EFFECT OF FOLIAR FERTILIZATION ON GROWTH, YIELD AND NUTRIENT CONTENTS OF BINA dhan 8 UNDER DIFFERENT SALINE CONDITIONS

By

EFFAT JAHAN
Reg. No. 08-2803

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APPROVED BY:

....	....
(Md. Azizur Rahman Mazumder)	**(Dr. Sheikh Shawkat Zamil)**
Professor	Assistant Professor
Department of Agricultural Chemistry	Department of Agricultural Chemistry
Sher-e-Bangla Agricultural University,	Sher-e-Bangla Agricultural University,
Dhaka-1207	Dhaka-1207
Supervisor	**Co-supervisor**

....
(Dr. Md. Abdur Razzaque)
Chairman
Examination committee

DEPARTMENT OF AGRICULTURAL CHEMISTRY

Sher- e –Bangla Agricultural University

Sher- e- Bangla Nagar, Dhaka-1207

Memo No: SAU/Agricultural Chemistry/ (12)/ **Date:**

CERTIFICATE

This is to certify that thesis entitled, "*EFFECT OF FOLIAR FERTILIZATION ON GROWTH, YIELD AND NUTRIENT CONTENTS OF BINA dhan 8 UNDER DIFFERENT SALINE CONDITIONS*" submitted to the *DEPARTMENT OF AGRICULTURAL CHEMISTRY*, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE (M.S.)* in *AGRICULTURAL CHEMISTRY* embodies the result of a piece of *bona fide* research work carried out by *EFFAT JAHAN, Registration No. 08-2803* under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged by him.

Date:

Place: **Dhaka, Bangladesh**

……………………………

Supervisor

Md. Azizur Rahman Mazumder
Professor
Department of Agricultural Chemistry
Sher-e-Bangla Agricultural University,
Dhaka-1207

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The Author

ABSTRACT

An experiment was conducted at the net house of the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka-1207 under pot-culture during the Boro season (December-June) of the year 2013-14 to study the reclamation of salinity by potassium fertilization methods. The experiment was completed using 4 salinity levels (0, 4, 8 and 12 dS m^{-1}) and 4 potassium fertilization processes (K_1 = Total soil application of MoP fertilizer, K_2 = 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4 =Total foliar spray of MoP fertilizer). BINA dhan 8 was used as variety. Data were taken on plant height, number of leaves $hill^{-1}$, root length, dry weight of stem and root, number of effective tiller $hill^{-1}$, number of panicle $hill^{-1}$, number of filled and unfilled grain $hill^{-1}$, weight of filled grain $hill^{-1}$, 1000-grain weight, grain yield $hill^{-1}$ and P, K, S, Na content in straw, root and grain of the selected rice cultivar. Salinity adversely affected all the growth and yield parameters of BINA dhan 8. Like most of the other parameters, highest 1000-grain weight, grain yield $hill^{-1}$ were recorded in "0" salinity (control) treatment. Use of potassium alleviated the adverse effects of high salinity on rice plant. Most of the growth and yield attributes varied significantly due to the different fertilization processes of potassium. Among them 2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer gave better performances. Even while combined with various salinity levels and 2/3 rd foliar spray & 1/3 rd soil application of total MoP fertilizer gave better results compared to others. Na content in straw, root and grain increased with the increase in the salinity level while K content decreased. In this case of foliar spray along with soil application of MoP fertilizer performed better while treated with salinity compared to sole foliar spray or soil applications.

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LIST OF ABBREVIATIONS

ABBREVIATION	FULL WORD
%	Percent
@	At the rate of
^0C	Degree Celsius
AEZ	Agro-Ecological Zone
BINA	Bangladesh Institute of Nuclear Agriculture
cm	Centimeter
CRD	Completely Randomized Design
$CuSO_4.5H_2O$	Green vitriol
CV%	Percentage of Coefficient of Variance
cv.	Cultivar (s)
DAS	Days After Sowing
DMRT	Duncan's Multiple Range Test
dS/m	Deci Semens per meter
EC	Electrical Conductivity
e.g.	As for example
et al.	and others
g	Gram
i.e.	that is
K	Potassium
kg	Kilogram
kg ha^{-1}	kg per hectare
KCl	Potassium Chloride
LSD	Least Significant Difference
m	Meter
MP	Muriate of Potash
N	Nitrogen
NaOH	Sodium Hydroxide
NS	Not Significant
OM	Organic matter
P	Phosphorus
pH	Hydrogen ion concentration
S	Sulphur
SAU	Sher-e-Bangla Agricultural University
t ha^{-1}	Ton per hectare
TSP	Triple Super Phosphate
Zn	Zinc

Chapter 1
Introduction

Chapter 1
INTRODUCTION

Rice is the most important crop at the global level, as it is used as a staple food in the most countries of the world. The present yield of rice is not sufficient to ensure the food security for the increasing population. Moreover there is no scope for horizontal expansion of land area; rather it will be decreased due to use of arable land for infrastructural development of increased population. Due to the high population, a remarkable quantity of food grains is imported from abroad. The possibility of increasing food production by increasing land area is quite out of question in Bangladesh. In Bangladesh more than 30% of the net cultivable lands lie in coastal area. Salinity is a major threat to crop productivity in the southern and south-western part of Bangladesh, where salinity is developed due to frequent flooding by sea water of the Bay of Bangla and on the other introduction of irrigation with saline waters. In Bangladesh there are approximately 2.85 million ha of coastal soils (Ponnamperuma, 1977). These soils occur in the southern parts of the Ganges Tidal Floodplain, in the Young Meghna Estuarine Floodplain and in tidal areas of the Chittagong coastal plain and offshore islands (Brammer, 1978). Out of 2.85 m ha of the coastal and off-shore areas, about 1.0 m ha of which are affected by different degrees of soil salinity (SRDI, 2010). Every year about 35,440 hectares of new land (3.5%) in the southern and southwestern part of the coastal areas is affected by very slight to slight salinity at the rate of 0.74% (SRDI, 2010). According to the report of Soil Resource Development Institute (SRDI) of Bangladesh, there are about 0.203 million ha of land is very slightly (2-4 dSm^{-1}) saline, 0.492 million ha is slightly (4-8 dSm^{-1}) saline, 0.461 million ha is moderately (8-12 dSm^{-1}) saline and 0.490 million ha is strongly (>12

dSm^{-1}) saline in the coastal area of Bangladesh. These coastal saline soils are distributed unevenly in 64 thanas of 13 coastal districts covering the parts of 8 agroecological zones (AEZ) of the country. The majority of the saline land (0.65 million ha) exists in the districts of Satkhira, Khulna, Bagerhat, Barguna, Patuakhali, Pirojpur and Bhola on the western coast and a smaller portion (0.18 million ha) in the district of Chittagong, Cox's Bazar, Noakhali, Lakshmipur, Feni and Chandpur. The scarcity of good quality irrigation water is a major problem in these areas. The surface water resources are insufficient and irrigation agriculture is largely dependent on ground water resource. The ground waters of these areas are generally saline and \or sodic. The use of these waters for irrigation without proper management may reduce the irrigated soils as salt affected and consequently crop production may be reduced.

Salinity in soil or water is one of the major stresses, can severely limit crop production (Shannon, 1998). The deleterious effects of salinity on plant growth are associated with 1.low osmotic potential of soil solution (water stress), 2.nutritional imbalance, 3.specific ion effect, or 4.a combination of these factors (Marschner, 1971). All of these causes adverse pleiotropic effects on plant growth and development at physiological and biochemical levels (Munns, 2002).

Salt seems to affect rice during pollination, decrease seed setting and grain yield (Maloo, 1993). Finck (1977) suggested that deficiency both K and Ca elements might play a significant role in plant growth depression in many saline soils. Reducing sodium and chlorine uptake into rice while maintaining potassium uptake would aid growth under saline condition (Koyama *et al.*, 2001). As saline soil generally has higher concentration of Na than K and Ca high ionic imbalance may impair the selectivity of root membranes. This may result in passive accumulation of Na in root and shoot. Addition of k to a saline culture solution and foliar fertilization have been found to increase the dry weight and K content of shoots with a corresponding decrease in Na content in rice. According to Yoshida (1981) rice is sensitive to salinity especially during early seedling growth and flowering. Therefore, maintain a low Na/k ratio on the soil during these two critical stages may benefit the rice plants. The yield parameters, tiller number per plant and spikelet number per panicle, have proved most sensitive to salinity and are highly significantly correlated to final seed yield in rice cultivar under salt stress (Zeng and Shannon, 2000).

Under saline condition the foliar fertilization is an effective method of providing a steady flow of nutrients, in combination with some traditional types of root-uptake from fertilizers, to achieve better control of nutrients. Foliar spray is widely used to supply specific nutrients to many crops growing under saline environment. Foliar application of nutrients is partially overcoming the negative effect of stress condition influencing root growth and absorption capacity (Salama *et al.*, 1996; El-Flouly & Abou El- Nour, 1998). In this respect, (El-Flouly & El-Sayad, 1997) stated that foliar fertilization of both macro and micronutrient is practiced whenever, nutrients uptake through the root system is restricted due to salt stress. The advantages of foliar spray compared to soil fertilization include: immediate response, convenience of combination spray and comparatively low cost. Potassium is essential to all plants and in most terrestrial plants K^+ is the major cationic inorganic nutrient and is also enhance several enzymes functions. Potassium acts to balance the change in the cytoplasm of the cell, where K^+ is the dominant counter ion for the large excess of negative charge on proteins and nucleic acids (Yang *et al.*, 2004). Potassium contributes more than Na^+, Cl^- and glycinebetaine in osmotic adjustment under saline conditions and activates the crucial enzymatic reactions such as formation of pyruvate. It is also a substantial contribution to osmotic pressure of the vacuole and thereby maintains cell turgor (Ashraf and Sarwar, 2002). Many factors determine the fertilizer efficiency for rice crop during cultivation such as soil, cultivar, season, environment, planting time, water management, weed control, cropping pattern, source, form, rate, time of application and method of application (De Datta, 1978). The feasible alternative is to increase the cultivated areas by bringing salt affected soils under cultivation with high yielding salt tolerant rice by foliar fertilization. Recently foliar application of nutrients has become an important practice in the production of crops while application of fertilizers to the soil remains the basic method of feeding the majority of the crop plants. But as far as the literature reviewed there are very few research works done on the effect of foliar fertilizer application on the production of rice in salinity affected areas of Bangladesh. In this aspect, the present study therefore was undertaken to see the effect of foliar spray on BINA dhan 8 under saline condition.

Objectives:

With a view to generate information a field experiment containing the treatments of each of potassium and sulphur was conducted with the following objectives:

1. To study the effect of different levels of salinity on growth, yield and nutrient content of BINA dhan 8
2. To observe the effect of different doses of foliar fertilizer application in order to mitigate the salinity stress, and
3. To find out the optimum dose of foliar fertilizer for maximum growth, yield and nutrient content of BINA dhan 8 under different levels of salinity stressed condition.

Chapter 2
Review of Literature

Chapter 2

REVIEW OF LITERATURE

Rice is the staple food in many parts of the world. It is sensitive to various environmental factors *viz.* variety, soil, nutrient availability, temperature, humidity, light intensity and moisture for proper growth and yield. Many researchers have been conducted on various aspects of rice in different countries. It is now realized that agriculture does not only refer to crop production but also to various other factors that are responsible for crop production. The available literatures related to the present study are reviewed here.

Ashraf *et al.* (2010) conducted a hydroponics experiment to evaluate the role of potassium (K) and silicon (Si) in mitigating the deleterious effects of NaCl on rice cultivars differing in salt tolerance. Two salt –sensitive (CPE243 and SPE 213) and two salt-tolerant (HSF 240 and CP 77-400) rice cultivars were grown for six weeks in ½ strength Johson nutrient solution. The nutrient solution was salinized by two NaCl levels: 0 and 100 mmoL NaCl) and supplied with two levels of K (0 and 3 $mmoL^{-1}$) and Si (0 and 2 $mmoL^{-1}$). Applied NaCl enhanced Na^+ concentration in plant tissues and significantly ($P < 0.05$) reduced shoot and root dry matter in four rice cultivars. However magnitude of reduction was much greater in salt-sensitive cultivars than salt-tolerant cultivars. The salts interfered with the absorption of K^+ and Ca^{2+} and significantly ($P< 0.05$) decreased their uptake in rice cultivars. Additional of K and Si either alone or in combination significantly ($P<0.05$) inhibited the uptake and transport of Na^+ form roots to shoots and improved dry matter yields under NaCl conditions. Potassium uptake, K^+/Na^+ ratios, and Ca^{2+} and Si uptake were also significantly ($p<0.05$) increased by the additional of K and or / Si to the root medium.

In this study, K and Si enhanced salt tolerance in rice cultivars was ascribed to decreased Na^+ connection and increased K^+ with a resultant in $K^{+/}$/Na+ ratio, which is a good indicator to assess plant tolerance to salt stress.

Baba and Fujiyama (2003) investigated short-term (72 h) responses of the water and nutritional status to Na-salinization in rice (*Oryza sativa* L. cv. *Koshihikair*) and tomato (*Lycopersicon esculentum* Mill cv. *Satun*) under pot experiments. The short-term effect of supplemental K and Ca to the nutrient solution on the water status and absorption and transport of ions in the plants was also investigated. In both species, Na salinity resulted in the deterioration of the water status of tops and in nutritional imbalance. However, in rice, it was possible to prevent the deterioration of the nutrient status by enhancing the transport of cations, especially K, while tomato could maintain an adequate water status by inhibiting the water loss associated with transpiration. On the other hand, the water status in rice and the nutritional status in tomato markedly deteriorated by high Na level in the solution. Supplement K and Ca could not ameliorate the water status in both species, and even worsened the status in rice. In rice, a close relationship was observed between the osmotic potential (OP) of the solution, water uptake and water content. The water status of rice, therefore, seemed to depend on OP of the solution. Supplemental K and Ca, on the other hand, were effective in the amelioration of the nutritional status. In tomato, supplemental Ca could improve the nutritional balance by suppressing the transport of Na and enhancing that of the other cations in avoidably the deterioration of the water status. Thus, the differences in the responses of the water and nutritional status of rice and tomato to high Na salinization and to supplemental K and Ca were evident in a short-term study and supported a similar tendency observed in a long-term study.

Foliar application is one of the methods of fertilizer application. Foliar application refers to the spraying on leaves of growing plants with suitable solutions. It is effective to the crops which are growing on water-logged condition. Plant may absorb fertilizers e.g. urea directly when applied to their foliage as aqueous solution. This method can be used for any plant nutrient, but commonly employed in case of micronutrients which are in relatively smaller amount.

In many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application (Jamal *et al.* 2006). Recently foliar of nutrients has become an important practice in the production of crops while application of fertilizers to the soil remains the basic method of feeding the majority of the crop plants.

