GERMINATION, SEEDLING GROWTH AND WATER RELATION BEHAVIOR OF WHEAT GENOTYPES AS AFFECTED BY SALT STRESS

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CERTIFICATE

This is to certify that the thesis entitled, "**GERMINATION, SEEDLING GROWTH AND WATER RELATION BEHAVIOR OF WHEAT GENOTYPES AS AFFECTED BY SALT STRESS**"submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **MD. MAHAMUDUL HASAN**bearing Registration No. 10-03849 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 been duly acknowledged.

Date:

Place: Dhaka, Bangladesh

Prof. Dr. Md. Abdullahil Baque

Research Supervisor

Dedicated To

My Beloved Parents

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ABSTRACT

For Screeningsalt tolerance of wheat genotypes through germination and seedling growth characters were used as screening test criteria against salt stress. Wheat genotypes (33) were tested under 5 different salt concentrations (0, 5, 10, 15 and 20 dSm^{-1}) at central laboratory, Sher-e-Bangla Agricultural University, Dhaka-1207, during February to March, 2016. The experiment was conducted in a complete randomize design (CRD) with 5 replications. The results of the experiment revealed that, germination and seedling growth parameters of wheat genotypes varied significantly under salt stress. A marked reduction on germination rate, shoot and root length, shoot and root dry weight, relative water content, water retention capacity and vigour indexwere observed with increasing of salt concentration for most of the wheat genotypes except ESWYT-5, ESWYT-6 and BARI GOM 28. ESWYT-5, ESWYT-6 and BARI GOM 28 showed consistently better performance against salt stress and there were a slow linear reduction observed with the increasing of salt concentration from 0 to 20 dSm^{-1}. So the ESWYT-5, ESWYT-6 and BARI GOM 28 could be recommended as salt tolerant genotype against moderatesaline conditions.

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ABBREVIATIONS AND ACRONYMS

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

CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important cereal crop and ranks first globally and second in Bangladesh both in terms of production and acreage (Anonymous, 2010). It is a staple food crop for more than one third of the world population (Shirazi *et al*., 2001). By 2050 the world population will be about 9.10 billion, which will be 34% higher from today and we need to feedanother2.30 billion people with limited resources. Food production must need to be increased about 70% and to meet this huge demand cereal production will need to increase about 3 billion metric tons from 2.10 billion metric tons today. But in a dilemma, the world agriculture in 21^{st} century faces versatile challenges (SRDI, 2010).

In Bangladesh, the area under wheat cultivation during 2013-2014 was about 1061602 acres producing 1302998 M tons with an average yield of 1233 kg acre-1 (BBS, 2014).The present population of Bangladesh will progressively increase to 223 million by 2030 requiring 48.0 million tons of food grains (Karim *et al*., 1990). Owing to population pressure the cultivable area is decreasing in the country day-by-day, and this problem will gradually but soon be acute.

Soil salinity is one of the major abiotic stresses which directly affect plants physiology causing drastic reduction of crop production. World’s 25% cultivable lands are salinity affected among 400 million ha of total land and the salt intrusion scenario is alarmingly increasing. Bangladesh is also not beyond this threat. In Bangladesh the salinity affected area was 83.3 million ha in 1973, 102 million ha in 2000 and in 2009 it has reached up to 105.5 million ha and the area is being expanded with times being Soil Resource and Development Institute (SRDI, 2010). The dramatic increasing of saline area is caused by rise of the sea levels due to global warming.

Salinity as a major abiotic stressors which hinder crop production. It creates and adversely impacts the socio-economic condition of many developing countries including Bangladesh. In Bangladesh, over 30% of the net cultivable areas lie in the coastal zone close to the Bay of Bengal of which approximately 53% are affected by varying degrees of salinity (Haque, 2006). Ali (2011) showed that the salt-affected areas in the coastal region of Bangladesh increased sharply, by 26.71%, to 950,780 hectares in 2009 from 750,350 hectares in 1973. Agricultural land use in salt affected areas is very poor in respect of crop production (Petersen and Shireen, 2010). Most of the high yielding salt sensitive crop might not be suitable for cultivation in the existing cropping pattern.

So to feed the huge population of Bangladesh, food production in saline areas must be increased. There are two ways to grow crops successfully in the salt affected area. The first one is to identify salt tolerant crops or varieties and the second one is the reclamation of the salt affected land. The reclamation procedures such as land levelling, surface and sub-surface drainage, soil amendments and improved irrigation practices for salt leaching are expensive and require continuous management (Ashraf *et al*., 1990).

Wheat is cultivated over a wide range of environments, because of wide adaptation to diverse environmental conditions. It is a moderately salt-tolerant crop (Moud *et al*., 2008). Wheat crop is mainly cultivated in the north and north-west part of Bangladesh. A vast area of cultivable land of the coastal region remains fallow (seasonal or complete) and the dominant cropping pattern of there is fallow-aman-fallow. At low or moderate soil salinity, decreased growth is primarily associated with a reduction in photosynthetic area rather than a reduction in photosynthesis per unit leaf area (Munns, 1993). At high salinity, however, leaf photosynthesis can be reduced by lower stomata conductance, reduced carboxylase activity, limited tissue CO_2 availability and inhibition of light reaction mechanism (Brugnoli and Lauteri, 1991; Munns, 1993). In addition, the transport of photosynthates in the phloem may be inhibited (Jyengar and Reddy, 1994).

Salinity reduces the growth of wheat plant by reducing the plants ability to absorb water from soil. Salinity also disturbs the physiology of plants by changing the metabolism of plants (Garg *et al*., 2002). Wheat under saline conditions increases the concentration of proline and sugar resulting in significant increase of electrolyte leakage at 10 and 15 dSm-1 (Khatkar *et al*., 2000). It has been reported that increase in salinity concentration brings about decrease in relative growth rate, net assimilation rate, K^+ and Ca_2^+ concentration, and grain yield of wheat, but causes an increase in Na+ and Cl- levels, this might be due to increase in Na^+/K^+ ratio in grain and straw at tillering stage (Chhipa *et al*., 1995; El-Hendawy *et al*., 2005).

Salinity affects wheat seedling growth by changing phytohormone levels (Shakirova *et al*., 2003). Furthermore, salinity induces reduction in photosynthetic rate and stomatal conductance in wheat. Adding more NaCl increases the action of superoxide dismutase and peroxidase and reduces the transpiration rate in *Triticumaestivum* (Sharma *et al*., 2005). Moreover, increased salinity induces a considerable reduction in height, number of fertile tillers and dry weight of shoots in wheat (Iqbal *et al*., 2005).

