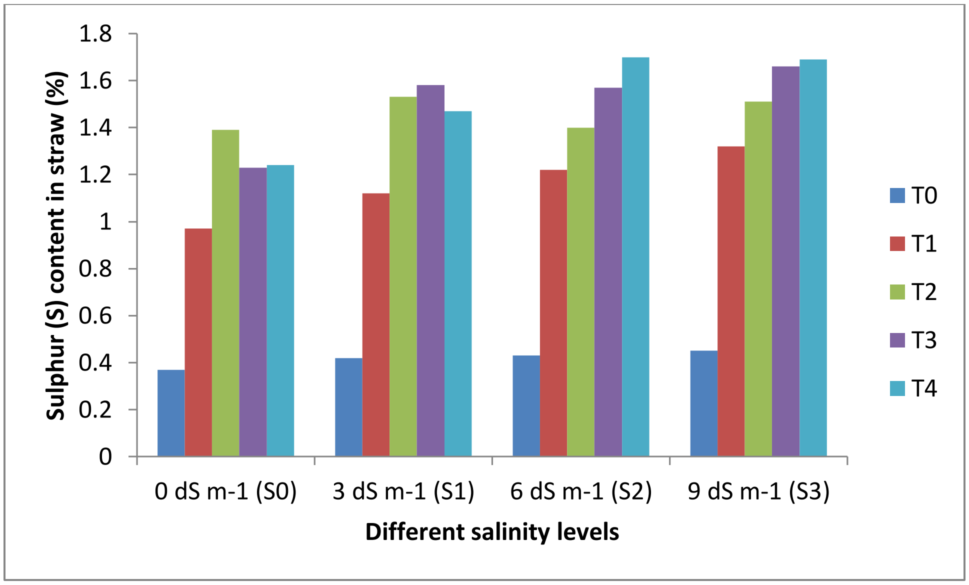

Fig.36. Sulphur (S) content in straw with different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed significant variation on sulphur (S) content in grain under different salinity levels (Table 14). Results revealed that at all salinity levels, V_2T_2 gave highest S content in straw (1.45, 1.63, 1.71 and 1.71 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) which statistically identical with V_2T_4 at S_0 (0 dS m^{-1}) salinity level and with V_1T_3, V_2T_3 and V_2T_4 at S_1 (3 dS m^{-1}) salinity level and with V_1T_2, V_1T_3 and V_1T_4 at S_2 (6 dS m^{-1}) salinity level and with V_1T_3, V_1T_4, V_2T_3 and V_2T_4 at S_3 (9 dS m^{-1}) salinity levels. At all salinity levels the lowest S content in straw (0.36, 0.41, 0.42 and 0.44 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were achieved from the treatment combination of V_2T_0 which was statistically identical with V_2T_0 at all salinity levels.

Table 14. Sulphur (S) content of BINA dhan 10 and BRRI dhan 29 after harvest with different fertilization method of TSP under different salt concentration

Treatment	Sulphur (S) content (%) at different salt concentration							
	Grain				Straw			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	0.65 e	1.20 b	1.41 a	1.58 a	0.38 e	0.42 e	0.43 e	0.45 d
V_1T_1	0.79 c	1.07 c	1.12 b	1.30 b	1.09 bc	1.23 c	1.42 b	1.55 ab
V_1T_2	0.81 c	1.09 c	1.18 b	1.34 b	1.33 ab	1.49 ab	1.62 a	1.42 b
V_1T_3	0.70 de	0.84 d	0.96 c	1.02 c	1.27 ab	1.56 a	1.63 a	1.69 a
V_1T_4	0.60 e	0.89 d	0.96 c	1.04 c	1.05 bc	1.57 a	1.68 a	1.60 a
V_2T_0	0.36 f	0.38 e	0.39 d	0.42 d	0.36 e	0.41 e	0.42 e	0.44 d
V_2T_1	0.86 c	1.40 a	1.14 b	1.66 a	0.85 d	1.01 d	1.02 d	1.08 c
V_2T_2	1.30 a	1.36 a	1.32 a	1.44 ab	1.45 a	1.63 a	1.71 a	1.71 a
V_2T_3	0.99 b	1.06 c	1.45 a	1.67 a	1.19 b	1.60 a	1.50 ab	1.62 a
V_2T_4	0.77 c	1.01 c	1.40 a	1.51 a	1.43 a	1.31 bc	1.17 c	1.66 a
$LSD_{0.05}$	0.077	0.059	0.031	0.042	0.049	0.046	0.059	0.031
CV (%)	3.74	3.88	2.96	3.11	2.89	4.26	3.42	3.30

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

4.11.9 Potassium (K) content (%) in grain

Effect of variety under different salinity levels

Considerable variation on potassium (K) content in grain was not found at different salinity levels influenced by different variety (Fig. 37). But it was observed that at all salinity levels, the highest K content in grain (0.0259, 0.0295, 0.0342 and 0.0312 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_2 (BRRI dhan 29) where the lowest K content in grain (0.0247, 0.0277, 0.0304 and 0.0305 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from the variety, V_1 (BINA dhan 10).