Moeini *et al.* (2006) conducted a 3-year trial from 1999 to 2001 in Karaj, Iran. Treatments included urea application in two methods (foliar application and top dressing). The results indicated that foliar application of urea had a significant effect on yield.

Pot experiments were conducted by Andreevska *et al.* (2003) to determine the effect of nitrogen fertilizers on the dry matter yield and the total nitrogen content in the roots, stems, leaves and panicles of rice. The complex fertilizer was applied as a basic treatment, while the nitrogen fertilizer was applied as a double foliar split application at the start of the heading stage. The result reported that the method and the time of nitrogen application showed a significant positive effect on the yield increase of row and dry matter of roots and aboveground parts and on their total nitrogen content.

Borjin and Emam (2001) conducted a field experiment in Shiraz, Iran during 1998-99 to study the effect of rate and time of foliar urea application on protein content and quality in two cultivars of winter wheat, 'Falat' and 'Marvdasht'. Five urea foliar application rates (0, 8, 16, 24 and 32 kg N per ha) and three stages of application (booting, anthesis and milk stage) were evaluated. The results showed that each 8 kg per ha increment in N applied urea was associated with a 0.6% increase in grain protein in both cultivars. Both grain yield and protein percentage increased, resulting in higher protein yield.

Duraisami *et al.* (2002) had conducted field experiments during the winter of 1991-95 and 1996-97 to determine the suitable nutrient management for rice. The treatments comprised soil application of 100% recommended NPK rate (T_1), T_1+ 20% additional N(T_2), 50% recommended N + 100% recommended P and K rates + 2.5% urea foliar spray at the active tillering and panicle initiation stages (T_3), 100% P and K rates +2.5% urea foliar spray at active tillering, panicle initiation, mid-heading, first flowering and 50% flowering stages (T_4), T_1 + 2 kg phmphor bacterium per ha (T_5), kg $ZnS0_4$ (T_6), T_1 + 2% urea foliar spray at active tillering and panicle initiation stages (T_7 and T_1 + 1% o $ZnSO_4$ spraying at active tillering and panicle initiation stages (T8). T_2 resulted in the tallest plant (101.9 cm) and highest number of productive tillers (10), grain yield (6713 kg ha^{-1}) and straw yield (918 kg ha^{-1}), whereas T_3, T_4 and T_7 gave the highest chaff per panicle (12.4) harvest index (43.64%) and number of grains per panicle, respectively.

Badole and Narkhede (2000) conducted a field experiment in Maharashtra, India during 1995-98 to study the effect of foliar spray of 2% urea for 6 times at l0 days intervals (27.5 kg N ha^{-1}) and 3 times at the tillering, panicle initiation and grain-filling stages, with and without basal application of NPK of transplanted rice (*Oryza sativa* cv. Sye-75). The growth and yield of rice increased significantly with the application of 50, 50 and 50 kg ha^{-1} (N: P: K) as a basal rate and foliar spray of urea at the 3 growth stages. This same treatment recorded the highest values for the yield attributing characters, nitrogen uptake, grain and straw yields (mean of 35.15 and 38.45 q ha^{-1} respectively) and the highest net profit of Rs 3546. It also saved up to 50 kg ha-1, and showed the best utilization of applied N. In contrast, treatment with the recommended fertilizer rate (100, 50 and 50 kg ha-1 (N:P:K) resulted a net profit of only Rs 1566.

Bohra and Doerffling (1993) grew a salt-tolerant (Pokkali) and a salt-sensitive (IR28) Variety of rice (*Oryza sativa*) in a phytotron to investigate the effect of K (0,25,50 and 75 mg K kg^{-1}= soil) application on their salt tolerance. Potassium application significantly increased potential photosynthetic activity (Rfd value), percentage of filled spikelets, yield and K concentration in straw. At the same time, it also significantly reduced Na and Mg concentrations and consequently improved the K/Na, K/Mg and K/Ca ratios. IR28 responded better to K application than Pokkali. Split application of K failed to exert any beneficial effect over basal application.

Cha-um *et al.* (2005) conducted an investigation with an objective to evaluate the effective salt-tolerance defense mechanisms in aromatic rice varieties. Pathumthani 1 (PT1), jasmine (KDML105), and Homjan (HJ) aromatic rice varieties were chosen as plant materials. Rice seedlings photoautotrophically grown in-vitro were treated with 0, 85, 171, 256, 342, and 427 mM NaCl in the media. Data including sodium ion (Na^+) and potassium ion (K^+) accumulation, osmolarity, chlorophyll pigment concentration, and the fresh and dry weights of seedlings were collected after salt treatment for 5 days. Na^+ in salt stressed seedlings gradually accumulated, while K^+ decreased, especially in the 342427 Mm NaCl salt treatments. The Na^+ accumulation in both salt stressed root and leaf tissues was positively related to osmolarity, leading to chlorophyll degradation. In the case of the different rice varieties, the results showed that the HJ variety was identified as being salt-tolerant, maintaining root and shoot osmolarities as well as pigment stabilization when exposed to salt stress or Na^+ enrichment in the cells. On the other hand, PT1 and KDML105 varieties were classified as salt-sensitive, determined by chlorophyll degradation using Hierarchical cluster analysis. In conclusion, the HJ-salt tolerant variety should be further utilized as a parental lion or genetic resource in breeding programs because of the osmoregulation defensive response to salt-salt-stress.

Din *et al.* (2001) used artificially salinized soils to see the effect of foliar and soil application of K on rice. Results indicated that the number of tillers plant^{-1}and paddy and straw yield and grains to straw ratio significantly decreased with the increase in salinity. All K application methods increased the above parameters significantly at all salinity levels over distilled water spray. Increasing levels of salinity decreased K concentration in shoots and straw, which was increased significantly by foliar and soil application. The K/Na ratio decreased significantly by the increase of salinity, while this ratio increased significantly by the foliar and soil application of K.

Din *et al.* (2001) conducted a pot experiment at salinity levels of 1.6, 6.0 and 12 dS m^{-1} with 50 mg kg^{-1} K_2SO_4 as soil application and 0.5% K_2SO_4 solution as foliar spray on rice. He concluded that foliar and soil application of K increased significantly the number of tillers plant^{-1}, plant height, number of grains plant^{-1}, paddy and straw yield and grain to straw ratio in saline conditions. He also found that with foliar and soil application of K increased significantly the number of tillers plant^{-1}, plant height, number of grains plant^{-1}, paddy and straw yield and grain to straw ratio in saline conditions. He also found that with foliar and soil application of potassium, the concentration of N and P increased in rice shoot and straw in saline conditions. He also found that foliar application of K increased the K^+ concentration in rice shoot and straw compared to soil application.

Fageria (2003) evaluated the dry matter production and the concentration of nutrients in rice (*Oryza sativa* L.) cultivars from soil adjusted to different levels of salinity under a greenhouse conditions. Soil salinity levels were produced by applying 0.34 mol L^{-1} solution of NaCl which resulted in the following levels, control (0.29), 5, 10 and 15 dS m^{-1} conductivity of saturation extract. The effect of salinity on dry matter production varied from cultivar to cultivar. The concentration of P and K in the tops of rice cultivars decreased with increasing soil salinity. But the concentrations of Na, Zn, Cu and Mn increased.

Mehdi *et al.* (2007) conducted a field experiment to evaluate the response of rice crop to potassium fertilization in saline-sodic soil during 2005. In this experiment five rates of K_2O (0, 25, 50, 75 and 100 kg ha^{-1}) were applied in the presence of basal doses of N and P_2O_5 i.e.,110 and 90 kg ha^{-1} respectively. The results showed that increasing rates of potassium fertilizer increased the number of tillers m^{-2}, plant height (cm), 1000-paddy weight and paddy as well as straw yield significantly. With increasing rates of potassium fertilizer, concentration of potassium in paddy and straw increased significantly. It was concluded from the results that there was an increase of 30.65% in paddy over control by applying potassium (100 kg K_2O ha^{-1}) in saline-sodic soil.

Alam *et al.* (2001) at the reproductive stage , salinity depressed grain yield much more than at the vegetative growth stage. These authors maintained that at critical salinity leveis straw yield was normal but produced little or no grain. The decrease in grain yield was found proportional to the salt covcentration and the duration of the saline treatment.

Girdhar (1988) observed that salinity delayed germination, but did not affect the final germination up to the EC of dSm^{-1} by evaluating the performance of under saline irrigation. In normal condition, the Na^+ concentration in the cytoplasm of plant cells is low in comparitipn to the K^+ content, frequently 10^{-2} versus 10^{-1} and even in conditions of toxicity, most of the cellular Na+ content is confined into the vacuoles (Apse *et al*., 1999).

Zayed *et al*. (2007) conducted two field experiments at the experimental farm of El Sirw Agriculture Research Dammiatta prefecture, Egypt during 2005 and 2006 seasons. The study aimed to investigate the effect of various potassium rates; Zero, 24, 48 and 72 Kg K_2O ha^{-1}, on growth, sodium, potassium leaf content and their ratio at heading, grain yield and yield components of three hybrids: SK2034H, SK2046H and SK2058H and three varieties; Giza 177, Giza 178 and Sakha 104. The economic values were also estimated. The experimental soil was clayey with salinity levels of 8.5 and 8.7 dS/m in the first and second seasons, respectively. The experiments were performed in a split plot design with four replications. The main plots were devoted to the tested rice varieties, while potassium rates were distributed in the sub plots. The studied varieties varied significantly in their growth parameters, Na^+ and K^+ leaf content at heading as well as ratio, yield components and their economic values. SK2034H surpassed the rest varieties without any significant differences with SK2046H. SK2058H didn't show advantage over Giza 178 or Sakha 104. Giza 177 was the worst under such conditions. Increasing potassium rate significantly improved all studied traits leading to high grain yield. Furthermore, potassium succeeded to reduce Na^+, lower Na^+/K^+ ratio and raised K^+ resulted in considerable salinity withstanding. The hybrids of SK2034H and SK2046H as well as the salt sensitive rice variety Giza 177 were the most responsive cultivars for potassium fertilizer up to 72 kg K_2O /ha. Consequently, the economic estimates SK2034H had the higher net return and the high potassium level of 72 kg K_2O ha^{-1} gave the highest values of economic parameters under the tested saline soil conditions.

Ebrahimi *et al.* (2012) conducted a pot experiment to examine the effects of potassium application methods on the response of rice (*Oryza sativa* L.) under different soil salinity levels. Four methods of potassium application: K_0: spraying with distilled water every 10 days interval (control); K_1: the use of 65mg K Kg^{-1} soil; K_2: spraying 5% K_2SO_4 solution in every 10 days interval; K_3: the use of 65mg K Kg^{-1} soil plus spraying with 5% K_2SO_4 solution every 10 days interval and four levels of irrigation water salinity (tap water and salinities 2, 4 and 6 dSm^{-1}) were investigated. Results showed that soil salinity affected growth and yield component parameters in most of the cases. Potassium application alleviated the stress condition and significantly improved dry matter yield and yield components in rice. Grain, straw, total biological yield, harvest index, 100 grains weigh, root dry weigh and total tillers significantly were decreased with increasing salinity while grain protein was increased with increasing salinity. The interaction between salinity levels and methods of potassium application was significant only for root dry weight.

Nelson (1978) believed that potassium has a positive role in plant growth under saline conditions, because this element plays an essential role in photosynthesis and osmoregulatory adaptations of plant to water stress. Adequate potassium supply is also desirable for the efficient use of Fe while higher potassium application results to competition with Fe.

Saqib *et al.* (2000) reported a significant reduction in all growth parameters considered and an increased concentration of Na^+ and Cl^-, decreased concentration K and decreased K^+:Na^+ ratio. Most of yield decreases caused by abiotic stresses result from salinity, drought, high or low temperature, inadequate mineral nutrient supply and soil acidity.

The application of K_2S0_4 produced highest tillers, straw and paddy yield. The maximum concentration of K and K uptake in straw and paddy was recorded with K_2S0_4 (Rhoades, 1982). Similarly the highest values for K recovery and agronomic efficiencies were calculated with K_2S0_4.Therefore it can be concluded that the K_2S0_4 is the best source of K for foliar spray to increase paddy yields (Ali et al. 2005) . Foliar spray of KNO_3 at 0.50% increased the seed yield by 85.7% over the unsprayed control in pooled data owing to the favorable effect on yield attributes. Spray of KNO_3 at 0.50% during flowering supplied N and K which are effectively absorbed as anion and cation by plants, and might have delayed the synthesis of abscisic acid and promoted cytokinin activity, causing higher chlorophyll retention (Mengal, 1976).

Gately *et al.* (1988) reported that calcium ammonium nitrate gave a greater yield and was a more efficient nitrogen source than urea and the grain N content was higher. Fageria *et al.* (2002) reported that the essential micronutrients for field crops are B Cu, Fe, Mn, Mo, and Zn. Other mineral nutrients at low concentrations considered essential to growth of some plants are Ni and Co. Increases in crop yields from application of micronutrients have been reported in many parts of the world.

Marchezan *et al.* (2001) carried out 3 years experiment on an Albagualt soil to study the effect of micro-nutrient (trace element) application on irrigated rice. The "complete" treatment had the micronutrients boron $(H_3BO_3)_2$ copper $(CuSO_4)_2$ iron

$(FeSO_4)_2$ manganese $(MnCl_2)_2$ molybdenum (Na_2MoO_4) and zinc $(ZnSO_4)$ and treatments in which each one of the micronutrients was omitted including a control without micronutrients and observed that leaf spraying application of micronutrients on leaves did not affect seed yield.

Patra and Poi (1998) applied different forms of trace elements to rice cv. IET-5665 and IET-6141 in trace elements deficient soil at North Bengal (India). The maximum grain yield (2.39 t ha-1) was obtained with foliar application of 500g chelated Zn ha^{-1}, followed by foliar application of Zn + B + Mo mixture + organic manure (grain yield 2.36 t ha^{-1}) as basal dose showed as good as chelated zinc.

Molina and Cabalceta (1992) conducted a field trial in Ciuanacaste, Costa Rica in 1988, rice cv. CR-1113 sown in early August. Fetrilon combi (Containing Fe, Cu, Zn, Mn, Mg, S, B and Mo)-also increased grain yield by 7%. It was concluded that supplementary foliar fertilizers could give economic returns by increasing grain yields of rice on Costa Rican soils at little extra cost.

The comparatively higher paddy yield (about 20% over control) registered by K_2SO_4 application might be due to perfect nutrition with adequate source of K application (K_2SO_4) that have resulted in vigor growth of crop and ultimately higher yield (Sarkar and Malik , 2001).

The highest values for K recovery (72.87%) and agronomic efficiency (13.12) were observed when K was applied as K_2SO_4 followed by KNO_3 and KCI. Potassium recovery as well as agronomic efficiency followed the same order as that of K uptake, i.e., $K_2SO_4 > KNO_3 >$ KCI (Uexkull von, 1978).