The varietal variation in salinity tolerance that exists among crop plant can be used through screening program by exposing target traits for salt tolerance (Kingsbury *et al*., 1984). Physiological tolerance along with some agronomic traits and their relationship with salt tolerance indices could be a feasible means are considered strong enough to be a selection tool in breeding of salt tolerance cultivars (Allakhverdiev *et al*., 2000).

Study of wheat to salinity stress response may be helpful in breeding salt tolerant varieties. With the above facts keeping in view the present investigation was undertaken with following objectives:

i) To determine seed germination, seedling growth and water relation behavior of wheat under salt stress.

ii) To find out the critical salinity tolerance level of wheat genotypes.

iii) To screen out salinity tolerant of wheat.

CHAPTER II

REVIEW OF LITERATURE

Salinity stress is one of the most deleterious abiotic stresses reducing crop production across the world. It is one of the most important stresses limiting crop production in arid and semiarid regions (Saboora, 2006) and it is a great problem in the coastal region of Bangladesh, where a vast area remains fallow for long time. Wheat is an important cereal crops in Bangladesh and it is a great source of carbohydrate and protein. The scientists of Bangladesh are conducting different experiments to adopt different crops in the saline area; wheat is one of them. Some of the countries like Australia, USA, Bangladesh, Pakistan, Sri Lanka etc. are having acute problem with the management of salinity and sustainable crop production. However, soil salinity is not harmful in similar manner for all wheat cultivars. Genetic improvement of salinity tolerance in crop plants is of high importance throughout the world. Very limited research works have been conducted to adapt wheat in the saline area of Bangladesh. An attempt has been made to find out the performance of wheat at different levels of salinity. To facilitate the research works, different literatures have been reviewed in this chapter under the following headings.

2.1 Effects of salinity on different wheat genotypes

Kahrizi *et al*. (2013) carried out a factorial experiment based on completely randomized design with three replications because of importance of durum wheat in human nutrition, identification of morphological and agronomic traits affecting tolerance to salt stress in order to use in selecting tolerant cultivars is essential. Treatments were salinity with three levels as control, 60 and 120 mM and ten durum wheat cultivars including Boomer, PGS, 71135, 61130, 605, C1351, KND, KDM, Haurani and G1252. Results showed that interaction of salinity and cultivars was only significant for number of grains per spike and grain weight per spike. It means that any stress during vegetative growth stages can affect yield through reduction in source to sink ratio. Boomer was the tolerant cultivar in all salinity levels according to final grain weight and C1351 was the most sensitive one. On the other hand, PGS can be grown under sever saline soils because of it high performance under salinity, but under normal conditions does not produce high yield.

Turki *et al*. (2012) found that Salinity is a big constraint to crop quality and production. In the major wheat growing region of the world, wheat growth, yield and quality are affected by salinity. To solve this problem it is necessary to breed tolerant varieties through selection and breeding techniques. An experiment was conducted to determine the salinity impact on grain yield, protein content and thousand kernel weight (TKW) among 55 varieties and accessions of common and durum wheat (16 winter wheat varieties and 39 spring wheat accessions). The results showed that salt treatment (100 mM of NaCl solution) depressed growth and yield production in 45 common and durum wheat varieties. While 6 varieties of durum wheat, 3 accessions of durum wheat and 1 accession of common wheat were insignificantly affected by salinity. The decrease in grain yield might be caused by the salinity, which induced reduction of photosynthetic capacity leading to less starch synthesis and accumulation in the grain. In addition the results showed that winter wheat is more tolerant to salt stress then spring wheat and that durum type of wheat showed more tolerance than common wheat. TKW also decreased in all 10 varieties and accessions regardless of the species by salinity effect.

El Hendawy *et al*. (2005) proved that salinity did not affect final germination percentage, while seeds subjected to 80 and 160 mM Nacl treatment. Salinity affected shoot growth more severely than root growth of seedlings. Height and dry weight of shoot of the genotypes ranked in the same order as their salt tolerance ranking in terms of grain yield, whereas root dry weight did not. So, the measurement of shoot growth may be one of the effective criteria for screening wheat genotypes for salt tolerance at early growth stages.

Barma *et al*. (2011) reported that two lines named BARI GOM 25 and BARI GOM 26) were selected for commercial production in the southern belt. BARI GOM 25 showed a good level of tolerance to salinity.

Hameed *et al*. (2009) conducted an experiment with two wheat genotypes differing in salt tolerance and observed that the 3 days old wheat seedlings were subjected to 5, 10 and 15 dSm^{-1} NaCl salinity for 6 days, application of low salinity ($5dSm^{-1}$) growth was suppressed even in tolerant genotype. The cv. Lu-26, exhibited a better protection mechanism against salinity as indicated by lower salt induced proteolysis, higher biomass accumulation and protein contents than the relatively sensitive cv. Pak-81.

Datta *et al*. (2009) undertook an experiment with five varieties of wheat viz., HOW-234, HD-2689, Raj-4101, Raj-4123, and HD-2045 varying the salinity levels to (0, 25, 50, 75, 100, 125, 150mM NaCl). They observed that different level of salinity significantly affected the growth attributes by reducing root and shoot length for salinity below 125mM. Fresh weight and dry weight of root and shoot were reduced significantly with subsequent treatment. Maximum germination was found in variety HD2689 in all the tratments and maximum inhibition was found to be in case of HOW234 variety at 150mM salilnity level.

Rahman *et al*. (2008) conducted an experiment with four cultivars of wheat (*Triticum aestivum* L.) to NaCl salinity treatments measuring 0.00, -2.457, -4.914, and -14.742 bars at germination and early seeding growth stage. They observed that water uptake and germination decreased in all cultivars. Increased salt concentration also affected the early seedling growth. Among the cultivars under investigation Zarlasht cultivar appeared to be more sensitive at germination stage.

Tammam *et al*. (2008) conducted a pot experiment with salt tolerance wheat cv. Banysoif-1. Seedlings were irrigated by different saline waters (0, 60,120,180,240 and 320 mM NaCl). They observed that fresh and dry weight of roots was unchanged up to the level of 120 mM NaCl then a significant reduction obtained at 240 and 320 mM NaCl. In shoots and spikes, dry matters were either unchanged or even stimulated to increase toward 180 mM NaCl then a quick reduction was observed.