Effect of different fertilization method of TSP under different salinity levels

Non-significant influence was observed on potassium (K) content in grain under different salinity levels affected by different application methods of TSP (Fig. 38). Results revealed that the highest K content (0.0341, 0.0352, 0.0373 and 0.0371 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from T_2 (⅔ foliar and ⅓ soil application of TSP) where the lowest K content at all salinity levels (0.0085, 0.0185, 0.0197 and 0.0105 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from T_0 (Control; 0 TSP) treatment.

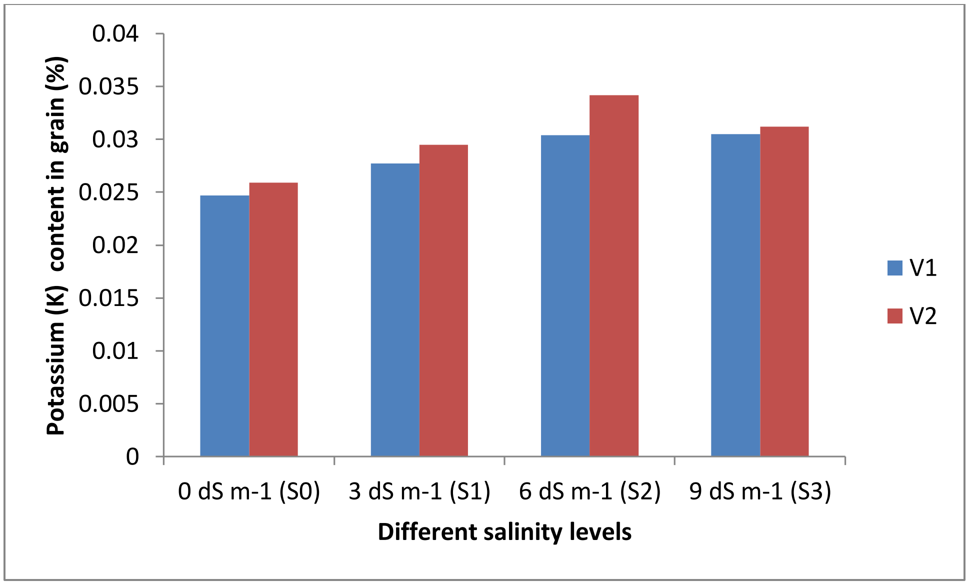

Fig.37. Potassium (K) content in grain of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