Approximately 7 and 11% lower paddy yield (as compared to obtained with K_2SO_4) produced with KNO_3 and KCl application respectively might be due to the reason that generally high concentration of NO_3 ions absorption by leaves directly increases acidity which could cause stomatal disturbance as well as firing of leaves and as excessive Cl ions are related to toxicity in growing plants through active absorption across the cytoplasm membrane. Hence, it is quite possible that K sources containing NO_3 and Cl resulted comparatively less growth and yield (Matsuda and Riaz,1981; Glass and Siddiqui ,1984 and Ramos *et al.* 1999).

Mohiti *et al.* (2011) conducted an experiment with the aim of comparing the efficiency of potassium spraying and application in soil; and its effect on yield and yield components of rice under salinity stress in a greenhouse experiment. Treatments included four levels of irrigation water salinity (tap water and salinities 2, 4 and 6 dS/m) and four methods of K application: a) spraying with distilled water as control; b) application of potassium on soil; c) potassium spraying and d) application of potassium on soil plus spraying. Every treatment was replicated three times and study was conducted as a complete randomized block design. The results show that grain yield and shoots, 100 seeds weight, tiller number, root dry weight and potassium uptake in seeds and shoot significantly decreased with increasing salinity. The best method of K application was soil intake plus spraying method.

Chapter 3
Materials and Methods

Chapter 3

MATERIALS AND METHODS

This chapter of dissertation is an important component that essentially maps out the methods those were utilized when researching and writing this work. It describes the key methods, use of different parameters to correlate with establishing rice plant. It further covers the data collection procedure, source of data and ways of data were analyzed.

3.1 Experimental site

The experiment was conducted under pot-culture at the net house of the Department of Soil science and Laboratory of Department of Agricultural Chemistry Sher-e-Bangla Agricultural University, Dhaka-1207 during Boro rice cropping 2013-14, to study the effect of foliar fertilization on growth yield and nutrient contents of BINA dhan 8 under different saline condition.

3.2 Description of soil

The soil of the experiment was collected from the field of Sher-e-Bangla Agricultural University (SAU) Farm. The soil was Shallow Red Brown Terrace soil under Tejgaon series belonging to the Agro-Ecological Zone 28 (Modhupur Tract). The soils were clay loam in texture with common fine medium distinct dark yellowish brown mottles. The collected soil was pulverized and inert materials, visible insect pest and propagules were removed. The soil was dried in the sun, crushed carefully and thoroughly mixed. The initial physical and chemical characteristics of the soil are presented in Table 3.1.

Table 3.1 Initial characteristics of the soil of the experimental field

1. Particle-size analysis of soil	Sand	30.55
	Silt	37.29
	Clay	32.16
2. Textural Class		Clay loam
3. P^H		6.3
4. Total N (%)		0.075
5. Organic matter (%)		0.80
6. Phosphorous (mg kg^{-1})		16
7. Potassium (mg kg^{-1})		15
8. Sulphur (mg kg^{-1})		10
9. Zinc (mg kg^{-1})		1.30

3.3 Description of the rice variety

BINA dhan 8, a high yielding and salt tolerant variety of rice was used as the test crop in this experiment. This variety was released by Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh in 2010. Life cycle of this variety ranges from 130 to 135 days.

3.4 Layout of the experiment

The experiment was set in Completely Randomized Design (CRD) having two factors with 3 replications. The treatment combination of the experiment was assigned at random into 16 pots of each at 3 replications.

3.5 Treatments

Salinity treatments consisted of 4 levels (0, 4, 8 and 12 dS m^{-1} designated as S_0, S_1, S_2 and S_3, respectively) and 4 levels of K (180 mg K/ 2 Kg soil , 120 mg K/ 2 Kg soil plus spraying with 3% KCl solution every 10 days interval, 60 mg K/ 2 Kg soil plus spraying with 6% KCl solution every 10 days interval and spraying with 9% KCl solution every 10 days interval designated as K_0, K_1, K_2 and K_3, respectively). There were 16 treatment combinations. The rates of K and S and their treatment combinations are shown below:

➢ Levels of salinity (4):	➢ Levels of potassium (4):
S_0 = 0 dS m^{-1} S_1 = 4 dS m^{-1} S_2 = 8 dS m^{-1} S_3 = 12 dS m^{-1}	K_1 = 180 mg K/ 2 Kg soil K_2 = 120 mg K/ 2 Kg soil plus spraying with 3% KCl solution every 10 days interval K_3 = 60 mg K/ 2 Kg soil plus spraying with 6% KCl solution every 10 days interval K_4 = spraying with 9% KCl solution every 10 days interval

Treatment combinations

Salinity level	Potassium level
S_0 (0 dS m^{-1})	K_1 (180 mg K/ 2 Kg soil)
	K_2 (120 mg K/ 2 Kg soil plus spraying with 3% KCl solution every 10 days interval)
	K_3 (60 mg K/ 2 Kg soil plus spraying with 6% KCl solution every 10 days interval)
	K_4 (spraying with 9% KCl solution every 10 days interval)
S_1 (4 dS m^{-1})	K_1 (180 mg K/ 2 Kg soil)
	K_2 (120 mg K/ 2 Kg soil plus spraying with 3% KCl solution every 10 days interval)
	K_3 (60 mg K/ 2 Kg soil plus spraying with 6% KCl solution every 10 days interval)
	K_4 (spraying with 9% KCl solution every 10 days interval)
S_2 (8 dS m^{-1})	K_1 (180 mg K/ 2 Kg soil)
	K_2 (120 mg K/ 2 Kg soil plus spraying with 3% KCl solution every 10 days interval)
	K_3 (60 mg K/ 2 Kg soil plus spraying with 6% KCl solution every 10 days interval)
	K_4 (spraying with 9% KCl solution every 10 days interval)
S_3 (12 dS m^{-1})	K_1 (180 mg K/ 2 Kg soil)
	K_2 (120 mg K/ 2 Kg soil plus spraying with 3% KCl solution every 10 days interval)
	K_3 (60 mg K/ 2 Kg soil plus spraying with 6% KCl solution every 10 days interval)
	K_4 (spraying with 9% KCl solution every 10 days interval)

3.6 Sterilization of seed

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 $121 +1^{0}$ C and at 15 bar air pressure.

3.7 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.

3.8 Sowing of seeds in seed bed

Previously collected seeds were soaked with water for 24 hours and then washed thoroughly in fresh water, and incubated for sprouting. Seeds were sown on the 9th December 2013 in the wet seed bed. Required amount of fertilizers were applied one day prior to sowing of seeds in the seed bed.

3.9 Preparation of pots for transplanting rice seedlings

Recommended doses of N, P and S (100 kg N from urea, 20kg P from TSP and 12 kg S per hectare from Gypsum respectively) were applied. The whole amount of TSP, MOP, gypsum and $1/3^{rd}$ of urea were applied prior to final preparation of the pots. According to treatment rate, the whole amount of supplemental K (as KCl) was also added in the respective pots. Thereafter the pots containing soil were moistened with water. Six weeks-old seedlings were transplanted on the 22th January 2014 in the respective pots. 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 litre distilled water for 1 $dS\ m^{-1}$) of salt solution was added in three equal installments on alternate days until the expected conductivity was reached. The salinity i.e. Electrical Conductivity (EC) of each tray was measured with a conductivity meter (Model-DiST 4 HANNA HI 98304) and the necessary adjustments of salinity were made. The remaining $2/3^{rd}$ urea were top dressed at two equal divisions after 25 and 50 days of transplanting.

3.10 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.

3.11 Harvesting

The crop was harvested at maturity on 6^{th} May 2014. The harvested crop of each individual pot was bundled separately. Grain and straw yields were recorded pot wise and the yields were expressed in g $hill^{-1}$.

3.12 Collection of data

Data collections were done on the following parameters

1. Plant height (cm)
2. Number of leaves $hill^{-1}$
3. Root length (cm)
4. Stem dry weight (g)
5. Root dry weight (g)
6. Number of effective tillers $hill^{-1}$
7. Number of panicles $hill^{-1}$
8. Number of grains $hill^{-1}$
9. Number of filled grains $hill^{-1}$
10. Number of unfilled grains $hill^{-1}$
11. Dry weight of filled grain (g $hill^{-1}$)
12. 1000-grain weight
13. Grain yield $hill^{-1}$ (g)
14. Chemical Analysis of rice and straw: P, K, S, Na.

3.12.1 Plant height (cm)

Plant height (cm) was measured from the root base to the tip of the longest leaf at the time of 30, 60 days after transplanting (DAT) and at harvest.

3.12.2 Number of leaves hill^{-1}

Number of leaves hill^{-1} of tagged plants was measured during the time of 30, 60 DAT and at harvest.

3.12.3 Root length (cm)

Root length (cm) was measured at harvest by meter scale.

3.12.4 Shoot and root dry weight (g)

Shoot and root dry weights were measured after separating the shoots and roots of tagged plants following by oven-drying.

3.12.5 Number of effective tillers and panicles hill^{-1}

Number of effective tillers and panicles hill^{-1} were counted at maturity.

3.12.6 Number of grain panicle^{-1}, filled grains hill^{-1} and unfilled grains hill^{-1}

In case of more than 8 effective tillers hill^{-1}, average number of grains hill^{-1} was calculated by counting the number of filled grains and unfilled grains of hill^{-1} of plants which were selected randomly. In case of less than 8 effective tiller hill^{-1}, average number of filled grain was calculated by counting the number of filled grains and unfilled grains of all the panicles hill^{-1}.

3.12.7 Thousand grain weight (g)

Thousand grains weight was calculated by weighing 100 grains of each treatment and then multiplied by 10.

3.12.8 Grain yield hill^{-1} (g)

The grain yield of the hill which had effective tiller was recorded by weighing after proper drying the grain.

3.12.9 Chemical analysis

Rice plants were separated into roots and shoots after uprooting and rinsed repeatedly with tap water and finally with distilled water and then dried in an oven at 70^0 C to obtain constant weight.

Oven-dried shoot samples, root samples and grain samples were ground in a Wiley Hammer Mill, passed through 40 mesh screens, mixed well and stored in plastic vials. The ground samples were digested by Micro-Kjeldahl method (Thomas and Nambisan, 1999). Exactly 1g oven-dried shoot samples of rice plant were taken in kjeldahl flasks. About 15 mL of diacid mixture (conc. HNO3: 60% HClO4 = 2:1) was taken in a digestion tube and left to stand for 20 minutes and then transferred to a digestion block and continued heating at 100^0C (Jackson, 1973). The temperature was increased to 365^0C gradually to prevent frothing (50^0C steps) and left to digest until yellowish color of the solution turned to whitish color. Then the digestion tubes were removed from the heating source and allowed to cool to room temperature. About 40 mL of de-ionised water was carefully added to the digestion tubes and the contents filtered through Whatman no. 40 filter paper into a 100 mL volumetric flask and the volume was made up to the mark with de-ionised water. The samples were stored at room temperature in clearly marked containers.

After digestion, approximately 100 mL of each digest samples was stored in a plastic bottle for determination of the Na^+, $K^{+,}$ S and P. Content of Na^+ and K^+ were determined by Flame photometer while S and P were determined by atomic absorption spectrophotometer (Model- PERKIN- ELMER, 2380).After that, the Na/K, values were also calculated from concentration of Na, K, P and S in the plant tissues.

3.13 Statistical analysis

The collected data were analyzed statistically following CRD design by MSTAT-C computer package programme developed by Russel (1986). The treatment means were compared by Least Significance Differences (LSD), Duncans Multiple Range Test (DMRT) and regression analysis were used as and where necessary.

Chapter 4
Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The different growth and yield parameters were studied including plant height, number of leaf hill^{-1}, root length, dry weight of stem and root, number of effective tiller hill^{-1}, number of panicle hill^{-1}, number of filled and unfilled grain hill^{-1}, weight of filled grain hill^{-1}, thousand grain weight, grain yield hill^{-1} and P, K, S, Na content in straw, root and grain of the selected rice cultivar (BINA dhan 8) in view to evaluate its response to potassium supplementation at different salinity levels. The results are presented in figures and tables in this chapter and their possible interpretations are done as follows-

4.1 Plant height

4.1.1 Effects of salinity

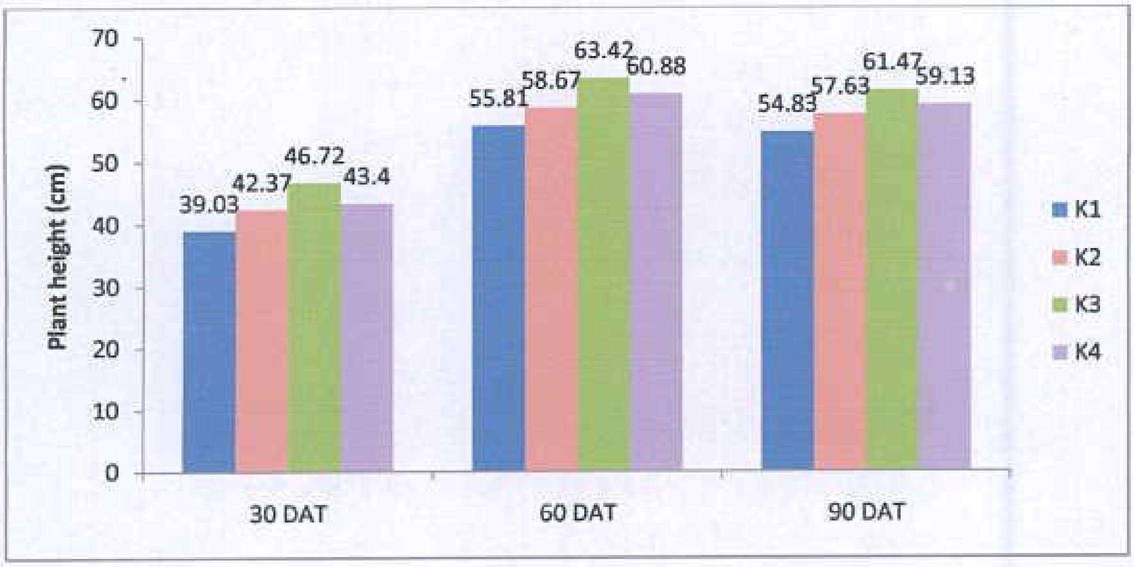
The plant height of BINA dhan 8 decreased as the level of salinity increased due to the mean effect of different K applications (Figure 1) at different days after transplanting (DAT). The plant height was highest (44.08, 67.12 and 83.58 cm respectively) at 30 DAT, 60 DAT and at harvest by 0 dSm^{-1} and the shortest plant (39.97, 51.33 and 0 cm) was obtained by 12 dSm^{-1} at 30 DAT, 60 DAT and at harvest (Appendix I).