Akhtar *et al*. (2002) conducted an experiment for the screening of wheat and wheat *Thinopyrum amphiploids* that can produce good yields under saline and water logged conditions.

Rajpar and Sial (2002) conducted a pot experiment with eight varieties of wheat such as Khar-chia-65, Anmol, NIAB-20, PAI-81, TW161, Bakhtwar, KTDH-19 and SARC-l. They observed that under salinity condition up to EC 19 dSm^{-1}, plant height, shoot dry weight and root length were decreased.

Singh *et al*. (2000) reported from a study that seeds of 20 wheat varieties were subjected to salinity stress during seedling growth along with the control. The salinity levels used were 0.0% (control) and 0.5% with corresponding EC values of 2.8 and 20.8 dSm^{-1} respectively. Seedling growth declined under salinity stress. The genotypes Raj-3077 and Kharchia-65 were tolerant to salinity with respect to seedling vigour while Raj-4530 and Raj-3934 were most susceptible genotypes under salinity.

Flagella *et al*. (2000) evaluated the effect of salinity on grain yield and yield components of durum wheat cv. Duilio subjected to the salinity levels of 0.5, 6, 12; 18 and 24 dSm^{-1} in a growth chamber. The changes in photosynthetic activity were not related to changes in leaf turgor. With regard to photosynthesis and grain yield, durum wheat was moderately resistant to salinity showing significant damages only when irrigation water with EC of 12 dsm^{-1} or higher was used.

Rahman *et al*. (1989) conducted an experiment in the glasshouse of BINA to screen out tolerant cultivars of wheat & barley. Results of the experiment indicated that all the crops, particularly wheat cultivars "Akbar" & "Kanchan," produced higher dry matter yield in varying degrees of salinity conditions created by mixing a saline soil of Shatkhira region. They reported that all these crops can be successfully grown in the salt affected areas of Bangladesh.

Chopra *et al*. (1997) conducted a field experiment with 6 wheat cultivars which were irrigated with water having salinity levels of 4.0 (control), 6.0, 7.0 and 12.0 dSm^{-1}. Grain yield decreased with increasing salinity level. The cv. Kharachia- 65 and IID-2189 were found the most salt tolerant.

Kumar *et al*. (1988) conducted a pot experiment where wheat areas grown in saline soil and irrigated with normal or saline water (8 or 12 irrigation with water containing caber ion ratios mmhos cm^{-1}) at Cl: S04 ratio of 1:1, 9:l Increasing salinity of the soil with water at l:l ratio gave markedly higher yield than that crop irrigation with water containing other ion ratios.

Akram *et al*. (2002) studied in a pot experiment the effect of salinity (10, 15, 20 dSm^{-1}) on the yield and yield components of salt tolerant (234/2), mediumresponsive (243/1), and susceptible (Fsd 83) wheat varieties. They reported that salinity reduced the spike length, number of spikelets $spike^{-1}$, number of grains $spikelet^{-1}$, 1000-grains weight, and yield per plant of all the varieties but the susceptible variety was affected the most adversely.

Noaman (2000) conducted a pot experiment with four durum wheat, (*Triticum turgidum* lines .133. 146, 56 and 83) with kanal transferred from *Tritcum aestivum* cv. Sakha-8 (control), Hordeum vulgarae cv. Giza (control), *Triticum turgidum* cv. Langdon (LDN) and recombinant DS4D (LDN4B), which were grown at 3 levels of salinity (2, 4 and 8g $liter^{-1}$). He reported that increasing salinity affected plant height in most lines (24.5% reduction). Increasing salinity levels had no significant effect on the number of days from planting to booting, heading or flowering, even though differences among genotypes were significant. The DS4D (LDN 413) had the highest biological yield and grain yield under all salinity than the lines 133, 146 and 83 of *Triticum turgidum* cv.Langdon (LDN) which showed the greatest sensitivity to salinity.

Ehsan *et al*., (1994) conducted a pot experiment having salinity levels of 2.0, 7.5, 15 and 22.5 mmhos cm^{-1} where they used wheat cv. Chenab-79, V-5444 and Layllpur-73 as a test crop. They reported that increasing salinity resulted reduction in plant height, dry matter and grain yield. All the cultivars failed to set seeds at the highest salinity level.

Khan (2007) conducted an experiment and observed that maximum plant heights, shoot fresh and dry weight were high at control salinity level and at high salinity level (10dSm^{-1}) had a negative effect on these parameters. Yield and yield components of various genotypes were significantly reduced due to the exposure of plants to various salinity levels. Among genotypes, SR-40 and SR-23 performed better than the other genotypes under study when exposed to various salinity levels.

Barrett-lennard (1988) conducted a Greenhouse experiment with wheat and observed that under moderately saline soil, 7days of water logging condition increased Na content by >200 percent in shoot. In a second experiment wheat was grown under either drained or water logged condition for 33 days with 0, 22 or 120 mM NaCl. A visual assessment showed that drained plants were healthy even with 120 mM NaCl.

Gawish *et al*. (1999) studied the responses of status and translocation of Na, Cl, N and production for both shoots and roots of two wheat varieties differing in salt tolerance, Giza-164 as a relatively salt tolerant and Sakha-69 as a relatively salt sensitive variety to salinity. The plants were treated with NaCl, CaCl or their mixture at a level of 50, 750, 1500 or 3000 ppm, after the 1st leaf had emerged. The status of Na and Cl positively responded in shoots. The rate of translocation for the different ions was higher under salinity conditions, particularly in relatively salt tolerant plants presumably due to osmotic adjustment as to reduce the adverse effect on root growth.

Halim *et al*. (1988) conducted a pot experiment with Maxipak wheat growth in soil salanized by the addition of MgSO4: NaCl : $CaCl_2$ (5: 2: 3respectively). The salinity level of EC 1.7, 4.2, 5.8, 9.4 and 11.0 dSm^{-1} were used at 25, 50 and 75 percent level of available soil moisture depletion. They observed that soil water decreased the soil salinity increased, the dry matter per plant, plant height, tiller or spike number per plant were decreased at all the growth stages. Grain yield, grain number and root dry matter decreased. Root growth show the greatest sensitivity to soil salinity.

Kemal-ur-Rahim (1988) carried out an experiment with 4 winter wheat cultivars grown in a culture solution where he failed to observe any adverse effects of salinity, up to 75 mM NaCl but greater than 120 mM NaCl was sufficient to jeopardize survival of the crop in salt sensitive cultures. Salinity had little effect on photosynthesis but a large effect on grain yield and dry matter production was noticed. It increased root:shoot ratio, stomatal density and specific leaf weight.