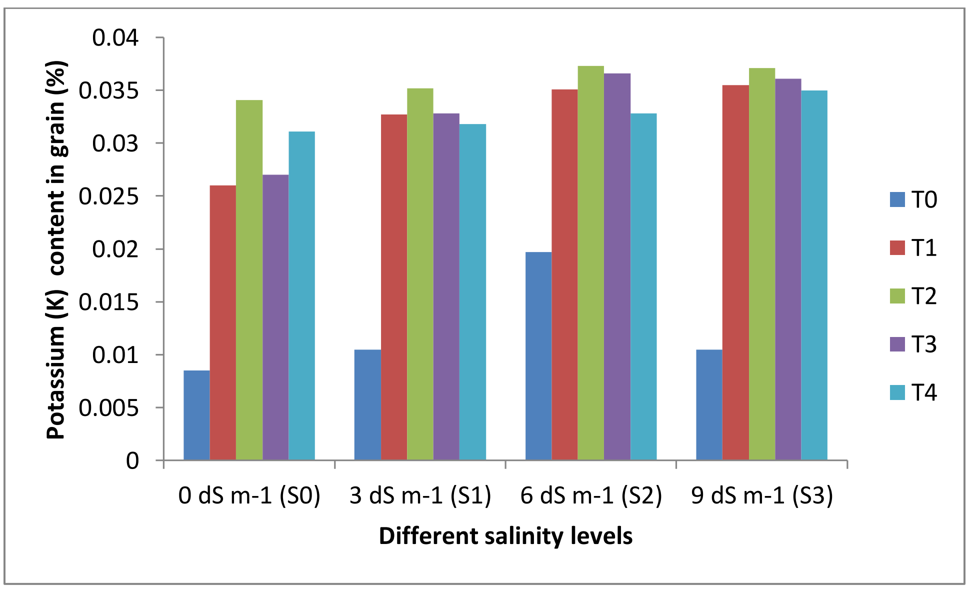

Fig.38. Potassium (K) content in grain with different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed non-significant variation on potassium (K) content in grain under different salinity levels (Table 15). But it was found that the highest K content in grain at S_0 (0 dS m^{-1}) and S_2 (6 dS m^{-1}) salinity level (0.0371 and 0.0374 % respectively) were found from V_1T_4 but at S_1 (3 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity level the highest K content in grain (0.0370 and 0.0392 % respectively) were found from V_2T_2 and V_1T_3 respectively where the lowest K content in grain (0.008, 0.01, 0.008 and 0.01 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were achieved from the treatment combination of V_2T_0.

4.11.10 Potassium (K) content (%) in straw

Effect of variety under different salinity levels

Considerable variation on potassium (K) content in straw was not found at different salinity levels influenced by different variety (Fig. 39). But it was observed that at all salinity levels, the highest K content in straw (0.0331, 0.0330, 0.0333 and 0.0337 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found in the variety, V_2 (BRRI dhan 29) where the lowest K content in straw (0.0302, 0.0319, 0.0322 and 0.0329 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from the variety, V_1 (BINA dhan 10).

Effect of different fertilization method of TSP under different salinity levels

Significant influence was observed on potassium (K) content in straw under different salinity levels affected by different application methods of TSP (Fig. 40). Results revealed that the highest K content (0.0389, 0.0383, 0.0396 and 0.0399 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from T_3 (Total foliar application of TSP) respectively where the lowest K content at all salinity levels

(0.0105, 0.0140, 0.0125 and 0.0110 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were found from T_0 (Control; 0 TSP) treatment.

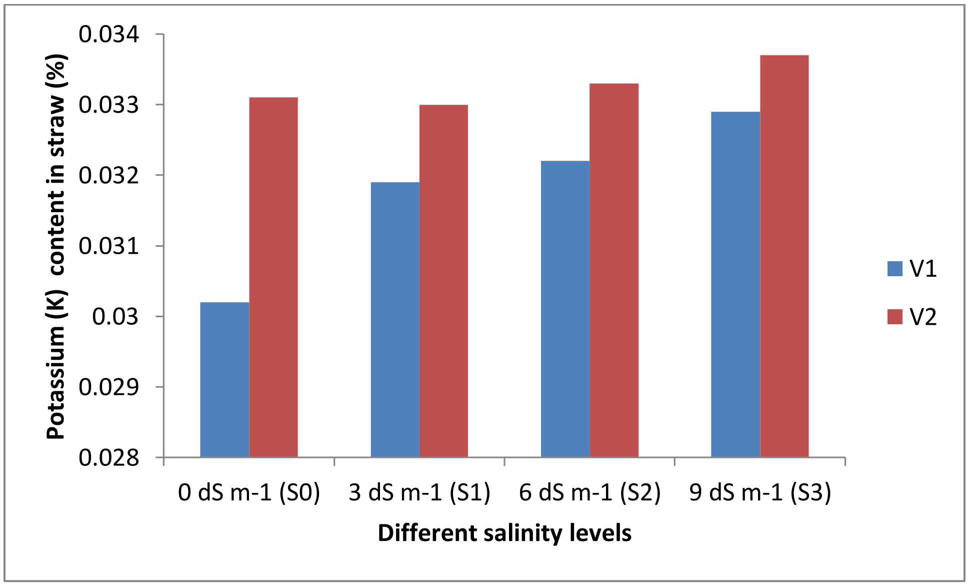

Fig.39. Potassium (K) content in straw of BINA dhan 10 and BRRI dhan 29 under different salt concentration