4.1.2 Effects of potassium (K)

The plant height of BINA dhan 8 differed significantly due to the different types of K application over all the levels of salinity (Figure 2). The highest plant height at 30 DAT, 60 DAT and at harvest (46.72, 63.42, and 61.47 cm respectively) was given by K_3 (2/3rd foliar spray and 1/3rd soil application of total MoP fertilizer) and the shortest plant (39.03, 55.81 and 54.83 cm) was obtained K_1 (total soil application of MoP fertilizer) at all stages (Figure 2 & Appendix II).

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Figure 1. Effect of salinity on plant height at different stages of BINA dhan 8



K_1= Total soil application of MoP fertilizer, K_2= 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

Figure 2. Effect of different fertilization methods of potassium on plant height at different stages of BINA dhan 8

Table 4.1. Interaction effect of salinity level and different fertilization methods of potassium on plant height and number of leaves hill^{-1} of BINA dhan 8

Treatment		Plant height(cm)			No of leaf		
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
S_0	K_1	41.63d-g	62.53cd	80cd	23.33b	34.67c	14.33b
	K_2	42.73c-f	65.30c	82.37bc	26.33a	36.00c	17.67a
	K_3	46.87ab	72.07a	87.40a	26.67a	43.33a	19a
	K_4	45.10a-c	68.57b	84.57ab	26.33a	41b	17.67a
S_1	K_1	39.63g	57.93e-g	72.97ef	14g	23d	11.33c
	K_2	43.87cd	62.13cd	77.33d	21.33c	17.67e	14.33b
	K_3	46.97ab	64.9c	82.40bc	22.67bc	23.33d	14.67b
	K_4	44.50bc	62.73cd	78.60cd	19.00d	22.33d	14.67b
S_2	K_1	40.70e-g	55.20g	66.33g	15.67fg	17e	3.33e
	K_2	42.80c-f	57.07fg	70.83f	18.67d	11g	3.67e
	K_3	47.9a	61.17de	76.07de	23.33b	14f	2.67e
	K_4	43.47c-e	60.20d-f	73.33ef	16.67ef	14f	5.33d
S_3	K_1	34.17h	47.57i	0h	15fg	2.33i	0f
	K_2	40.07fg	50.17hi	0h	16f	2.67i	0f
	K_3	45.13a-c	55.57g	0h	18de	4.67h	0f
	K_4	40.53fg	52.00h	0h	15.67fg	3.67hi	0f
LSD		2.612	3.199	3.694	1.752	1.781	1.652
CV%		6.36		3.99	13.87	17.79	22.28
Level of significance		**	**	*	*	*	*

*=Significant at 5% level, **= Significant at 1% level

S_0=0 dSm^{-1}, S_1 = 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

K_1 = Total soil application of MoP fertilizer, K_2 = 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

4.1.3 Interaction effect of salinity and potassium

The effect of different application methods of K on plant height of BINA dhan 8 at different salinity levels was found significant. At 30 DAT the highest plant height (47.9 cm) was recorded in S_2K_3 (8 dSm^{-1} treated with 2/3rd foliar spray and 1/3rd soil application of total MoP fertilizer) while at 60 DAT and at harvest it was highest (72.07 and 87.40 cm) in S_0K_3 (0 dSm^{-1} treated with 2/3rd foliar spray and 1/3rd soil application of total MoP fertilizer) treatment. At 30 and 60 DAT the lowest plant height (34.17 and 47.57 cm) was recorded in S_3K_1 (12 dSm^{-1} treated with total soil application of MoP fertilizer). At harvest it was lowest in all combinations where potassium treatments were treated with 12 dSm^{-1} salinity (0 cm) as no plant survived (Table 4.1).

These results are in agreement with that of Qadar (1998) who found that the supplementation of K (30 kg K_2O ha^{-1}) in sodic soil increased plant height, shoot dry weight and grain yield of rice, where these growth and yield components of rice adversely affected by increasing the sodicity. The increasing levels of K application improved plant height, tiller numbers, shoot dry weight of both salt tolerant and susceptible cultivars and this beneficial effect of K application under saline conditions may be attributed to its influence on net photosynthesis (Bohra and Doerffling, 1993).

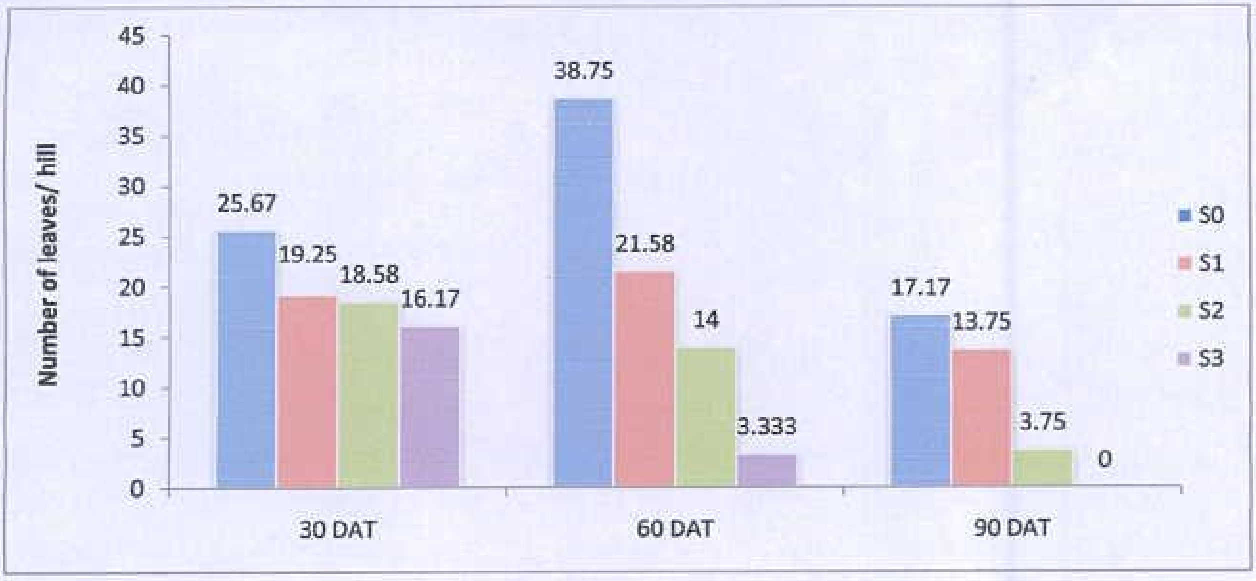
4.2 Number of leaves $hill^{-1}$

4.2.1 Effects of salinity

Number of leaves $hill^{-1}$ of BINA dhan 8 decreased as the level of salinity increased due to the mean effect of different sort of K applications (Figure 3) at different days after transplanting (DAT). At 30 and 60 DAT and at harvest the highest number of leaves $hill^{-1}$ (25.67, 38.75 and 17.17 respectively) were recorded in S_0 (0 dSm^{-1}). The lowest number of leaves $hill^{-1}$ at 30 DAT, 60 DAT and at harvest (16.17, 3.33 and 0 respectively) were obtained from 12 dSm^{-1} (Appendix I).

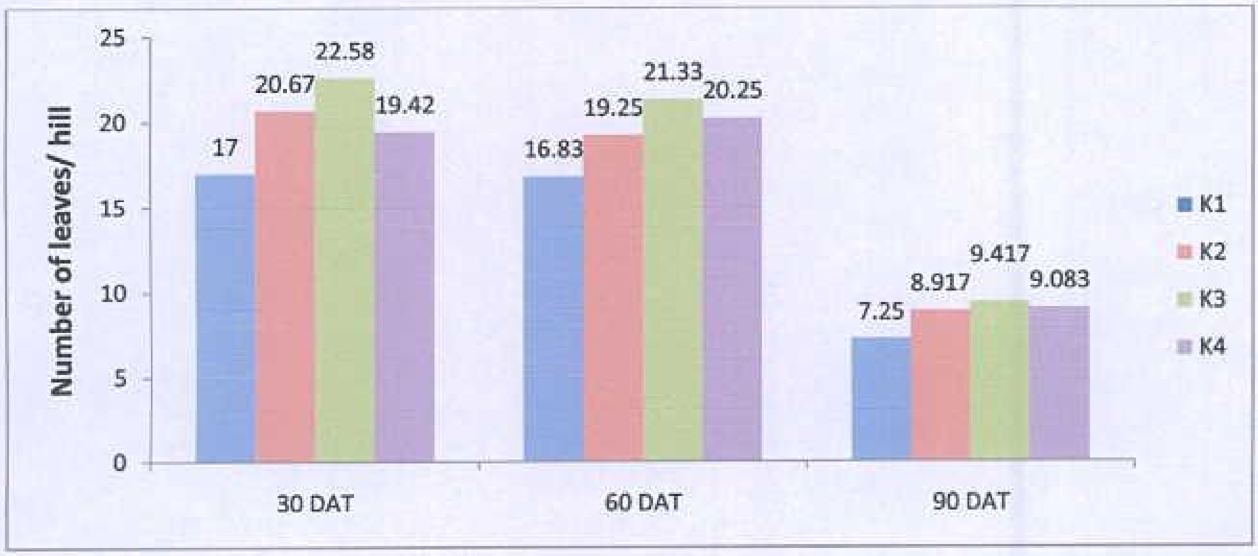
4.2.2 Effects of potassium (K)

Number of leaves $hill^{-1}$ of BINA dhan 8 differed significantly due to the different types of K application over all the levels of salinity (Figure 4) in all stages except at harvest. The highest number of leaves $hill^{-1}$ at 30 DAT, 60 DAT and at harvest (22.58, 21.33, and 9.417 respectively) was given by K_3 (2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) and the lowest number of leaves $hill^{-1}$ (17.00, 16.83 and 7.25) was obtained K_1 (total soil application of MoP fertilizer) at all stages (Figure 4 & Appendix II).



S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Figure 3. Effect of salinity on number of leaves hill^{-1} at different stages of BINA dhan 8



K_1 = Total soil application of MoP fertilizer, K_2 = 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4 =Total foliar spray of MoP fertilizer

Figure 4. Effect of different fertilization methods of potassium on number of leaves hill^{-1} at different stages of BINA dhan 8

4.2.3 Interaction effect of salinity and potassium

The effect of different application methods of K on number of leaves hill^{-1} of BINA dhan 8 at different salinity levels was found significant. At 30 and 60 DAT and at harvest the highest number of leaves hill^{-1} (26.67, 43.33 and 19 respectively) was recorded S_0K_3 (0 dSm^{-1} treated with 2/3rd foliar spray and 1/3rdsoil application of total MoP fertilizer). At 30 DAT it was lowest (14) in S_1K_1 treatment (4 dSm^{-1} treated with total soil application of MoP fertilizer) (Table). At 60 DAT the lowest number of leaves hill^{-1} (2.33) was recorded in S_3K_1 (12 dSm^{-1} treated with total soil application of MoP fertilizer). At harvest it was lowest in all combinations where potassium treatments were treated with 12 dSm^{-1} salinity (0) as no plant survived (Table 4.1).

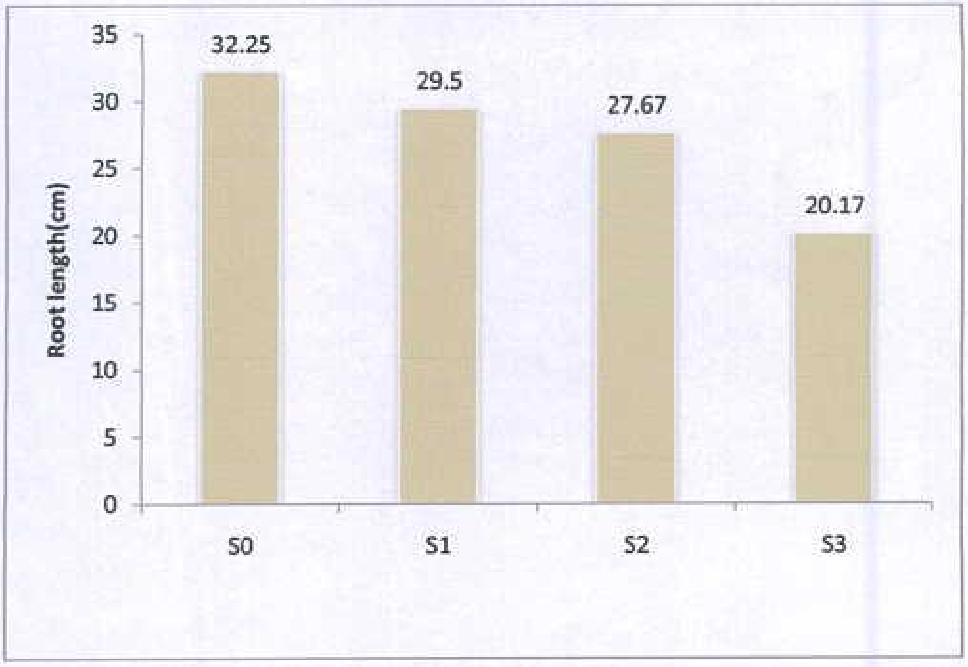
4.3. Root length

4.3.1 Effects of salinity

The root length of BINA dhan 8 decreased significantly as the level of salinity increased due to the mean effect of different K applications (Figure 5). The root length was highest (32.25 cm) in 0 dSm^{-1} salinity followed by 4 dSm^{-1} (29.50 cm) and the shortest root length (20.17 cm) was obtained by 12 dSm^{-1} at harvest (Appendix III).

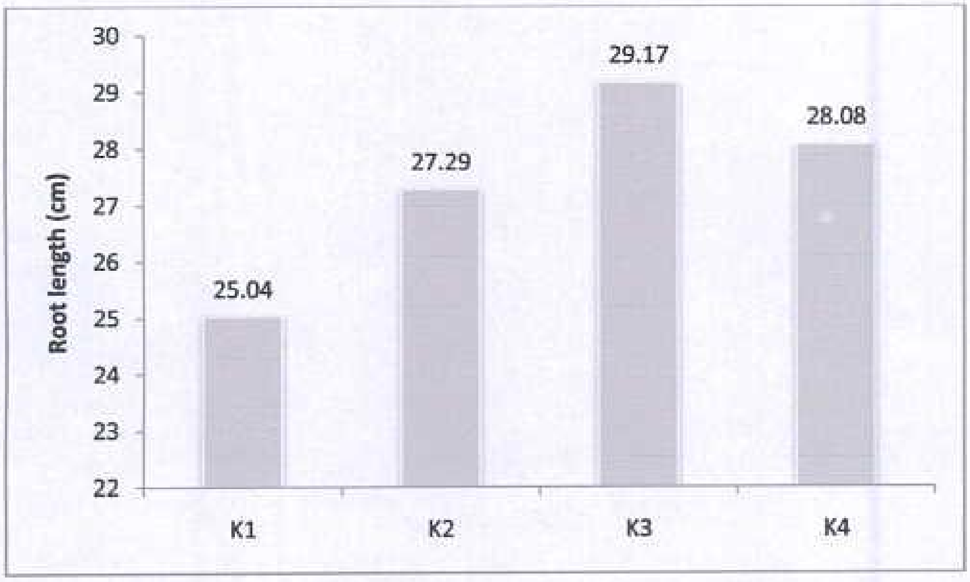
4.3.2 Effects of potassium (K)

The root length of BINA dhan 8 differed significantly due to the different sorts of K application over all the levels of salinity (Figure 6). The highest root length (29.17 cm) was given by K_3 (2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was closely followed by and statistically similar with K_4 (28.08 cm) and K_2 (27.29 cm). The shortest root length (25.04 cm) was obtained from K_1 (total soil application of MoP fertilizer) (Figure 6 & Appendix IV).