Bouaounia *et al*. (2000) studied the salt tolerance of durum wheat (*Triticum turgidum*). They observed decreased growth of whole plants, delayed emergence of new leaves and limited K^+ and Ca^{++} accumulation in these organs under NaCl treated soil salinity. Moreever, Na^+ accumulation decreased from older to younger leaves. Cellular dry matter production was not much affected in spite of a drop in cellular water content. Depressive effects of K^+ and Ca^{++} accumulation were evident while Na^+ cellular accumulation increased with NaCl concentration. These results suggest that wheat has mechanisms to restrict Na^+ transport and accumulation in younger leaves.

Gupta and Shrivastava (1989) also observed in a sand culture trial that the effects of ionic osmotic stress alone and in comnination with NaCl, tow wheat cultivars differed significantly. They observed Karicha-65(tolerant) was superior to Kalayansona (susceptible) in maintaining higher leaf area and root growth under both types of stress. They had the opinion the salinity stress was less injurious than osmotic ionic stress.

Islam and Salam (1996) conducted a pot experiment. The variety Pokkali, BINA 19, BINA 13 and IRATOM 24 were grown in nutrient solutions with different salinity levels (control, 0.9% NaCl). The biomass of BINA 19 was not affected with increased salinity. The biomass of Pokkali and IRATOM 24 decreased with increase in salinity.

Mohammad *et al*. (1995) conducted an experiment with five wheat lines (PK-15869, PK-15885, PL-16171, PK-16172 and PK-16187) under saline condition. These lines were tested for salt tolerance in the presence of specific ions (Na^+, Ca^{++}, Cl^-, SO_4^{--}). The seeds were germinated on agar medium containing varying salt concentrations (EC0,5,10,20,25 and 30 dSm^{-1}). The genotypes PK-16171 showed the highest percentage germination, shoot length, plant fresh weight and dry matter yield under different salinity levels. Fresh and dry weights of plants were reduced in the presence of salinity in majority of the trails. Two genotypes, PK-15885 and PK-16171 showed salt tolerance.

2.2 Effect of salinity on morphological characters of plant

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

Akbari-Ghogdi *et al*. (2012) studied the effect of salt stress on some physiological traits of wheat (*Triticum aestivum* L.) was studied in a factorial experiment based on completely randomized design with three replications, under greenhouse condition. Salinity treatments carried out in four levels (1.3 dS m^{-1} as control, 5, 10, 15 dS m^{-}1) via calcium chloride and sodium chloride with 1:10 (Ca^{2+}:Na^{+} ratio). Wheat genotypes included four cultivars, Sistani and Neishabour as tolerant cultivars, and Tajan and Bahar as sensitive cultivars. Chlorophyll content (CHL), Leaf relative water content (RWC), sodium and potassium contents, and also K^{+}/Na^{+} ratio were measured at tillering and flowering stages, Total grain yield and yield components were determined. Salinity stress decreased relative water content (RWC), K^{+} content, K^{+}/Na^{+} ratio and grain yield; however Na^{+} content in all the genotypes and in both stages were increased. CHL content increased at tillering stage while it is decreased at flowering stage. Sistani and Neishabour cultivars had more amounts of K^{+} content, K^{+}/Na^{+} ratio and RWC under salt conditions, at tillering stage Bahar and Tajan cultivars recorded higher CHL and sodium content at both stages. Bahar showed the highest Na^{+} content and the most reduction in yield, so it can be considered as more salt sensitive than Tajan genotype. Results showed that the salinity tolerance in tolerant cultivars as manifested by lower decrease in grain yield is associated with the lower sodium accumulation and higher K^{+}/Na^{+} compared to the sensitive cultivars.

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

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

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

Jafari *et al*. (2009) studied the interactive effects of salinity, calcium and potassium on physio-morphological traits of sorghum (*Sorghum biclolor* L.) in a green-house experiment. Treatments included 4 levels of NaCl (0, 80, 160, and 240 mM NaCl), 2 levels of $CaCl_2$ (0 and 20 mM), and 2 levels of KCl (0 and 20 mM). Salinity substantially reduced the plant growth as reflected by a decrease in the plant height, shoot and root weight.

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

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

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

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

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

Mortazainezhad *et al*. (2006) had observed that tiller number decreased with increasing salinity levels imposed at all growth stages in rice. Soil salinity affects the growth of rice plant, but the degree of deleterious effect may vary on the growth stages of plant. During germination rice is tolerant, but it becomes very sensitive during the early seedling stage. Similar result was also reported by many workers in rice (Linghe *et al.,* 2000; Burman *et al*., 2002; Weon Young *et al*., 2003; Islam, 2004; Rashid, 2005; Karim, 2007).

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

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

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

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

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

Netondo *et al*. (2004) conducted an experiment where sorghum plants were grown in sand culture under controlled greenhouse conditions. The NaCl concentrations in complete nutrient solution were 0 (control), 50, 100, 150, 200, and 250 mM. Salinity significantly reduced leaf area by about 86% for both varieties of sorghum and these decreases were similar for the two sorghum varieties.

Çiçek and Çakirlar (2002) observed salt stress caused a significant decrease in shoot length, fresh and dry weights of shoot and leaf area of both cultivars with the increase of stress treatments.

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

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

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

Babu and Thirumurugan (2001) conducted a pot experiment to study the effect of salt priming on growth and development of sesame under induced salinity condition. Salinity was induced by addition of 35, 70 and 140 mM NaCl solution to create three levels of salinity and observed that plant height decreased with the increased salinity level.

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

El-Midaoui *et al*. (1999) conducted a greenhouse experiment with three sunflower cultivars (cv. Oro 9, Flamme pinto and Ludo) under four salinity levels of 0, 50, 75 and 100 mM NaCl. They reported that plant growth was adversely affected by increasing salinity. Similar results were also reported by Steduto *et al*. (2000) in sunflower.

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

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

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

2.3 Effect of salinity on yield and yield contributing characters of plant:

An experiment was conducted by Saberi *et al*. (2011). She found that increased salinity significantly reduced forage dry yield from 44.09 gm plant^{-1} in the control to 32.76 g plant^{-1} at salinity with 15 dSm^{-1}. For every one unit increase in salinity, the forage yield decreased by 5.2 units and for every one unit increase in water stress (irrigation frequency), the forage yield decreased by 3.6 units.