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

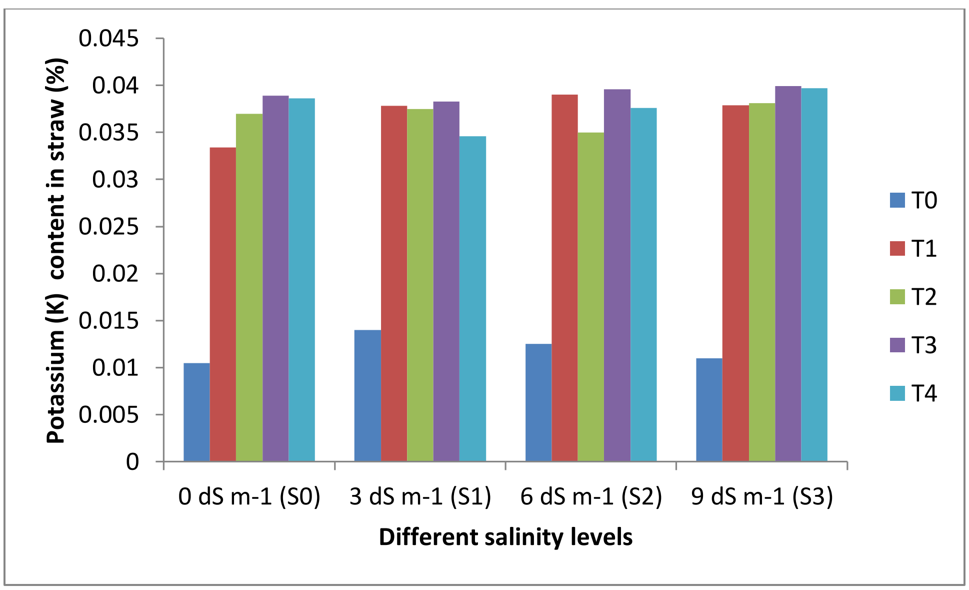

Fig.40. Potassium (K) content in straw with different fertilization method of TSP under different salt concentration

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

Combined effect of variety and TSP under different salinity levels

Combined effect of variety and TSP application methods showed non-significant variation on potassium (K) content in straw under different salinity levels (Table 15). But it was found that the highest K content in straw at S_1 (3 dS m^{-1}) and S_3 (9 dS m^{-1}) salinity level (0.0390 and 0.0410 % respectively) were found from V_1T_3 but at S_0 (0 dS m^{-1}) and S_2 (6 dS m^{-1}) salinity level the highest K content in straw (0.0402 and 0.0403 % respectively) were found from V_2T_1 and V_1T_1 respectively where the lowest K content in grain (0.01, 0.014, 0.012 and 0.011 % at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) were achieved from the treatment combination of V_2T_0.

Table 15. Potassium (K) content of BINA dhan 10 and BRRI dhan 29 after harvest with different fertilization method of TSP under different salt concentration

Treatment	Potassium (K) content (%) at different salt concentration							
	Grain				Straw			
	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0	0.0090	0.0110	0.0313	0.0110	0.0110	0.0142	0.0130	0.0120
V_1T_1	0.0250	0.0334	0.0362	0.0324	0.0370	0.0378	0.0403	0.0370
V_1T_2	0.0320	0.0334	0.0342	0.0372	0.0370	0.0370	0.0368	0.0374
V_1T_3	0.0266	0.0334	0.0362	0.0392	0.0267	0.0390	0.0398	0.0410
V_1T_4	0.0371	0.0362	0.0374	0.0338	0.0391	0.0372	0.0375	0.0390
V_2T_0	0.0080	0.0100	0.0080	0.0100	0.0100	0.0140	0.0120	0.0110
V_2T_1	0.0270	0.0320	0.0340	0.0386	0.0402	0.0378	0.0390	0.0388
V_2T_2	0.0362	0.0370	0.0314	0.0370	0.0370	0.0380	0.0332	0.0388
V_2T_3	0.0274	0.0322	0.0370	0.0330	0.0401	0.0376	0.0382	0.0387
V_2T_4	0.0250	0.0274	0.0372	0.0362	0.0381	0.0320	0.0377	0.0404
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	3.78	3.44	2.57	3.67	3.86	4.04	4.63	5.07

V_1 = BINA dhan 10, V_2 = BRRI dhan 29

T_0 = Control (0 TSP), T_1 = ⅓ foliar and ⅔ soil application of TSP, T_2 = ⅔ foliar and ⅓ soil application of TSP, T_3 = Total foliar application of TSP, T_4 = Total soil application of TSP

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted during the period from December 2016 to June 2017 to evaluate the remediation of salt stress on growth, yield and nutrient content of BINA dhan 10 and BRRI dhan 29 by different fertilization method of TSP. In this experiment, the treatments consisted of three factors; Factor A: Two variety - (i) V_1 (BINA dhan 10) and (ii) V_2 (BRRI dhan 29) and Factor B: Five levels of TSP application methods - (i) T_0 (Control; 0 TSP), (ii) T_1 (⅓ foliar and ⅔ soil application of TSP), (iii) T_2 (⅔ foliar and ⅓ soil application of TSP), (iv) T_3 (Total foliar application of TSP) and (v) T_4 (Total soil application of TSP) and Factor C: Four types of salinity application - S_0 (0 dS m^{-1}), S_1 (3 dS m^{-1}), S_2 (6 dS m^{-1}) and S_3 (9 dS m^{-1}). The experiment was laid out in three factors Randomized complete Block Design (RCBD) with three replications.