S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Figure 5. Effect of salinity on root length of BINA dhan 8



K_1= Total soil application of MoP fertilizer, K_2= 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

Figure 6. Effect of different fertilization methods of potassium on root length of BINA dhan 8

4.3.3 Interaction effect of salinity and potassium

The effect of different application methods of K on root length of BINA dhan 8 at different salinity levels was found significant. The highest root length (33 cm) was recorded in S_0K_1 (0 dSm^{-1} treated with total soil application of MoP fertilizer) which was statistically same with S_0K_3 (32.33 cm), S_0K_4 (32.33 cm), S_0K_2 (31.33 cm), S_2K_3 (31.33 cm) and S_1K_3 (30.33 cm). Root length was found lowest (17.83 cm) in S_3K_1 (12 dSm^{-1} treated with total soil application of MoP fertilizer) which was statistically same with S_3K_2 (19.50 cm) (Table 4.2).

Table 4.2. Interaction effect of salinity level and different fertilization methods of potassium on root length, dry weight of shoot and dry weight of root of BINA dhan 8

Treatment		Root length(cm)	Dry weigh of shoot (g)	Dry weight of root(g)
S_0	K_1	33a	11.33b	5.890c
	K_2	31.33a-c	13.10ab	10.33b
	K_3	32.33ab	15.39a	6.980c
	K_4	32.33ab	13.62ab	13.07a
S_1	K_1	27.67d	12.16ab	5.687c
	K_2	30.00b-d	10.12bc	5.170cd
	K_3	30.33a-d	10.25bc	5.200cd
	K_4	30.00b-d	12.72ab	6.840c
S_2	K_1	21.67ef	5.667d-f	2.057e
	K_2	28.33d	7.303cd	2.627de
	K_3	31.33a-c	6.647de	2.247e
	K_4	29.33cd	7.360cd	2.037e
S_3	K_1	17.83g	2.177g	0.3967e
	K_2	19.50fg	2.997fg	0.9233e
	K_3	22.67e	3.667e-g	0.5633e
	K_4	20.67ef	2.543fg	0.4700e
LSD		2.677	3.199	2.612
CV%		8.26	23.63	6.53
Level of significance		**	*	*

*=Significant at 5% level, **= Significant at 1% level

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

K_1= Total soil application of MoP fertilizer, K_2= 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

4.4 Dry weight of shoot

4.4.1 Effects of salinity

The dry weight of shoot (g) of BINA dhan 8 decreased significantly as the level of salinity increased (Figure 7). Dry weight of shoot was highest (13.36 g) in 0 dSm^{-1} salinity which was statistically similar and closely followed by 4 dSm^{-1} (11.31 g) and the lowest shoot dry weight (2.846 g) was obtained by 12 dSm^{-1} salinity at harvest (Appendix III).

4.4.2 Effects of potassium (K)

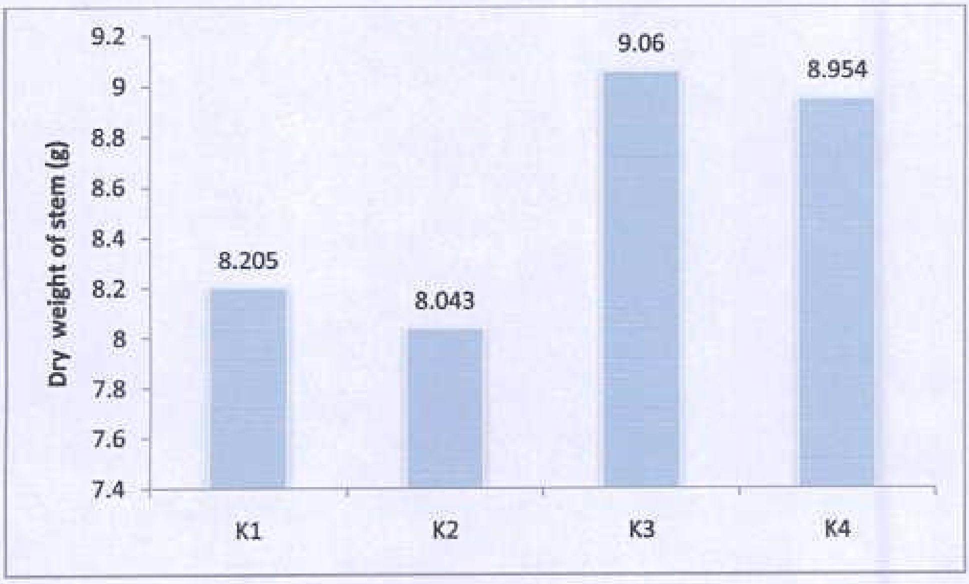
The dry weight of shoot of BINA dhan 8 differed non-significantly due to the different sorts of K application over all the levels of salinity (Figure 8). Though the highest dry weight of shoot (9.060 g) was given by K_3 (2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was closely followed by K_4 (8.954 g) and K_2 (8.205 g). The lowest shoot dry weight (8.043 g) was obtained from K_1 (total soil application of MoP fertilizer) (Figure 8 & Appendix IV).

4.4.3 Interaction effect of salinity and potassium

The effect of different application methods of K on shoot dry weight of BINA dhan 8 at different salinity levels was found significant. The highest shoot dry weight (15.39 g) was recorded in S_0K_3 (0 dSm^{-1} treated with 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was statistically same with S_0K_2 (13.10 g), S_0K_4 (13.62 g), S_1K_4 (12.72 g) and S_1K_1 (12.16 g). Lowest shoot dry weight (2.177 g) was found in S_3K_1 (12 dSm^{-1} treated with total soil application of MoP fertilizer) which was closely followed by S_3K_4 (2.543 g) (Table 4.2). It was observed that, in all salinity levels, foliar K application incorporated with soil fertilization increased the dry weight of shoot than sole foliar or soil application of potassium.

S_0=0 dSm^{-1}, S_1=4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Figure 7. Effect of salinity on shoot dry weight of BINA dhan 8



K_1= Total soil application of MoP fertilizer, K_2= 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

Figure 8. Effect of different fertilization methods of potassium on shoot dry weight of BINA dhan 8

4.5 Dry weight of root

4.5.1 Effects of salinity

The dry weight of root (g) of BINA dhan 8 decreased significantly as the level of salinity increased (Figure 9). Dry weight of root was highest (9.067 g) in 0 dSm^{-1} which followed by 4 dSm^{-1} (5.724 g) and the lowest root dry weight (0.588 g) was obtained by 12 dSm^{-1} at harvest (Appendix III).

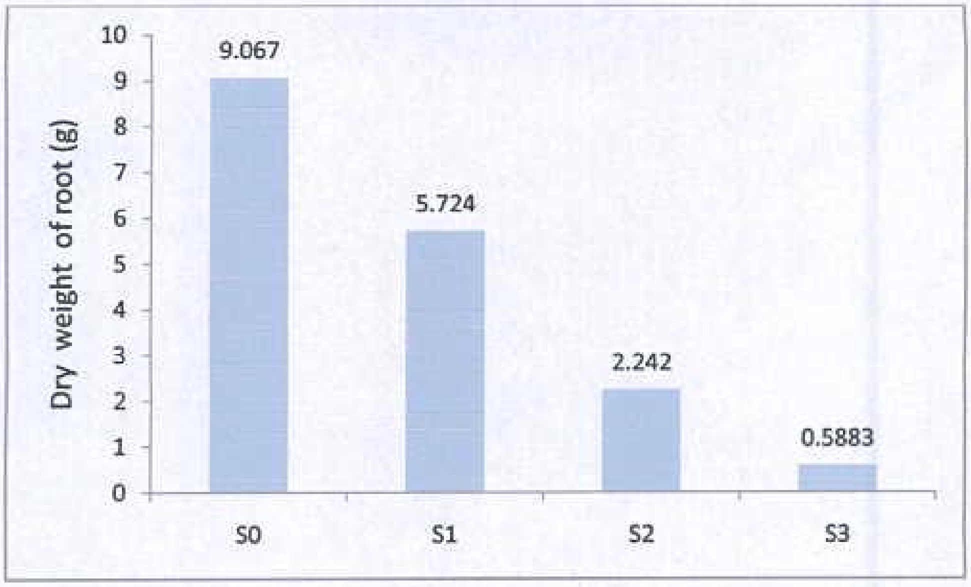
4.5.2 Effects of potassium (K)

The dry weight of root of BINA dhan 8 differed significantly due to the different sorts of K application over all the levels of salinity (Figure 10). The highest dry weight of root (5.603 g) was given by K_4 (Total foliar spray of MoP fertilizer) which was statistically same with K_3 (3.747 g) and K_2 (4.762 g). The lowest root dry weight (3.507 g) was obtained from K_1 (total soil application of MoP fertilizer) (Figure 10 & Appendix IV).

4.5.3 Interaction effect of salinity and potassium

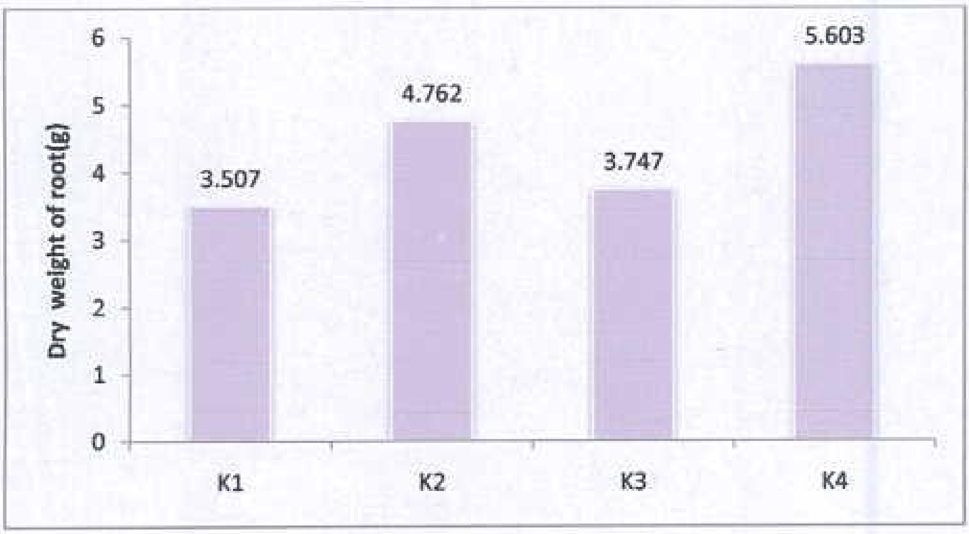
The effect of different application methods of K on root dry weight of BINA dhan 8 at different salinity levels was found significant. The highest root dry weight (13.07 g) was recorded in S_0K_4 (0 dSm^{-1} treated with total foliar spray of MoP fertilizer) while lowest root dry weight (0.3967 g) was found in S_3K_1 (12 dSm^{-1} treated with total soil application of MoP fertilizer) which was closely followed by S_3K_4 (0.4700 g) (Table 4.2).

Our results corroborate with that of Qadar (1998) who found that application of P or P + K fertilizers at sodic soil significantly increased root and shoot dry weights of rice cultivars. Ebrahimi *et al.* (2012) found that dry weight was significantly ($P<0.05$) affected by salt levels, methods of potassium application and the interaction of both ($P<0.01$).



S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Figure 9. Effect of salinity on root dry weight of BINA dhan 8



K_1 = Total soil application of MoP fertilizer, K_2= 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

Figure 10. Effect of different fertilization methods of potassium on root dry weight of BINA dhan 8

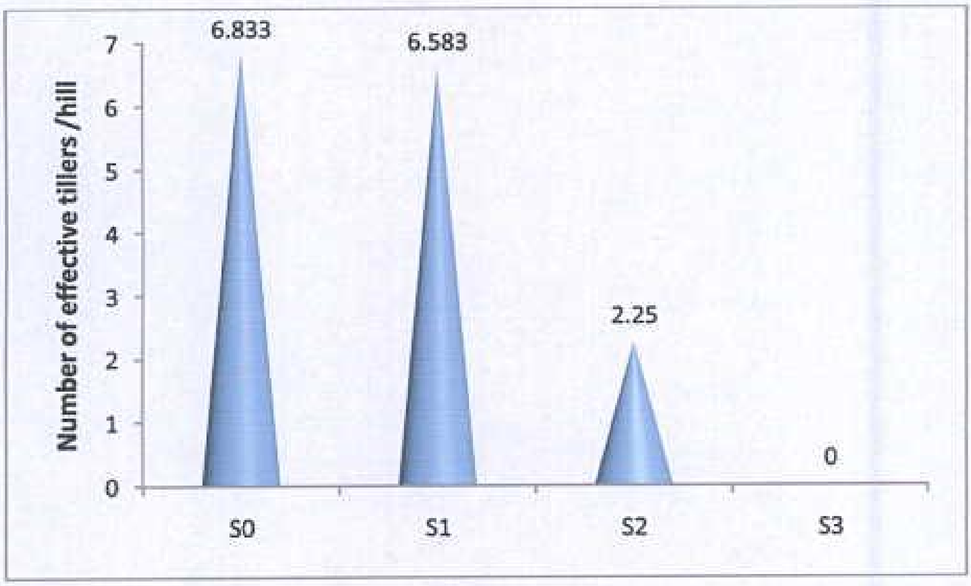
4.6 Number of effective tillers hill^{-1}

4.6.1 Effects of salinity

It was observed that, as the salinity level increased, the number of effective tillers hill^{-1} decreased significantly (Figure 11). The highest number of effective tillers hill^{-1} was recorded in S_1 (6.833) which was statistically same with S_2 (6.583) and the lowest number of effective tillers hill^{-1} was found from S_4 (0) (Appendix V).