Hamayun *et al*. (2010) reported that, the adverse effects of NaCl induced salt stress on growth attributes and endogenous levels of gibberellins (GA), abscisic acid (ABA), jasmonic acid (JA) and salicylic acid (SA) soybean cv. Hwangkeumkong was showed. 1000 seed weight and yield significantly decreased in response 70 mM and 140 mM concentrations of NaCl.

Prakash and Chen (2010) observed that all the physiological properties and yield were negatively affected by increasing salinity levels due to less water use and radiation interception. Compared to the low salinity level, medium and high salinity levels reduced the above-ground dry weight of the crop at harvest by 40 and 41%, accumulated intercepted radiation by 23 and 37%, radiation use efficiency by 25 and 52%, water use by 18 and 35% and grain yield by 41 and 48%, respectively.

Rafat and Rafiq (2009) reported that, total chlorophyll content in tomato plant proportionally decreased with the increase in salinity levels up to 0.4% sea salt solution (EC 5.4 dSm^{-1}).

Karim (2007) conducted an experiment to investigate the effect of different salinity levels (0, 6, 9 and 12 dSm^{-1}) and reported that all parameters including panicle length decreased with increased salinity levels. Panicle length was adversely affected by soil salinity levels as reported by most of the researchers (Islam *et al*., 1998; Hossain, 2002; Islam, 2004; Natarajan *et al*., 2005 and Rana, 2007).

Karim (2007) reported that grain yield decreased with increased salinity levels. The yield was decreased due to production of decreased number of effective tillers $hill^{-1}$, decreased number of grains $panicle^{-1}$and 1000-seed weight. Similar result was also reported by many researchers (Islam *et al*., 1998. Hossain, 2002; Sen, 2002; Islam 2004; Rashid, 2005 and Hossain, 2006).

Rana (2007) carried out a pot experiment with 5 levels of salinity (0, 3, 6, 9 and 12 dS/m) of three rice varieties viz., BRRl dhan-42, STM-1 and STM-2 and reported that plant height, number of tillers $hill^{-1}$, TDM $hill^{-1}$, leaf area $hill^{-1}$, root dry weight $hill^{-1}$ and yield contributing characters and yield decreased significantly with increase in salinity levels. Among the advanced rice lines BRRIdhan-42 showed more tolerance for all studied parameters compared to STM-1 and STM-2.

Hajer *et al*. (2006) and Cuartero and Munoz (1999) conducted two different experiment separately on tomato under saline condition and reported the effect of NaCl salinity stress on the growth of tomato plants was reflected in lower fresh and as well as dry weights.

Ali *et al*. (2005) conducted a pot experiment with three salinity levels (0, 6 and 9 dSm^{-1}) and observed that 1000-seed weight decreased with increased salinity level in sesame. Again, Thakral *et al*. (1996) studied six *B. carinatus* species under 0-125 meq L^{-1} chloride solution and observed that siliqua $plant^{-1}$, 1000-seed weight and seed yield decreased under salinity.

El-Hendawy *et al*. (2005) reported that tiller number of wheat was affected more by salinity than leaf number and leaf area at the vegetative stage. Salinity decreased dry weight per plant significantly at all growth stages. Spikelet number on the main stem decreased much more with salinity than spike length, grain number and 1000-grain weight at maturity. They also concluded that an increase in tiller number per plant and spikelet number per spike will improve the salt tolerance of wheat genotypes in breeding programs.

Uddin *et al*. (2005) conducted an experiment to study salt tolerance of B. napus and B. campestris varieties under saline conditions (1.2-11.5 dSm^{-1}) and observed that siliqua number and seeds siliqua^{-1} decreased with increased salinity.

Gain *et al*. (2004) studied the effect of salinity (0, 7.81, 15.62, 23.43 and 31.25 dSm^{-1}) on yield attributes and yield in rice and reported that number of spikelet panicle^{-1}, 1000-grain weight and dry mass decreased with increasing salinity levels but the decrement was less in salt tolerant varieties than salt susceptible varieties This statement was supported many workers (Ahmed *et al*., 1980; Islam *et al*., 1998; Islam, 2004 and Hossain, 2006).

Netondo *et al*. (2004) conducted an experiment to determine how salinity affects growth, water relations, and accumulation of cations of nutritional importance in various organs of grain sorghum. Two Kenyan sorghum varieties, Serena and Seredo, were grown in a greenhouse in quartz sand supplied with a complete nutrient solution to which 0 (control), 50, 100, 150, 200, and 250 mM NaCl was added. The 250 mM NaCl treatment significantly reduced the relative shoot growth rates, measured 25 days after the start of salt application, by 75 and 73%, respectively, for Serena and Seredo, and stem dry weight by 75 and 53%.

A field experiment was conducted by Leena and Kiran (2003) in Vadodara, Gujarat, India to test the effect of salt stress on *Sorghum bicolor*. Though there was a reduction in the chlorophyll content of the plants subjected to salt stress, the fresh and dry weights of the plants were reduced only at the earlier stages.

Debnath (2003) and Rahman (2003) worked with mustard to know the effect of different levels of salinity (0, 5, 7, 10 and 15 dSm^{-1}) on yield attributes and dry matter partitioning and reported that harvest index decreased with increased salinity levels.

Hossain (2002) conducted a pot experiment with three salinity levels (0, 6 and 9 dSm^{-1}) and observed that harvest index decreased with increase of salinity level in rice. Similarly, Islam (2004) reported that harvest index decreased with the increase of salinity level in rice. Again, Hossain*et al*. (2006) worked with rice to know the effect of different levels of salinity (0, 6, 9, and 15 dSm^{-1}) on yield attributes and dry matter partitioning and reported that harvest index decreased with increased salinity levels. Similar result was also reported by Rana (2007) in rice.

Parti *et al*. (2002) conducted an experiment where salinity levels of 4, 8 and 12 dSm^{-1} were obtained from adding chloride and sulphate salts of sodium, calcium and magnesium. All salinity treatments affected plant growth considerably. The dry matter weight was maximum at 4 dSm^{-1} and beyond this level, a constant decreased with increased salinity in TDM, plant height and siliqua $plant^{-1}$ was observed.

Sen (2002) conducted a pot experiment with three salinity levels (3, 6 and 9 dSm^{-1}) and observed that 1000- grain weight decreased with increased salinity level in rice. Similar result was also reported by Abudullah *et al*. (2001) in rice.