Data on different growth parameters and yield with yield contributing characters and also nutrient content in grain and straw were recorded. The collected data were statistically analyzed for evaluation of the treatment effect. Significant variation among the treatments was found while different salinity levels were applied in different treatment combinations.

Considering varietal performance in terms of growth, yield and yield contributing parameters the highest plant height (90.73, 98.46, 99.53 cm and 96.07 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) and highest number of unfilled grains $panicle^{-1}$ (4.27, 4.67, 5.00 and 5.27 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was recorded from the variety, V_2 (BRRI dhan 29). Again, at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively the highest root length (33.20, 35.00, 30.88 and 31.60 cm), shoot dry weight $plant^{-1}$ (22.36, 20.54, 15.97 and 17.19 g), root dry weight $plant^{-1}$ (8.74, 9.37, 10.16 and 8.96 g), number of effective tillers plant^{-1} (7.27, 6.87, 6.67 and 7.00), panicle length (24.40, 23.87, 24.00 and 22.93 cm), number of filled grains panicle^{-1} (94.40, 62.53, 86.00 and 79.40), grain weight plant^{-1} (12.95, 10.21, 11.37 and 10.97 g) and straw weight plant^{-1} (27.75, 25.39, 23.20 and 22.16 g) were found from the variety, V_1 (BINA dhan 10). On the other hand, the lowest plant height (77.63, 79.57, 83.67 and 80.81 cm) and lowest number of unfilled grains panicle^{-1} (4.00, 4.34, 4.87 and 5.24 a) at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively were observed from the variety, V_1 (BINA dhan 10). Similarly, at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively the lowest root length (28.05, 26.51, 24.36 and 22.65), shoot dry weight (18.75, 12.39, 18.95 and 13.17 g), root dry weight plant^{-1} (4.19, 4.18, 3.09 and 3.39 g), number of effective tillers plant^{-1} (6.20, 6.20, 6.27 and 5.80), panicle length (23.87, 23.60, 22.73 and 21.92 cm), number of filled grains panicle^{-1} (91.47, 81.27, 72.67 and 72.47), grain weight plant^{-1} (11.35, 13.03, 11.55 and 9.36 g) and straw weight plant^{-1} (26.58, 24.75, 23.36 and 22.57 g) were found from the variety, V_2 (BRRI dhan 29).

Regarding the effect of different fertilization method of TSP, the treatment T_2 (⅔ foliar and ⅓ soil application of TSP) showed the best performance for most of the parameters against all salinity levels. Results revealed that at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively the highest plant height (91.00, 92.68, 93.42 and 88.17 cm), root length (31.84, 32.70, 31.63 and 29.17 cm), shoot dry weight plant^{-1} (23.77, 20.68, 22.27 and 21.29 g), root dry weight plant^{-1} (7.79, 9.29, 8.24 and 8.26 g), number of effective tillers plant^{-1} (7.67, 7.00, 7.00, 7.00 and 7.00), panicle length (25.84, 24.67, 24.67 and 24.33 cm), number of filled grains panicle^{-1} (99.00, 96.67, 87.83 and 88.34), grain weight plant^{-1} (14.57, 14.10, 13.26 and 13.93 g) and straw weight plant^{-1} (30.24, 26.74, 24.36 and 23.76 g) were recorded from the treatment, T_2 (⅔ foliar and ⅓ soil application of TSP) where treatment T_1 (⅓ foliar and ⅔ soil application of TSP) showed highest number of unfilled grains panicle^{-1} (5.33, 5.50, 6.17 and 6.60 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) at all salinity levels. Similarly, at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively the lowest plant height (67.67, 83.00, 88.67 and 87.00 cm), root length (29.97, 29.50, 25.22 and 25.84 cm), shoot dry weight $plant^{-1}$ (16.22, 11.81, 15.22 and 8.79 g), root dry weight $plant^{-1}$ (4.71, 4.72, 4.46 and 3.96 g), number of effective tillers $plant^{-1}$ (5.67, 6.17, 5.50 and 5.50), panicle length (22.00, 22.34, 21.33 and 21.00 cm), number of filled grains $panicle^{-1}$ (82.17, 79.84, 61.84 and 54.17), grain weight $plant^{-1}$ (9.42, 7.92, 8.28 and 7.76 g) and straw weight $plant^{-1}$ (9.24.86, 23.28, 22.75 and 21.77 g) were found from the the treatment T_0 (Control; 0 TSP).