4.6.2 Effects of potassium (K)

Different methods of MoP application not showed any significant variation among them for number of effective tillers hill^{-1}. Though the highest number of effective tillers hill^{-1} (4.500) was recorded in K_3 (2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) followed by K_4 (Total foliar spray of MoP fertilizer) (4.000) and the lowest was in K_1 (total soil application of MoP fertilizer) (3.333) (Figure 12 and Appendix VI).



S_0=0 dSm^{-1}, S_1=4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Figure 11. Effect of salinity on number of effective tillers hill^{-1} of BINA dhan 8

K_1 = Total soil application of MoP fertilizer, K_2 = 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

Figure 12. Effect of different fertilization methods of potassium on number of effective tillers hill^{-1}of BINA dhan 8

4.6.3 Interaction effect of salinity and potassium

The effect of different application methods of K on number of effective tillers hill^{-1} of BINA dhan 8 at different salinity levels was found significant. The highest number of effective tillers hill^{-1} (8.333) was recorded in S_0K_3 (0 dSm^{-1} treated with 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was statistically same with S_0K_4 (7.333), S_1K_4 (7.333), S_0K_2 (7.000) and S_0K_2 (7.000). Lowest number of effective tillers hill^{-1} (0) was found in combinations of 12 dSm^{-1} treated with all sort of application of MoP fertilizer as no plant survived (Table 4.3). it was observed that, in saline soil foliar application of K along with soil fertilization increased the number of effective tillers. Ebrahimi *et a.l* (2012) also found that foliar application of 2/3 rd K and 1/3 rd soil application of K significantly increased the number of effective tillers hill^{-1} in saline soil (EC = 6 dSm^{-1}).

These results corroborate with that of Qadar (1998) who found that application of P or P + K fertilizers at sodic soil significantly increased effective tiller $hill^{-1}$ of rice cultivars. The results are also in agreement with those reported by Mohiti *et al.* (2011).

Table 4.3. Interaction effect of salinity level and different fertilization methods of potassium on number of effective tillers $hill^{-1}$, grains $hill^{-1}$, filled grains $hill^{-1}$ and unfilled grains $hill^{-1}$ of BINA dhan 8

Treatment		Number of effective tillers $hill^{-1}$	Number of grains $hill^{-1}$	Number of filled grains $hill^{-1}$	Number of unfilled grains $hill^{-1}$
S_0	K_1	6.000b	609.7c	331.0c	149.3e
	K_2	7.000ab	639.0b	445.3b	237.0a
	K_3	8.333a	680.0a	504.7a	148.3e
	K_4	7.333ab	599.7d	453.0b	198.7d
S_1	K_1	5.667b	350.3h	160.0g	236.3ab
	K_2	6.000b	403.7g	200.7f	230.3b
	K_3	6.000b	481.3e	267.0d	152.7e
	K_4	7.333ab	449.0f	229.7e	212.7c
S_2	K_1	1.667cd	125.7j	44.0ij	114.7f
	K_2	2.333c	154.0i	48.67i	119.3f
	K_3	2.667c	158.3i	38.0j	32.67h
	K_4	2.333c	155.0i	78.33h	87.67g
S_3	K_1	0.0d	0.0k	0.0k	0.0i
	K_2	0.0d	0.0k	0.0k	0.0i
	K_3	0.0d	0.0k	0.0k	0.0i
	K_4	0.0d	0.0k	0.0k	0.0i
LSD		1.742	8.858	8.051	6.209
CV%		24.44	16.44	2.38	4.58
Level of significance		*	*	**	*

*=Significant at 5% level, **= Significant at 1% level

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

K_1= Total soil application of MoP fertilizer, K_2= 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

4.7 Number of grains hill^{-1}

4.7.1 Effects of salinity

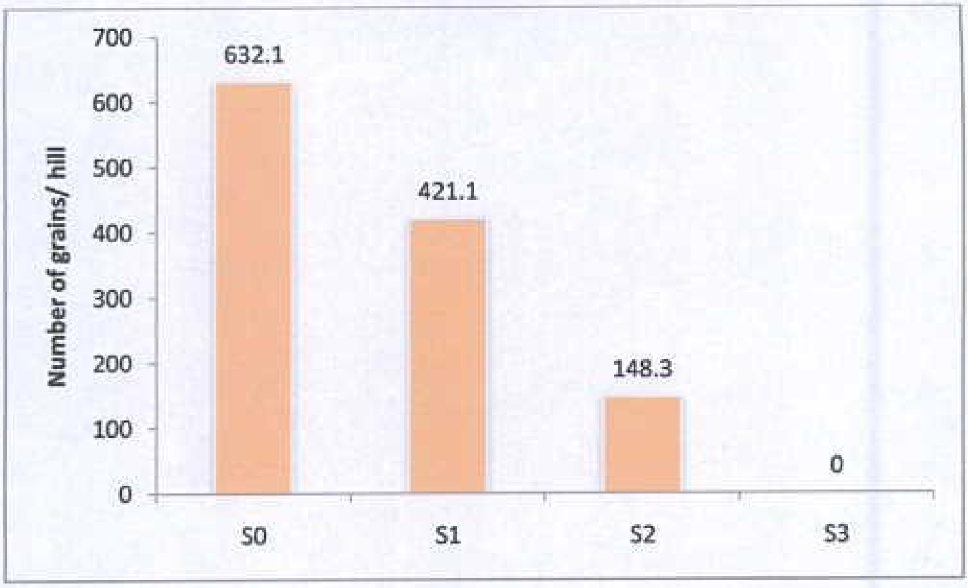
Number of grains hill^{-1} of BINA dhan 8 decreased significantly as the level of salinity increased (Figure 15). Highest grains hill^{-1} (632.1) was recorded in 0 dSm^{-1} which was followed by 4 dSm^{-1} (421.1) and the lowest grains hill^{-1} (0) was observed in 12 dSm^{-1} at harvest (Appendix V).

4.7.2 Effects of potassium (K)

Number of grains hill^{-1} of BINA dhan 8 differed significantly due to the different sorts of K application over all the levels of salinity (Figure 16). The highest number of grains hill^{-1} (329.9) was given by K_3 (2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was followed by K_4 (300.9) and K_2 (299.2). The lowest number of grains hill^{-1} (271.4) was obtained from K_1 (total soil application of MoP fertilizer) (Figure 16 & Appendix VI).

4.7.3 Interaction effect of salinity and potassium

The effect of different application methods of K on number of grains hill^{-1} of BINA dhan 8 at different salinity levels was found significant. The highest number of grains hill^{-1} (680.0) was recorded in S_0K_3 (0 dSm^{-1} treated with 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was followed by S_0K_2 (639.0). Lowest numbers of grains hill^{-1} (0) were recorded in 12 dSm^{-1} while combined with all four types of application of MoP fertilizer as no plants survived at that level of salinity (Table 4.3). Here it was found that foliar application of K increased the number of grains hill^{-1} even in higher salinity level (8 dSm^{-1}) which corroborates with the findings of Ebrahimi *et al.* (2012).



S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Figure 13. Effect of salinity on number of grains panicles^{-1} of BINA dhan 8

K_1= Total soil application of MoP fertilizer, K_2=1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

Figure 14. Effect of different fertilization methods of potassium on number of grains panicles^{-1} of BINA dhan 8

4.8 Number of filled grains hill^{-1}

4.8.1 Effects of salinity

Number of filled grains hill^{-1} of BINA dhan 8 decreased significantly as the level of salinity increased (Figure 17). Highest filled grains hill^{-1} (433.5) was recorded in 0 dSm^{-1} which was followed by 4 dSm^{-1} (214.3) and the lowest filled grains hill^{-1} (0) was observed in 12 dSm^{-1} at harvest (Appendix V).

4.8.2 Effects of potassium (K)

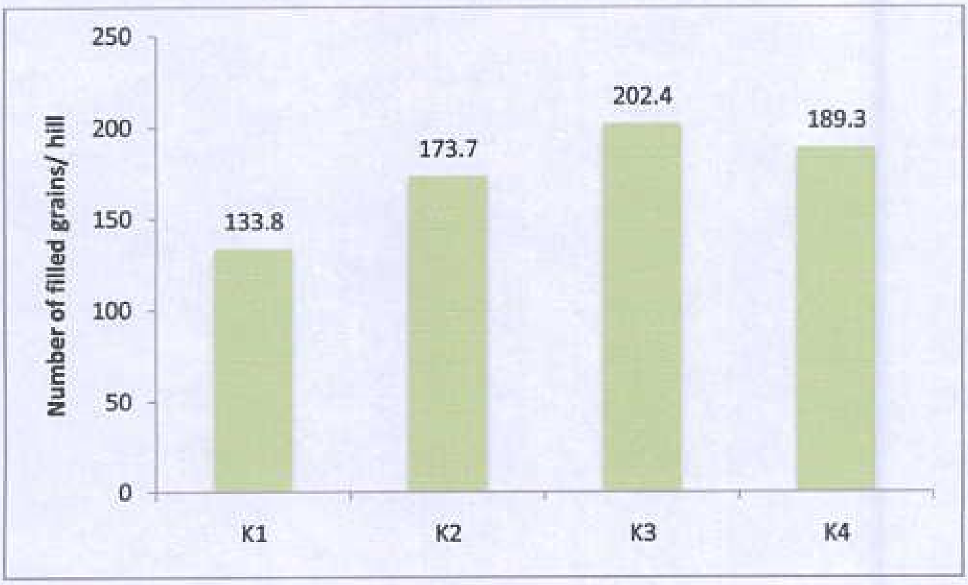
Number of filled grains hill^{-1} of BINA dhan 8 differed significantly due to the different sorts of K application over all the levels of salinity (Figure 18). The highest number of filled grains hill^{-1} (202.4) was given by K_3 (2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was followed by K_4 (189.3) and K_2 (173.7). The lowest number of filled grains hill^{-1} (133.8) was obtained from K_1 (total soil application of MoP fertilizer) (Figure 18 & Appendix VI).

4.8.3 Interaction effect of salinity and potassium

The effect of different application methods of K on number of filled grains hill^{-1} of BINA dhan 8 at different salinity levels was found significant. The highest number of filled grains hill^{-1} (504.7) was recorded in S_0K_3 (0 dSm^{-1} treated with 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was followed by S_0K_4 (453.0) and S_0K_2 (445.3). Lowest numbers of filled grains hill^{-1} (0) were found in 12 dSm^{-1} while combined with all four types of application of MoP fertilizer as no plants survived at that level of salinity (Table 4.3).

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Figure 15. Effect of salinity on number of filled grains hill^{-1} of BINA dhan 8



K_1= Total soil application of MoP fertilizer, K_2=1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

Figure 16. Effect of different fertilization methods of potassium on number of filled grains hill^{-1} of BINA dhan 8

4.9 Number of unfilled grains hill^{-1}

4.9.1 Effects of salinity

Number of unfilled grains hill^{-1} of BINA dhan 8 increased significantly as the level of salinity increased upto 4 dSm^{-1} and then decreased drastically (Figure 19). Highest number of unfilled grains hill^{-1} (208.0) was recorded in 4 dSm^{-1} which was followed by 0 dSm^{-1} (183.3) and the lowest unfilled grains hill^{-1} (0) was observed in 12 dSm^{-1} at harvest (Appendix V).

4.9.2 Effects of potassium (K)

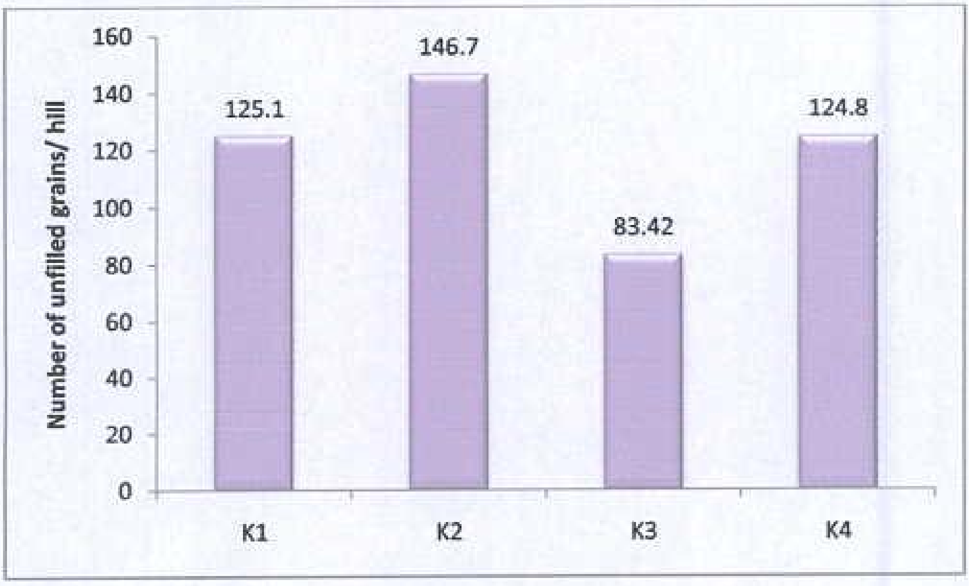
Number of unfilled grains hill^{-1} of BINA dhan 8 differed significantly due to the different sorts of K application over all the levels of salinity (Figure 20). The highest number of unfilled grains hill^{-1} (146.7) was given by K_2 (1/3 rd foliar spray and 2/3 rd soil application of total MoP fertilizer) which was followed by K_1 (125.1) and K_4 (124.8). The lowest number of unfilled grains hill^{-1} (83.42) was obtained from K_3 (2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer) (Figure 20 & Appendix VI).

4.9.3 Interaction effect of salinity and potassium

The effect of different application methods of K on number of unfilled grains hill^{-1} of BINA dhan 8 at different salinity levels was found significant. The highest number of unfilled grains hill^{-1} (237.0) was recorded in S_0K_2 (0 dSm^{-1} treated with 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer) which was statistically same with S_1K_1 (236.3). Lowest numbers of unfilled grains hill^{-1} (0) were found in treatments where 12 dSm^{-1} combined with all four types of application of MoP fertilizer as no plants survived at that level of salinity (Table 4.3).

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Figure 17. Effect of salinity on number of unfilled grains hill^{-1} of BINA dhan 8



K_1= Total soil application of MoP fertilizer, K_2= 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

Figure 18. Effect of different fertilization methods of potassium on number of unfilled grains hill^{-1} of BINA dhan 8

4.10 1000-grain weight

4.10.1 Effects of salinity

1000-grain weight (g) of BINA dhan 8 decreased significantly as the level of salinity increased. Highest 1000-grain weight (20.81 g) was recorded in 0 dSm^{-1} which was followed by 4 dSm^{-1} (17.48 g) and the lowest 1000-grain weight (0 g) was observed in 12 dSm^{-1} at harvest (Table 4.4).