Thimmaiah (2002) grew sorghum (Sorghum bicolor) under different levels of salinity (1, 2, 4, 6, 8 and 12 dSm^{-1}) in irrigation water and investigated for yield and yield components and biochemical composition. Seed and straw yield, seed weight per ear, N, P, K and Ca content, protein content and total amylolytic enzyme activity differed significantly due to salinity. However, these parameters were, more or less, at par with each other in the range of 2 to 8 dSm^{-1}. The 1000-seed weight, Mg2+ content and invertase [beta-fructofuranosidase] enzyme 14 activity were unaffected by salinity. Except 1000-seed weight, yield and yield components decreased significantly at 12 dSm^{-1} salinity.

Abdullah *et al*. (2001) conducted an experiment for finding out the effect salinity stress on seed set of IR-28 rice under different salinity levels and found that panicle length was significantly decreased due to salinity stress.

Chakraborti and Basu (2001) studied salt tolerance ability in 9 sesame varieties under saline condition and reported that capsule per plant, seeds per capsule and seed yield decreased under saline condition in all studied varieties of sesame.

From the above discussed review of the literature it can be concluded that the growth and yield of wheat is adversely affected due to salinity stress and there is a significant in varietal variation in wheat exists in the respond of wheat to salinity stress.

CHAPTER III

MATERIALS AND METHODS

A screening trial of 33 wheat cultivars for salinity tolerance was conducted during the period fromFebruary to March, 2016. The materials and methods followed for conducting the experiment have been presented under the following headings.

3.1 Experimental site

This study was carried out in the Central Laboratory of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh from February to March, 2016.

3.2 Planting materials

Thirty three (33) wheat genotypes were collected from Wheat Research Centre, Nashipur, Dinajpur and Bangladesh Agricultural Research Institute. Among them 5 were wheat varieties and 28 were advanced lines. Collected seed samples were dried for 3 hours under sunlight. The five (5) test varieties wereBARI GOM 25, BARI GOM 26, BARI GOM 27, BARI GOM 28 and BARI GOM 29 and twenty eight (28) advanced lines were SATYN-22, SATYN-15, SATYN-21, SAYYN-17, SATYN-23, ESWYT-5, SATYN-24, ESWYT-6, SATYN-3, SATYN-27, SATYN-12, SATYN-6, SATYN-19, SATYN-16, SATYN-25, WICYT-7, WICYT-9, WICYT-28, WICYT-35, WICYT-41, WICYT-15, WICYT-20, WICYT-25, WICYT-26, SATYN-2, SATYN-10, SATYN-14 and SATYN-20. Seedlings were raised in a separate Petridish for each genotype.

3.3 Equipment used

Petridish and filter paper were used for raising of seedlings. Filter paper were cut according to the Petridish size and placed into the bottom of the dish. 30 sun dried seeds of each wheat genotypes were placed into the Petri dish.

3.4 Seed treatment

Seed were soaked into water and then allowed to dry in room temperature at room. Two or three days required for drying to regain optimum moisture level. Alcohol was used for surface sterilization to reduce fungal infection.

3.5 Treatment

Thirty three (33) wheat genotypes with 5 salinity levels were used for the experiment. The following wheat genotypes and salinity levels were used:

A. Thirty three (33) wheat genotypes:

1. SATYN-22
2. SATYN-15
3. SATYN-21
4. SAYYN-17
5. SATYN-23
6. ESWYT-5
7. SATYN-24
8. ESWYT-6
9. SATYN-3
10. SATYN-27
11. SATYN-12
12. SATYN-6
13. SATYN-19
14. SATYN-16
15. SATYN-25
16. WICYT-7
17. WICYT-9
18. WICYT-28
19. WICYT-35
20. WICYT-41
21. WICYT-15
22. WICYT-20
23. WICYT-25
24. WICYT-26
25. SATYN-2
26. SATYN-10
27. SATYN-14

28 SATYN-20

29. BARI GOM 25
30. BARI GOM 26
31. BARI GOM 27
32. BARI GOM 28
33. BARI GOM 29

B. Five (5) salinity levels:

1. Control (No salt)
2. 5 dSm^{-1} NaCl
3. 10 dSm^{-1} NaCl
4. 15 dSm^{-1} NaCl
5. 20 dSm^{-1} NaCl

3.6 Seed placement for germination

Filter paper were cut according to the Petridish size and placed into the bottom of the dish. For germination 30 seeds of each wheat genotypes were placed on each Petridish. 0, 1.4625, 2.925, 4.3875 and 5.85 g NaCl seperately were dissolved in 500 ml distill water to get 0, 5, 10, 15 and 20 dSm^{-1} NaCl solution, respectively. The salt solutions were sprayed as per treatment on Petri dish until the saturated condition and spraying continued with 6 hrs interval.

3.7 Monitoring of the experiment

3.7.1 Seed collection

Wheat Research Centre, Nashipur, Dinajpur and Bangladesh Agricultural Research Institute.

3.7.2 Observation and precaution

During the experiment keen observation was done. Use of different equipments were used properly. Fungus infected seeds were removed from Petridish to keep the other seeds safe from fungal infection. The salt solutions were sprayed as per treatment on Petri dish until getting the saturated condition and it was continued 6 hr interval. Moisture levels in Petridishes were maintained carefully and never dried during the experimental period.

3.8 Data collection

Data on seedling emergence of all the wheat genotypes were collected from 1 to 12 days after sowing. Normal seedlings were counted and percent of seedling emergence was recorded upto 12 days after planting (DAP) of seeds. Seedling mortality was also counted upto12 days after seed planting (DAP). The uprooted seedlings were washed with tap water and excess water was soaked with tissue paper. After 11 days of planting (DAP) data was collected from 5 selected healthy seedlings randomly.

The following data were taken:

1. Germination rate (%)
2. Shoot length (mm)
3. Root length (mm)
4. Fresh weight of whole plant
5. Turgid weight (mg)
6. Shoot dry weight (mg)
7. Root dry weight (mg)
8. Relative water content (%)
9. Water saturation deficit (%)
10. Water retention capacity (%)
11. Coefficient of velocity
12. Vigour index

3.9 Procedure of recording data

3.9.1 Germination percentage

The numbers of sprouted and germinated seeds were counted daily commencing. Germination was recorded at 24 hrs interval and continued up to 12 days. More than 2 mm long plumule and radicle after sproutingwas considered as germinated seed.