In terms of treatment combinations of variety and different TSP application method significant influence was observed among the treatment combinations regarding different parameters studied against different salinity levels. Results exposed that the highest plant height (97.33, 99.33, 102.70 and 98.33 at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was achieved from the treatment combination of V_2T_2. But at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively the highest root length (35.17, 38.50, 29.33 and 35.00 cm), shoot dry weight $plant^{-1}$ (26.76, 27.60, 22.81 and 23.81 g), root dry weight $plant^{-1}$ (10.77, 12.80, 12.70 and 11.74 g), number of effective tillers $plant^{-1}$ (8.33, 7.33, 7.33 and 7.67), panicle length (26.00, 25.00, 25.00 and 24.33 cm), number of filled grains $panicle^{-1}$ (81.00, 75.67, 61.67 and 52.67), number of unfilled grains $panicle^{-1}$ (5.67, 5.67, 6.67 and 7.33), grain weight $plant^{-1}$ (14.72, 15.77, 13.42 and 15.08 g) and straw weight $plant^{-1}$ (31.72, 27.76, 24.96 and 23.77 g) were found from the treatment combination of V_1T_2. On the contrary, the lowest plant height (67.67, 69.00, 82.33 and 79.00 cm at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively) was found from the treatment combination of V_1T_0. But at 0, 3, 6 and 9 dS m^{-1} salinity levels respectively the lowest root length (26.93, 23.33, 22.10 and 21.67 cm), shoot dry weight $plant^{-1}$ (14.72, 10.84, 12.74 and 6.80 g), root dry weight $plant^{-1}$ (3.70, 2.68, 2.10 and 2.14 g), number of effective tillers $plant^{-1}$ (5.33, 5.67, 5.33 and 5.00), panicle length (22.00, 22.00, 20.33 and 20.33 cm), number of filled grains panicle^{-1} (81.00, 75.67, 61.67 and 52.67), number of unfilled grains panicle^{-1} (2.00, 2.00, 3.67 and 4.33), grain weight plant^{-1} (6.77, 7.10, 7.78 and 7.42 g) and straw weight plant^{-1} (24.75, 22.74, 21.75 and 20.75 g) were found from the treatment combinations of V_2T_0.

In view of nutrient content in grain and straw considerable variation was not found between two varieties (BINA dhan 10 and BRRI dhan 29) regarding Phosphorus (P) content, Sodium (Na) content, Calcium (Ca) content (ppm, Sulphur (S) content and Potassium (K) content under different salinity levels under the present study. But it was found that in maximum cases the variety V_1 (BINA dhan 10) showed better performance on nutrient content against different salinity stress.

In case of nutrient content in grain and straw affected by different application methods of TSP significant variation was observed on P and S content in grain and straw but Na, Ca and K content in grain and straw was not significant. No definite pattern was observed on nutrient content in grain and straw but it was observed that P content was increased with decreased Na content.

Considering combined effect of variety and different application methods of TSP, both the variety V_1 (BINA dhan 10) and V_2 (BRRI dhan 29) with the combination of treatment T_2 (⅔ foliar and ⅓ soil application of TSP) gave better performance against different salinity levels regarding Na content in grain and straw.

From the above findings, it can be concluded that

1. The variety, V_1 (BINA dhan 10) gave better performance on yield and yield contributing parameters and the variety, V_2 (BRRI dhan 29) was sensitive to salt stress
2. Use of TSP lighten the adverse of effect of salinity on rice plant and improved yield and yield contributing characters
3. Treatment T_2 (⅔ foliar and ⅓ soil application of TSP) along with variety, V_1 (BINA dhan 10) gave better performance against different salinity stress.

The following recommendations can be made following the experimental results

1. Farmers can take on foliar application of TSP along with soil application to get better performance in boro rice cultivation
2. Similar study can be conducted in salinity affected areas for better understanding of TSP against salinity stress.