4.10.2 Effects of potassium (K)

1000-grain weight of BINA dhan 8 differed significantly due to the different sorts of K application over all the levels of salinity. The highest 1000-grain weight (13.06 g) was given by K_3 (2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was followed by K_2 (12.84 g) and K_1 (12.30 g). The lowest 1000-grain weight (12.07 g) was obtained from K_1 (total soil application of MoP fertilizer) (Table 4.5).

4.10.3 Interaction effect of salinity and potassium

The effect of different application methods of K on 1000-grain weight of BINA dhan 8 at different salinity levels was found significant. The highest 1000-grain weight (21.05 g) was recorded in S_0K_3 (0 dSm^{-1} treated with 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was statistically same with S_0K_2 (20.83 g), S_0K_4 (20.76 g) and S_0K_1 (20.59 g). Lowest 1000-grain weight (0) was found in 12 dSm^{-1} while combined with all four application types of MoP fertilizer as no plants survived at that level of salinity (Table 4.6).

4.11 Grain yield $hill^{-1}$

4.11.1 Effects of salinity

Grain yield $hill^{-1}$ (g) of BINA dhan 8 decreased significantly as the level of salinity increased. Highest grain yield $hill^{-1}$ (9.556 g) was recorded in 0 dSm^{-1} which was followed by 4 dSm^{-1} (4.312 g) and the lowest grain yield $hill^{-1}$ (0 g) was observed in 12 dSm^{-1} at harvest (Table 4.4).

4.11.2 Effects of potassium (K)

Grain yield $hill^{-1}$ of BINA dhan 8 differed non-significantly due to the different sorts of K application over all the levels of salinity. The highest grain yield $hill^{-1}$ (3.845 g) was given by K_3 (2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was followed by K_2 (3.733 g) and K_4 (3.631 g). The lowest grain yield $hill^{-1}$ (3.452 g) was obtained from K_1 (total soil application of MoP fertilizer) (Table 4.5).

4.11.3 Interaction effect of salinity and potassium

The effect of different application methods of K on grain yield $hill^{-1}$ of BINA dhan 8 at different salinity levels was found significant. The highest grain yield $hill^{-1}$ (10.29 g) was recorded in S_0K_3 (0 dSm^{-1} treated with 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer) which was statistically similar with S_0K_2 (10.00 g) and S_0K_4 (9.357 g). Lowest grain yield $hill^{-1}$ (0) was found in 12 dSm^{-1} while combined with all four types of application of MoP fertilizer as no plants survived at that level of salinity (Table 4.6).

These results are in agreement with that of Mehdi *et al.*, (2002) who stated that the supplementation of K (0, 20, 40, 65 and 80 mg K kg^{-1} soil) in artificially developed salinity (5.6, 8.7 and 11.5 dSm^{-1} levels) in soil of the experiment of rice the tillers, straw and grain yield significantly increased with increasing levels of K but increasing the salinity levels decreased tillers, straw and grain yield of rice. Similar results also found in the findings of Bohra & Doerffling (1993). Ebrahimi *et al.* (2012) found minimum grain, straw, total biological yield, 100 grains weigh and harvest index in 6 dS m^{-1} and stated that this may be due to reduced growth of rice as a result of reduced uptake of water and nutrients and reduction of enzymatic and photosynthetic efficiency and other physiological disorders. They found that highest grain yield (18.7 g/pot), straw yield (22.8 g/pot), total biological yield (41.5 g/pot) and 100 grains weigh (2.2 g/pot) were noted in K3 where potassium was applied in soil plus foliar spray. This increase might be due to the participation of potassium in mechanism of stomata movement, photosynthesis and osmoregulatory adaptation of plants to water stress in saline soils. Jurgens

(1976) reported that potassium absorption by plant leaves is possible under saline conditions and potassium absorbed under such conditions might help the plants for regulating stomata opening and closing.

Table 4.4. Effect of salinity on 1000-grain weight, and grain yield hill^{-1} of BINA dhan 8

Treatment	1000-grain weight (g)	Grain yield hill^{-1} (g)
S_0	20.81a	9.556a
S_1	17.48b	4.312b
S_2	11.97c	0.793c
S_3	0.0d	0.0d
LSD	2.308	0.3919
CV%	11.27	5.54
Level of significance	**	*

*=Significant at 5% level, **= Significant at 1% level
S_0=0 dSm^{-1}, S_1 = 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Table 4.5. Effect of different fertilization methods of potassium on 1000-grain weight, and grain yield hill^{-1} of BINA dhan 8

Treatment	1000-grain weight (g)	Grain yield hill^{-1} (g)
K_1	12.30c	3.452
K_2	12.84b	3.733
K_3	13.06a	3.845
K_4	12.07d	3.631
LSD	0.1791	0.3962
CV%	11.27	5.54
Level of significance	*	*

*=Significant at 5% level, **= Significant at 1% level
K_1 = Total soil application of MoP fertilizer, K_2 = 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4 =Total foliar spray of MoP fertilizer

Table 4.6. Interaction effect of salinity level and different fertilization methods of potassium on 1000-grain weight, and grain yield hill^{-1} of BINA dhan 8

Treatment		1000-grain weight (g)	Grain yield hill^{-1} (g)
S_0	K_1	8.580 b	20.59a
	K_2	10.00 a	20.83a
	K_3	10.29 a	21.05a
	K_4	9.357 ab	20.76a
S_1	K_1	4.987c	17.00c
	K_2	3.940cd	17.76b
	K_3	3.773d	17.86b
	K_4	4.547cd	17.32bc
S_2	K_1	0.6800e	11.15f
	K_2	0.9933e	12.65e
	K_3	1.037e	13.71d
	K_4	0.4633e	10.36g
S_3	K_1	0.0e	0.0h
	K_2	0.0e	0.0h
	K_3	0.0e	0.0h
	K_4	0.0e	0.0h
LSD		0.5693	1.061
CV%		11.27	5.54
Level of significance		*	*

*=Significant at 5% level, **= Significant at 1% level

S_0=0 dSm^{-1}, S_1=4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

K_1= Total soil application of MoP fertilizer, K_2=1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

4.12 Phosphorus content in straw, root and grain (%)

4.12.1 Effect of salinity

Phosphorus (P) content (%) in straw and root of BINA dhan 8 were affected significantly by the various levels of salinity. The highest P content in straw (0.1230 %) was recorded in 12 dSm^{-1} which was followed by 0 dSm^{-1} (0.09125%) and the lowest (0.07950%) was observed in 4 dSm^{-1}. The highest P content in root (0.2582 %) was recorded in 4 dSm^{-1} which was followed by

12 dSm^{-1} (0.2375%) and the lowest (0.1702%) was observed in 0 dSm^{-1}. P in grain was not varied significantly due to salinity effects (Table 4.7).

4.12.2 Effect of potassium

Phosphorus content (%) in straw and root of BINA dhan 8 were affected significantly by the various fertilization types of potassium. Highest P in straw (0.1377%) was recorded in K_3 and the lowest (0.0750%) was observed in K_1. Highest P in root (0.2395%) was recorded in K_4 which was closely followed by K_3 (0.2237%) and the lowest (0.198%) was observed in K_1. P in grain was not varied significantly due to effects of potassium (Table 4.8).

4.12.3 Interaction effect of salinity and potassium

Phosphorus content (%) in straw, root and grain of BINA dhan 8 were affected significantly by the interaction effect of salinity and potassium. Highest P in straw (0.270%) was recorded in S_0K_3 and lowest (0.010%) in S_0K_4. Highest P in root (0.280%) was recorded in S_1K_3 and lowest (0.151%) in S_2K_2. Highest P in grain (0.202%) was recorded in S_1K_1 and lowest (0%) in all foliar and soil application of potassium while treated with 12 dSm^{-1} as no plants survived to produce any grain at all (Table 4.9).

4.13 Sulphur content in straw, root and grain (%)

4.13.1 Effect of salinity

Sulphur (S) content (%) in straw, root and grain of BINA dhan 8 were affected significantly by the various levels of salinity. Highest S in straw (0.4675%) was recorded in 12 dSm^{-1} which was followed by 4 dSm^{-1} (0.4238%) and the lowest (0.3475%) was observed in 0 dSm^{-1}. Highest S in root (0.885%) was recorded in 4 dSm^{-1} which was followed by 8 dSm^{-1} (0.762%) and the lowest (0.620%) was observed in 0 dSm^{-1}. S in grain was highest (0.3338%) in 4 and 8 dSm^{-1} and the lowest (0%) was observed in 12 dSm^{-1} (Table 4.7).

4.13.1 Effect of potassium

Sulphur (S) content (%) in straw, root and grain of BINA dhan 8 were affected significantly by the various fertilization types of potassium. Highest S in straw (0.4525%) was recorded in K_4 and the lowest (0.3625%) was observed in K_2. Highest S in root (0.7675%) was recorded in K_4

which was closely followed by K_1 (0.7400%) and the lowest (0.6675%) was observed in K_4. S in grain was highest (0.2612%) in K_3 and the lowest (0.2262%) was observed in K_1 (Table 4.8).

4.13.3 Interaction effect of salinity and potassium

Sulphur (S) content (%) in straw, root and grain of BINA dhan 8 were affected significantly by the interaction effect of salinity and potassium. Highest S in straw (0.750%) was recorded in S_3K_4 and lowest (0.280%) in S_1K_4. Highest S in root (0.890%) was recorded in S_1K_1 and S_1K_4 while lowest (0.390%) in S_1K_4. Highest S in grain (0.400%) was recorded in S_1K_3 and S_2K_4 while lowest (0%) in all foliar and soil application of potassium while treated with 12 dSm^{-1} as no plants survived to produce any grain at all (Table 4.9).

4.14 Sodium content in straw, root and grain (%)

4.14.1 Effect of salinity

Sodium (Na) content (%) in straw, root and grain of BINA dhan 8 were affected significantly by the various levels of salinity. Highest Na in straw (7.957%) was recorded in 12 dSm^{-1} and the lowest (0.3988%) was observed in 0 dSm^{-1}. Highest Na in root (0.6850%) was recorded in 8 dSm^{-1} which was followed by 4 dSm^{-1} (0.6300%) and the lowest (0.5350%) was observed in 0 dSm^{-1}. Na in grain was highest (0.3575%) in 4 and 8 dSm^{-1} and the lowest (0%) was observed in 12 dSm^{-1} (Table 4.7).

4.14.2 Effect of potassium

Sodium (Na) content (%) in straw, root and grain of BINA dhan 8 were affected significantly by the various fertilization types of potassium. Highest Na in straw (4.068%) was recorded in K_3 and the lowest (3.855%) was observed in K_2. Highest Na in root (0.7650%) was recorded in K_4 which was closely followed by K_4 (0.6175%) and the lowest (0.4675%) was observed in K_3. Na in grain was highest (0.2488%) in K_1 and the lowest (0.1825%) was observed in K_3 (Table 4.8).

4.14.3 Interaction effect of salinity and potassium

Sodium (Na) content (%) in straw, root and grain of BINA dhan 8 were affected significantly by the interaction effect of salinity and potassium. Highest Na in straw (8.200%) was recorded in S_3K_4 and lowest (0.310%) in S_0K_4. Highest Na in root (1.11%) was recorded in S_2K_1 while lowest (0.330%) in S_0K_3. Highest Na in grain (0.630%) was recorded in S_1K_1 while lowest (0%) in all foliar and soil application of potassium while treated with 12 dSm^{-1} as no plants survived to produce any grain at all (Table 4.9).

4.15 Potassium content in straw, root and grain (%)

4.15.1 Effect of salinity

Potassium (K) content (%) in straw, root and grain of BINA dhan 8 were affected significantly by the various levels of salinity. Highest K in straw (1.538%) was recorded in 0 dSm^{-1} which was followed by 4 dSm^{-1} (1.072%) and the lowest (0.815%) was observed in 12 dSm^{-1}. Highest K in root (0.6150%) was recorded in 0 dSm^{-1} which was followed by 4 dSm^{-1} (0.52%) and the lowest (0.4925%) was observed in 0 dSm^{-1}. K in grain was highest (0.3900%) in 4 dSm^{-1} and the lowest (0%) was observed in 12 dSm^{-1} (Table 4.7).

4.15.1 Effect of potassium

Potassium (K) content (%) in straw, root and grain of BINA dhan 8 were affected significantly by the various fertilization types of potassium. Highest K in straw (1.279%) was recorded in K_4 and the lowest (0.951%) was observed in K_2. Highest K in root (0.7575%) was recorded in K_1 which was closely followed by K_4 (0.6525%) and the lowest (0.260%) was observed in K_2. Potassium in grain was highest (0.2738%) in K_1 and the lowest (0.2075%) was observed in K_4 (Table 4.8).

4.15.3 Interaction effect of salinity and potassium

Potassium (K) content (%) in straw, root and grain of BINA dhan 8 were affected significantly by the interaction effect of salinity and potassium. Highest K in straw (1.775%) was recorded in S_0K_4 and lowest (0.425%) in S_2K_2. Highest K in root (0.790%) was recorded in S_0K_1 while lowest

(0.150%) in S_2K_2. Highest K in grain (0.500%) was recorded in S_1K_1 while lowest (0%) in all foliar and soil application of potassium while treated with 12 dSm^{-1} as no plants survived to produce any grain at all (Table 4.9).