The germination rate was calculated using following formula:

Rate of germination (%) =$\frac{Totalnumberofgerminatedseeds}{Totalseedplacedforgermination}\times 100$

3.9.2 Shoot length

The shoot length of five seedlings from each Petridish was measured finally at 11 DAP. Measurement was done using the unit millimeter (mm) by a meter scale.

3.9.3 Root length (mm)

The root length of five seedlings from each Petridish was recorded finally at 12 DAP. Measurement was done using a meter scale and unit was expressed in millimeter (mm).

3.9.4 Fresh weight plant^{-1}

Five plants at 12 days after planting (DAP) were collected and cleaned then weighed separately by shoot and root. The total weight of shoot and root was calculated to get fresh weight of whole plant and then averaged.

3.9.5 Turgid weight (mg)

After recording the fresh weight leaf of each seedling place into Petridish for 24 hours then leaf soaking with distilled water, turgid weight was recorded.

3.9.6 Dry weight of shoot and root (mg)

The dry weight of shoot and root of the five seedlings from each Petridish was measured finally at 12 DAP. Dry weight was recorded by drying the sample in an oven at 70°C till attained a constant weight. Then the weight was converted to (mg).

3.9.7 Relative water content (%)

Relative water content was measured using following formula

Relative water content (RWC) (%) = $\frac{Fresh\ weight - Dry\ weight}{Turgid\ weight - Dry\ weight} \times 100$

3.9.8 Water saturation deficit

Water saturation deficit was recorded using following formula:

Water saturation deficit (WSD) = 100- Relative water content

3.9.9 Water retention capacity

Water retention capacity was measured following formula

Water retention capacity (WRC) $=\frac{Turgid\ weight}{Dry\ weight}$

3.9.10 Coefficient of germination (%)

Co- efficient of germination (CG) was calculated using the following formula

Coefficient of velocity (%) $= \frac{A1+A2+\cdots+Ax}{A1T1+A2T2+\cdots AxTx} \times 100$

Where,

A= Number of seeds germinated

T= Time corresponding to A

x= Number of days to final count

3.9.11 Vigour index

Vigour index was calculated using following formula

Vigour index $=\frac{Total\ germination \times Seedling\ length\ (mm)}{100}$

3.10 Statistical Analysis

Data recorded for different parameters were compiled and tabulated in proper form for statistical analysis. CRD analysis was done for statistical test. The data were analyzed using “Analysis of Variance (ANOVA)” technique with the help of computer package programme “MSTAT-C” and mean difference among the treatments were adjudged with Duncan’s Multiple Range Test (DMRT) as described by Gomez and Gomez (1984).

CHAPTER IV

RESULTS AND DISCUSSION

An experiment was conducted to screen 33 wheat genotypes under 5 levels of salinity stress to evaluate their performance in terms of seedling emergence, seedling growth parameters such as root length, shoot length, and root and shoot dry weight. To strengthen the discussion, information in the forms of tables and graphs are provided. The summary of analysis of variance of germination (%) of wheat varieties and parameters of seedlings has been presented in Appendices V and VI, respectively. The results obtained are presented and discussed under the following headings:

4.1 Effect of salinity on seed germination (%)

Germination percentage significantly varied among wheat genotypes under different levels of saline concentration (Appendix II and Table 1). In terms of no salinity level, ESWYT-5 gave the best performance (98.89%) on seed germination which was closely followed by ESWYT-6, SATYN-2, SATYN-10 and BARI GOM 28.The rate of germination decreases with the increasing of saline concentration. ESWYT-5,ESWYT-6 and BARI GOM 28 shown consistence result against all the NaCl concentration and gave the highest germination rate (98.89, 94.44, 92.11, 91.57 and 88.00% for ESWYT-5; 97.78, 94.44, 90.19, 90.23 and 87.10% for ESWYT-6 and 97.46, 92.72, 89.89, 89.31 and 86.67% for BARI GOM 28 at 0, 5, 10, 15 and 20 dSm^{-1}, respectively). On the other hand the lowest germination was counted for BARI GOM 29 and SATYN-20 (32.22 and 33.33% at 0 dSm^{-1}, respectively) and the reduction rate of germination percentages rapidly increase with the increasing of NaCl concentration for BARI GOM 29 (85.00, 87.78, 88.89 and 90.00% at 5, 10, 15 and 20 dSm^{-1}, respectively). So, in the context of germination percentage to salinity tolerance/sensitivity, it may be concluded that among 33 wheat genotypes ESWYT-5, ESWYT-6 and BARI

GOM 28 might be referred as salt tolerance cultivar and BARI GOM 29 as most salinity sensitive cultivar.

The reduction of germination rate with the increasing of salt concentration has also been reported by Rahman *et al*. (2000), Mirza and Mahmood (1986), Mujeeb*et al*. (2008), Sing *et al*. (2000), Akbarimoghaddam *et al*. (2011) and Datta *et al*. (2009). Similar result also found by different scientist in different crops like: Khatkar and Kuhad in wheat, Shirazi (2001), Lallu and Dixit (2005) in mustard and Bera *et al*. (2006) in chickpea. The germination of wheat genotupes could be affected in two ways: in the germination media presenting of excess salt resulting the reduction of osmotic potential to such extent that seeds that placed for germination unable to absorb enough water necessary for transportation of mineral nutrients crucial for germination and the second one is embryo of the seed adversely affected by the toxicity of salt salutesRahman *et al*. (2008).

In the physiological point of view, the absorption of more K^+/Na^+ is beneficial. Increasing trend of salinity level decrease the ratio (Carmer *et al*, 1994) and probable reason injured the embryo. Khan *et al*. (2000) also reported that up taking of salt in sensitive plant competes with the uptaking of beneficial nutrients ions, especially K^+, causing K+ deficiency.

In saline stress condition, sensitive wheat genotypes absorb more Na^+ than K^+ (Ashraf and Oleary, 1996; Sairam *et al*., 2002). Amount of Na^+ uptaken by cereals was reported as salt tolerant indices (Ashraf and Khanum, 1997). In some halophytes like wheat, the exclusion of Na^+ and inclusion of K^+, salt tolerance mechanism might absence referred as sensitive cultivar (Poustini and Siosemardeh, 2004). On the other hand increasing the absorption of osmotically active constituents like sugar organic acid, proline glycine, K^+ and Cl^- which trigger nutrient release selectivity and osmotic adjustment to salinity referred as salt tolerance genotypes.