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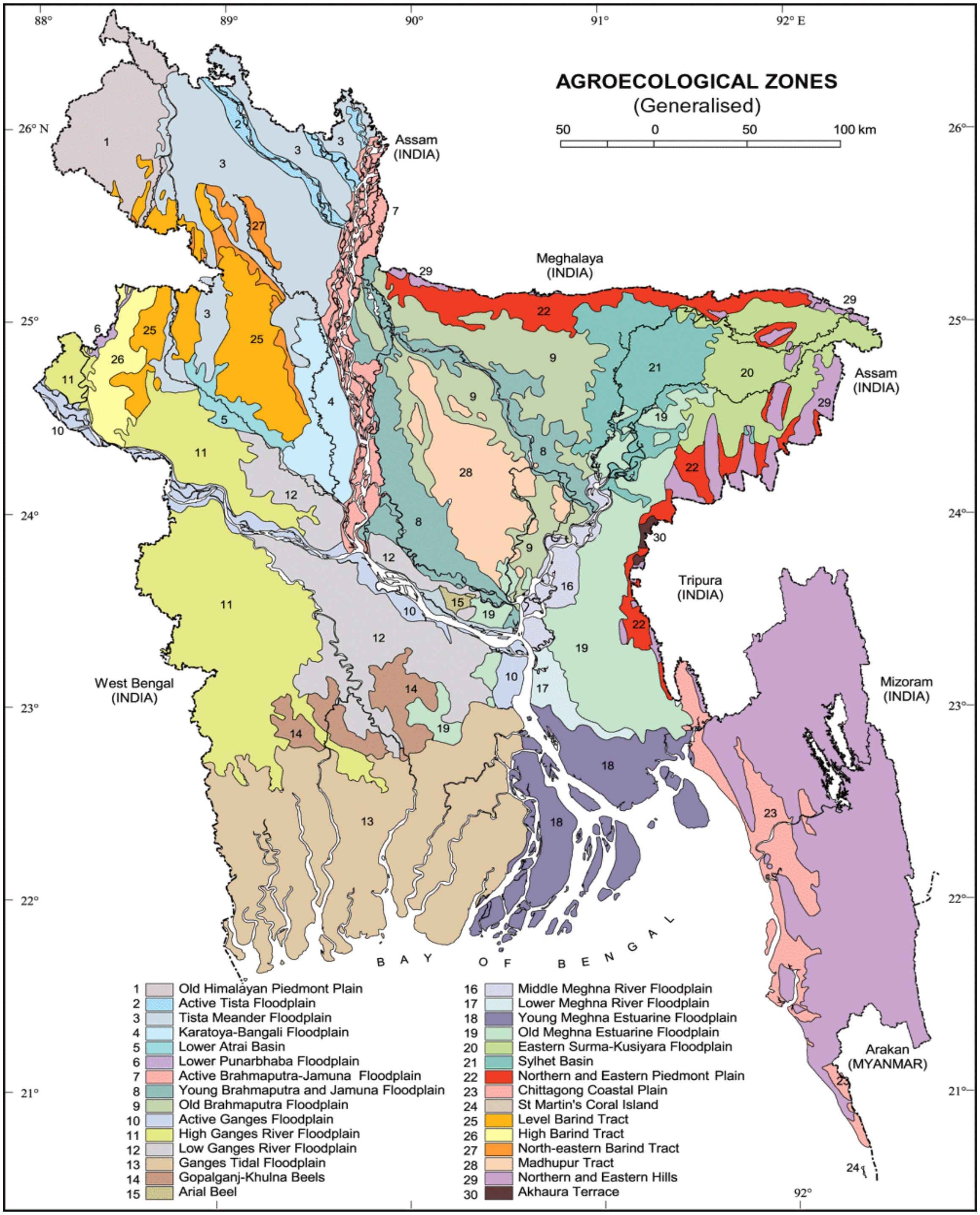
APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location



Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from December, 2016 to May, 2017

Month	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	*Min.*	*Mean*	
December, 2016	54.80	25.50	6.70	16.10	0.0
January, 2017	46.20	23.80	11.70	17.75	0.0
February, 2017	37.90	22.75	14.26	18.51	0.0
March, 2017	52.44	35.20	21.00	28.10	20.4
April, 2017	65.40	34.70	24.60	29.65	165.0
May, 2017	68.30	32.64	23.85	28.25	182.2

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Plant height of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of plant height (cm) at different salt concentration			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	1.025	1.301	2.004	0.655
Treatment	9	85.64**	74.34**	62.48**	58.88**
Error	18	2.836	2.746	1.519	1.882

Appendix V. Root length of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of root length (cm) at different salt concentration			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.362	0.527	0.286	0.384
Treatment	9	42.23**	32.16**	26.28**	22.79**
Error	18	2.446	2.442	1.411	1.714