Table 4.7. Effect of salinity on P, S, Na and K content in straw, root and grain of BINA dhan 8

Treatment	P in straw	P in root	P in grain	S in straw	S in root	S in grain	Na in straw	Na in root	Na in grain	K in straw	K in root	K in grain
S_0	0.09125 ab	0.1702b	0.179	0.3475c	0.620 d	0.3212 a	0.3988 d	0.5625 c	0.0950 b	1.538 a	0.6150a	0.3688b
S_1	0.07950 b	0.2582a	0.186	0.4238b	0.885 a	0.3338 a	1.849 c	0.6300 b	0.3575 a	1.072b	0.5200b	0.3900a
S_2	0.08400 ab	0.1955b	0.118	0.4025b	0.762 b	0.3338 a	5.690 b	0.6850 a	0.3575 a	0.937c	0.5050b	0.1912c
S_3	0.1230 a	0.2375a	0.000	0.4675a	0.640 c	0.0000 b	7.957 a	0.5350 c	0.0000 c	0.815d	0.4925b	0.0000d
LSD	0.04109	0.02905	0.0711	0.0430	0.0183	0.0129	0.0225	0.04109	0.0711	0.02905	0.03437	0.01363
CV%	2.3	6.7	10.2	9.6	5.42	3.93	2.6	6.76	11.9	14.3	2.69	3.97
Level of significance	8	**	ns	**	**	**	**	*	**	*	*	*

*=Significant at 5% level, **= Significant at 1% level

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Table 4.8. Effect of different fertilization methods of potassium on P, S, Na and K content in straw, root and grain of BINA dhan 8

Treatment	P in straw	P in root	P in grain	S in straw	S in root	S in grain	Na in straw	Na in root	Na in grain	K in straw	K in root	K in grain
K_1	0.0750b	0.198b	0.1178	0.4363b	0.7400ab	0.2262b	3.960c	0.7650a	0.2488a	1.006c	0.7575a	0.2738a
K_2	0.08725b	0.2002b	0.1203	0.3625d	0.7675a	0.2575ab	3.855d	0.5625c	0.1925b	0.9512d	0.260d	0.2412b
K_3	0.1377a	0.2237a	0.1203	0.3900c	0.7325b	0.2612a	4.068a	0.4675d	0.1825b	1.126b	0.4625c	0.2275bc
K_4	0.07775b	0.2395a	0.1252	0.4525 a	0.6675c	0.2438ab	4.012b	0.6175b	0.1863b	1.279a	0.6525b	0.2075c
LSD	0.01363	0.0225	0.0197	0.01481	0.02905	0.03437	0.0188	0.04684	0.02	0.0228	0.0259	0.03209
CV%	2.3	6.7	10.2	9.6	5.42	3.93	2.6	6.76	11.9	14.3	2.69	3.97
Level of significance	*	*	ns	**	*	*	*	*	*	*	*	*

*=Significant at 5% level, **= Significant at 1% level

K_1 = Total soil application of MoP fertilizer, K_2 = 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4 =Total foliar spray of MoP fertilizer

Table 4.9. Interaction effect of salinity level and different fertilization methods of potassium on P, S, Na and K content in straw, root and grain of BINA dhan 8

Treatment		P in straw	P in root	P in grain	S in straw	S in root	S in grain	Na in straw	Na in root	Na in grain	K in straw	K in root	K in grain
S_0	K_1	0.015 cd	0.171 de	0.173 a-c	0.335 c-e	0.700 cd	0.350i	0.580e	0.0250i	0.295cd	1.250e	0.790a	0.395b
	K_2	0.070b-d	0.175 de	0.180 a-c	0.350 c-e	0.720 c	0.455i	0.660c	0.110h	0.360ab	1.425c	0.250fg	0.355bc
	K_3	0.270 a	0.155 e	0.180 a-c	0.400 c-e	0.670 d	0.480i	0.330j	0.155g	0.350abc	1.700b	0.660c	0.400b
	K_4	0.010 d	0.180 de	0.182 a-c	0.305 de	0.390 f	0.310i	0.68c	0.0900h	0.280d	1.775a	0.760ab	0.325bc
S_1	K_1	0.075 bc	0.230 a-d	0.202 a	0.610 ab	0.890 a	1.47h	0.820b	0.630a	0.305bcd	1.050g	0.800a	0.500a
	K_2	0.080 b	0.255 a-c	0.155 b-d	0.445 cd	0.880 a	2.195f	0.490 h	0.310d	0.335bcd	0.9000i	0.220gh	0.400b
	K_3	0.071b-d	0.280 a	0.191 a	0.360 c-e	0.880 a	1.900g	0.610 d	0.230f	0.400a	0.8100j	0.450de	0.305c
	K_4	0.092 b	0.268 ab	0.196 ab	0.280 e	0.890 a	1.829g	0.600de	0.260e	0.295cd	0.9900h	0.500d	0.355bc
S_2	K_1	0.076 bc	0.191 c-e	0.110 de	0.440 cd	0.700 cd	6.110c	1.11a	0.340c	0.305bcd	0.9250i	0.800a	0.200d
	K_2	0.092 b	0.151 e	0.0960 e	0.295 e	0.800 b	4.960e	0.610d	0.350c	0.335bcd	0.4250k	0.150h	0.210d
	K_3	0.076 bc	0.210 b-e	0.145 cd	0.400 c-e	0.880 a	5.980c	0.410i	0.345c	0.295 cd	0.9100i	0.420e	0.205d
	K_4	0.092 b	0.230 a-d	0.110 de	0.475 bc	0.670d	5.710d	0.610d	0.345c	0.400 a	1.000h	0.710bc	0.150d
S_3	K_1	0.134 b	0.200 b-e	0.000 f	0.360 c-e	0.670 d	7.910b	0.550 f	0.000 i	0.000 e	0.8000j	0.640c	0.000e
	K_2	0.107 b	0.220 a-e	0.000 f	0.360 c-e	0.670 d	7.810b	0.490 h	0.000i	0.000 e	1.055fg	0.420e	0.000e
	K_3	0.134 b	0.250 a-c	0.000 f	0.400 c-e	0.500 e	7.910b	0.520 g	0.000i	0.000 e	1.085f	0.320f	0.000e
	K_4	0.117 b	0.280 a	0.000 f	0.750 a	0.720 c	8.200a	0.580 e	0.000i	0.000 e	1.350d	0.640c	0.000e
LSD		0.064	0.069	0.04575	0.142	0.0376	0.0643	0.185	0.029	0.02598	0.03398	0.0779	0.08262
CV%		2.3	6.7	10.2	9.6	5.42	3.93	2.6	6.76	11.9	14.3	2.69	3.97
Level of significance		*	*	*	**	*	*	*	*	**	**	*	*

*=Significant at 5% level, **= Significant at 1% level

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

K_1= Total soil application of MoP fertilizer, K_2= 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

Chapter 5
Summary and Conclusion

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SUMMARY AND CONCLUSION

An experiment was conducted at the net house of the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka-1207 under pot-culture during the Boro season (December-June) of the year 2013-14 to study the reclamation of salinity by potassium fertilization methods. The experiment was completed using 4 salinity levels (0, 4, 8 and 12 dS m^{-1}) and 4 potassium fertilization processes (K_1 = Total soil application of MoP fertilizer, K_2 = 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4 =Total foliar spray of MoP fertilizer).BINA dhan 8 was used as variety. Data were taken on plant height, number of leaves $hill^{-1}$, root length, dry weight of stem and root, number of effective tiller $hill^{-1}$, number of panicle $hill^{-1}$, number of filled and unfilled grain $hill^{-1}$, weight of filled grain $hill^{-1}$, thousand grain weight, grain yield $hill^{-1}$ and P, K, S, Na content in straw, root and grain of the selected rice cultivar.

Significant variation was found in most of the parameters due to effect of different salinity levels. As the level of salinity increased almost all the growth and yield parameters showed declining tendency except number of unfilled grain $hill^{-1}$ who showed an opposite trend. Plant height, number of leaves $hill^{-1}$, root length, dry weight of stem and root, number of effective tiller $hill^{-1}$, number of panicle $hill^{-1}$, number of filled grain $hill^{-1}$, weight of filled grain $hill^{-1}$, thousand grain weight, grain yield $hill^{-1}$ were found highest in 0 dS m^{-1} and lowest in 12 dS m^{-1}.

Most of the growth and yield parameters varied significantly due to different foliar and soil fertilization of potassium. The highest plant height and highest number of leaves $hill^{-1}$ at 30 DAT, 60 DAT and at harvest were given by 2/3rd foliar spray and 1/3rd soil application of total MoP fertilizer and the shortest plant & lowest number of leaves $hill^{-1}$ were obtained in total soil application of MoP fertilizer. Same trend was observed for root length. The dry weight of stem of BINA dhan 8 differed non-significantly due to the different sorts of K application. The highest dry weight of root was given by total foliar spray of MoP fertilizer. The lowest root dry weight was obtained from total soil application of MoP fertilizer. Different methods of MoP application not showed any significant variation among them for number of effective tillers $hill^{-1}$. The highest number of panicles $hill^{-1}$ was given by 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer. The lowest number of panicles $hill^{-1}$ was obtained from total soil application of MoP fertilizer. The highest number of grains $panicles^{-1}$ was given by 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer. The lowest number of grains $panicles^{-1}$ was obtained from total soil application of MoP fertilizer. The highest number of filled grains $hill^{-1}$ was given by 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer. The lowest number of filled grains $hill^{-1}$ was obtained from total soil application of MoP fertilizer. The highest number of unfilled grains $hill^{-1}$ was given by 1/3 rd foliar spray and 2/3 rd soil application of total MoP fertilizer. The lowest number of unfilled grains $hill^{-1}$ was obtained from 2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer. The highest dry weight of filled grains $hill^{-1}$ was given by 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer. The lowest dry weight of filled grains $hill^{-1}$ was obtained from total soil application of MoP fertilizer. The highest 1000-grain weight was given by 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer. The lowest 1000-grain weight was obtained from total soil application of MoP fertilizer. The highest grain yield $hill^{-1}$ was given by 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer. The lowest grain yield $hill^{-1}$ was obtained from total soil application of MoP fertilizer.

All the growth and yield parameters were significantly affected by the interaction effect of salinity and fertilization methods of potassium. It was observed that at higher levels of salinity like 4 and 8 dS m^{-1}, 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer gave better results compared to others. The highest number of filled grains $hill^{-1}$, highest dry weight, highest 1000-grain weight, highest grain yield $hill^{-1}$ were recorded in 0 dSm^{-1} treated with 2/3 rd foliar spray and 1/3 rd soil application of total MoP fertilizer. In later growth stages no plants were survived to give any yield at maximum salinity level (12 dS m^{-1}).

P, S, K and Na content in straw, root and grain varied significantly most of the cases. But in most of the cases no specific pattern was found. Though it was observed that Na content increased and K content decreased with increasing salinity level. Foliar spray along with soil application of MoP fertilizer showed better results while combined with salinity.

From the above results it can be concluded that,

- Salinity adversely affects all the growth and yield related attributes of BINA dhan 8.
- Use of potassium alleviated the adverse effects of high salinity till 8 dSm^{-1} on rice plant and improved all traits mentioned above.
- High NaCl induced potassium deficiency in rice plant.
- Foliar spray along with soil application of MoP fertilizer gave better performance while treated with salinity compared to sole foliar spray or soil applications.

From above conclusions, the following recommendations can be made:

- Farmers of saline areas can perform this technique to ameliorate salinity.
- Studies are needed to find out the grain protein content and other quality attributes of rice.
- Such studies should be carried out to different saline prone areas of the country.

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Chapter 6

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Appendices

APPENDICES

Appendix I. The effect of different salinity levels on plant height and number of leaves $hill^{-1}$ of BINA dhan 8

Treatment	Plant height(cm)			Number of leaves $hill^{-1}$		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
S_0	44.08a	67.12a	83.58a	25.67a	38.75a	17.17a
S_1	43.74a	61.92b	77.82b	19.25b	21.58b	13.75b
S_2	43.72a	58.41c	71.64c	18.58b	14.00c	3.750c
S_3	39.97b	51.33d	0.0d	16.17c	3.333d	0.0d
LSD	1.300	1.443	1.638	1.615	2.295	2.641
CV%	6.36	4.53	3.99	13.87	17.79	22.28
Level of significance	**	**	**	**	**	*

*=Significant at 5% level, **= Significant at 1% level

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Appendix II. The effect of different foliar and soil fertilization of potassium on plant height and number of leaves $hill^{-1}$ of BINA dhan 8

Treatment	Plant height(cm)			Number of leaves $hill^{-1}$		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
K_1	39.03c	55.81c	54.83b	17.00c	16.83b	7.250
K_2	42.37b	58.67b	57.63ab	20.67ab	19.25ab	8.917
K_3	46.72a	63.42a	61.47a	22.58a	21.33a	9.417
K_4	43.40b	60.88b	59.13ab	19.42b	20.25a	9.083
LSD	1.907	2.288	4.329	2.262	2.914	2.722
CV%	6.36		3.99	13.87	17.79	22.28
Level of significance	**	**	**	*	*	ns

*=Significant at 5% level, **= Significant at 1% level

K_1 = Total soil application of MoP fertilizer, K_2= 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4=Total foliar spray of MoP fertilizer

Appendix III. The effect of different salinity levels on root length, dry weight of stem and dry weight of root of BINA dhan 8

Treatment	Root length(cm)	Dry weight of stem(g)	Dry weight of root(g)
S_0	32.25a	13.36a	9.067a
S_1	29.50ab	11.31a	5.724b
S_2	27.67b	6.744b	2.242c
S_3	20.17c	2.846c	0.5883d
LSD	2.938	2.944	1.373
CV%	8.26	23.63	6.53
Level of significance	**	*	**

*=Significant at 5% level, **= Significant at 1% level

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Appendix IV. The effect of different foliar and soil fertilization of potassium on root length, dry weight of stem and dry weight of root of BINA dhan 8

Treatment	Root length(cm)	Dry weight of stem(g)	Dry weight of root(g)
K_1	25.04b	8.205a	3.507b
K_2	27.29ab	8.043a	4.762ab
K_3	29.17a	9.060a	3.747ab
K_4	28.08a	8.954a	5.603a
LSD	2.497	2.417	1.322
CV%	8.26	23.63	6.53
Level of significance	**	*	*

*=Significant at 5% level, **= Significant at 1% level

K_1 = Total soil application of MoP fertilizer, K_2 = 1/3 rd foliar spray, 2/3 rd soil application of total MoP fertilizer, K_3=2/3 rd foliar spray, 1/3 rd soil application of total MoP fertilizer, K_4 =Total foliar spray of MoP fertilizer

Appendix V. The effect of different salinity levels on number of effective tillers hill^{-1}, grains hill^{-1}, filled grains hill^{-1} and unfilled grains hill^{-1} of BINA dhan 8

Treatment	Number of effective tillers hill^{-1}	Number of grains hill^{-1}	Number of filled grains hill^{-1}	Number of unfilled grains hill^{-1}
S_0	6.833a	632.1a	433.5a	183.3b
S_1	6.583a	421.1b	214.3b	208.0a
S_2	2.250b	148.3c	51.25c	88.58c
S_3	0.0c	0.0d	0.0d	0.0d
LSD	1.158	9.307	7.484	7.086
CV%	24.44	16.44	2.38	4.58
Level of significance	**	**	**	**

*=Significant at 5% level, **= Significant at 1% level

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}

Appendix VI. The effect of different foliar and soil fertilization of potassium on number of effective tillers hill^{-1}, grains hill^{-1}, filled grains hill^{-1} and unfilled grains hill^{-1} of BINA dhan 8

Treatment	Number of effective tillers hill^{-1}	Number of panicles hill^{-1}	Number of grains panicles^{-1}	Number of filled grains hill^{-1}	Number of unfilled grains hill^{-1}
K_1	3.333a	3.167b	271.4c	133.8d	125.1b
K_2	3.833a	4.000a	299.2b	173.7c	146.7a
K_3	4.500a	4.167a	329.9a	202.4a	83.42 c
K_4	4.000a	4.083a	300.9b	189.3b	124.8b
LSD	1.660	0.2469	9.397	8.929	8.117
CV%	24.44	23.39	16.44	2.38	4.58
Level of significance	*	*	*	**	*

*=Significant at 5% level, **= Significant at 1% level

S_0=0 dSm^{-1}, S_1= 4 dSm^{-1}, S_2=8 dSm^{-1} and S_3=12 dSm^{-1}