Appendix VI. Shoot dry weight $plant^{-1}$ of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of Shoot dry weight $plant^{-1}$ at different salt concentration			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.007	0.006	0.004	0.006
Treatment	9	2.827**	2.874**	2.205**	1.676*
Error	18	0.052	0.087	0.044	0.013

Appendix VII. Root dry weight plant $plant^{-1}$ of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of Root dry weight $plantplant^{-1}$ at different salt concentration			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.02	0.004	0.005	0.002
Treatment	9	1.504**	1.092**	0.735*	0.923**
Error	18	0.006	0.011	0.005	0.004

Appendix VIII. Number of effective tillers plant^{-1} dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of Number of effective tillers plant^{-1} at different salt concentration			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.132	0.214	0.117	0.102
Treatment	9	33.633**	26.053*	18.753*	15.022*
Error	18	0.158	0.127	0.112	0.104

Appendix IX. Panicle length (cm) of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Treatment		Mean square of Panicle length (cm) plant^{-1} (g) at different salt concentration			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
V_1T_0		0.526	0.423	0.314	0.242
V_1T_1		42.867**	36.244*	21.249*	14.423**
V_1T_2		1.091	1.081	1.063	1.034

Appendix X. Number of filled grains panicle^{-1} of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of Number of filled grains panicle^{-1} at different salt concentration			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2				
Treatment	9	52.128**	61.961**	42.897**	31.958**
Error	18	2.449	2.478	1.877	1.704

Appendix XI. Number of unfilled grains panicle^{-1} dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of Number of unfilled grains panicle^{-1} at different salt concentration			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	1.046	1.004	0.529	0.416
Treatment	9	71.309**	73.014**	68.989*	49.821**
Error	18	2.229	2.058	1.726	0.703

Appendix XII. Grain weight plant^{-1} (g) of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of Grain weight plant^{-1} (g) at different salt concentration			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.523	0.414	0.316	0.217
Treatment	9	24.036**	21.795*	16.386*	12.633**
Error	18	1.402	0.316	0.182	0.145

Appendix XIII. Straw weight plant^{-1} (g) of BINA dhan 10 and BRRI dhan 29 at harvest with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of Straw weight plant^{-1} (g) at different salt concentration			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.419	0.422	0.347	0.514
Treatment	9	42.633**	26.215*	18.753*	15.022*
Error	18	0.158	0.127	0.112	0.104

Appendix XIV. Phosphorus (P) content of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of phosphorus (P) content (ppm) at different salt concentration							
		Phosphorus content in grain				Phosphorus content in straw			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.012	0.011	0.014	0.007	0.005	0.003	0.002	0.002
Treatment	9	1.14**	1.15**	1.13**	0.48**	NS	NS	NS	NS
Error	18	0.018	0.014	0.012	0.008	0.004	0.006	0.003	0.002

Appendix XV. Sodium (Na) content of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of sodium (Na) content (ppm) at different salt concentration							
		Grain				Straw			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.001	0.001	0.002	0.001	0.002	0.001	0.001	0.001
Treatment	9	NS	NS	NS	NS	NS	NS	NS	NS
Error	18	0.001	0.002	0.002	0.001	0.002	0.001	0.001	0.001

Appendix XVI. Calcium (Ca) content of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of calcium (Ca) content (ppm) at different salt concentration							
		Grain				Straw			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.001	0.00	0.001	0.00	0.001	0.001	0.00	0.00
Treatment	9	NS	NS	NS	NS	NS	NS	NS	NS
Error	18	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001

Appendix XVII. Sulphur (S) content of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of sulphur (S) content (ppm) at different salt concentration							
		Grain				Straw			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.014	0.011	0.016	0.004	0.012	0.008	0.005	0.002
Treatment	9	2.117	2.10**	1.31**	1.61**	1.48**	1.08**	0.62**	0.52**
Error	18	0.018	0.016	0.015	0.011	0.014	0.012	0.007	0.003

Appendix XVIII. Potassium (K) content of BINA dhan 10 and BRRI dhan 29 with different fertilization method of TSP under different salt concentration

Sources of variation	Degrees of freedom	Mean square of potassium (K) content (ppm) at different salt concentration							
		Grain				Straw			
		0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)	0 dS m^{-1} (S_0)	3 dS m^{-1} (S_1)	6 dS m^{-1} (S_2)	9 dS m^{-1} (S_3)
Replication	2	0.002	0.001	0.001	0.001	0.001	0.001	0.00	0.00
Treatment	9	NS	NS	NS	NS	NS	NS	NS	NS
Error	18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

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