Table 1. Effect of different salinity levels on germination rate of different wheat genotypes at different salt concentrations

Genotypes	Germination rate (%) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	77.33 i	75.55 f-h	51.11 n	41.10 kl	33.34 kl
SATYN-15	88.89 e-g	80.00 de	73.44 f-h	67.05 e	53.31 ef
SATYN-21	88.89 e-g	87.78 c	82.40 bc	66.66 ef	63.60 d
SAYYN-17	77.66 i	52.22 l	48.05 n	43.14 k	31.11 lm
SATYN-23	87.78 f-h	74.44 g-i	66.66 jk	67.77 e	55.55 e
ESWYT-5	98.89 a	94.44 a	92.11 a	91.57 a	88.00 a
SATYN-24	84.44 h	82.11 d	74.44 e-g	75.55 c	67.77 c
ESWYT-6	97.78 ab	94.44 a	90.19 a	90.23 a	87.10 a
SATYN-3	62.22 k	50.00 l	31.11 o	30.22 m	25.55 n
SATYN-27	76.66 i	65.55 k	47.75 n	38.47 l	35.98 jk
SATYN-12	70.00 j	68.92 jk	62.22 lm	50.00 j	37.77 j
SATYN-6	93.33 cd	88.89 bc	84.49 b	76.66 c	71.44 b
SATYN-19	88.89 e-g	78.89 d-f	74.44 e-g	66.66 ef	45.55 i
SATYN-16	86.66 gh	78.89 d-f	64.44 kl	63.33 f-h	49.96 gh
SATYN-25	91.11 d-f	82.22 d	78.88 cd	73.86 cd	68.89 bc
WICYT-7	93.33 cd	70.00 j	61.11 lm	59.51 i	55.55 e
WICYT-9	88.88 e-g	82.22 d	68.89 ij	62.89 g-i	52.17 fg
WICYT-28	93.33 cd	75.55 f-h	70.51 h-j	66.43 e-g	54.98 ef
WICYT-35	91.11 d-f	82.22 d	75.55 def	67.77 e	62.03 d
WICYT-41	94.42 b-d	77.77 e-g	74.44 efg	71.63 d	68.62 bc
WICYT-15	80.00 i	71.11 ij	60.00 m	61.11 hi	61.82 d
WICYT-20	94.44 b-d	65.55 k	63.33 k-m	60.15 hi	56.22 e
WICYT-25	48.88 l	34.39 m	31.24 o	15.55 o	10.37 p
WICYT-26	92.22 c-e	77.77 e-g	76.66 d-f	67.77 e	48.89 h
SATYN-2	95.55 a-c	87.77 c	85.55 b	84.44 b	67.77 c
SATYN-10	95.55 a-c	88.88 bc	77.77 de	75.55 c	66.66 c
SATYN-14	78.89 i	72.22 h-j	70.59 g-i	51.11 j	49.64 gh
SATYN-20	33.33 n	28.88 n	17.77 q	14.74 op	9.988 p
BARI GOM 25	37.77 m	34.83 m	24.44 p	19.94 n	19.98 o
BARI GOM 26	92.22 c-e	77.77 e-g	63.33 k-m	61.11 hi	53.42 ef
BARI GOM 27	84.44 h	53.33 l	31.11 o	27.77 m	28.89 m
BARI GOM 28	97.46 ab	92.72 ab	89.89 a	89.31 a	86.67 a
BARI GOM 29	32.22 n	15.00 o	12.22 r	11.11 p	10.00 p
LSD $_{(0.05)}$	3.66	4.12	3.91	3.67	3.03
CV (%)	3.58	4.64	4.97	5.06	4.77

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

4.2 Shoot length

Shoot length of wheat genotypes was significantly affected by different salinity level the (Appendix III and Table 2). Results revealed that at no salinity level, the genotype, ESWYT-5 gave the highest shoot length and this genotype also showed best performance on shoot length at different salinity levels where BARI GOM 29 showed lowest shoot length at no salinity level. The magnitude of reduction of shoot length was lower in ESWYT-5, ESWYT-6 and BARI GOM 28 in different levels of salt concentration. The shoot length ranges from 180.2 mm in ESWYT-5 to 122.00 in BARI GOM 29 at control solution; 161.70 mm in ESWYT-5 to 39.60 mm in SATYN-20 at 5 dSm^{-1} NaCl solution; 147.20 mm in ESWYT-5 to 28.27 mm in SATYN-14 at 10 dSm^{-1} NaCl solution; 120.50 mm in ESWYT-5 to 10.47 mm in WICYT-41 at 15 dSm^{-1} NaCl solution. Wheat genotype ESWYT-5 showed statistically similarity with ESWYT-6 at 5 dSm^{-1} NaCl solution; at 15 dSm^{-1} NaCl solution WICYT- 41was statistically at par with WICYT-9 and WICYT-14 wheat genotypes. At 20 dSm^{-1} NaCl solution maximum shoot length was recorded for ESWYT-5 followed by ESWYT-6 and BARI GOM 28 but there was a dramatic change of shoot length in SATYN-22 and SATYN-25 and they did not survive at 20 dSm^{-1} NaCl solution. For a consequence it may be reported that ESWYT-5, ESWYT-6 and BARI GOM 28 wheat cultivars may be tolerance to salt.

Shoot severely affected by salt stress and as a consequence a drastic reduction was observed for salt stress sensitive genotypes. Similar findings also reported by Moud and Maghsoudi (2008), Datta *et al*. (2009), Rahman*et al*. (2008), Tarmatt and Munns (1996) and Dager *et al*. (2004).

Table 2. Effect of different salinity levels on shoot length of different wheat genotypes at different salt concentrations

Genotypes	Shoot length (mm) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	147.3 c-e	140.0 c-e	40.35 o	33.35 p-r	0.00 r
SATYN-15	136.4 g-k	129.0 fg	59.13 m	41.79 n	29.03 k
SATYN-21	131.8 j-n	128.5 fg	103.5 d	91.13 c	39.53 hi
SAYYN-17	134.1 h-l	125.0 g-j	100.7 de	68.60 h	37.58 ij
SATYN-23	139.3 f-j	114.5 k-m	98.15 ef	81.36 f	29.31 k
ESWYT-5	180.2 a	161.7 a	147.2 a	120.5 a	116.2 a
SATYN-24	130.7 k-n	117.3 k-m	101.5 de	86.17 de	71.40 d
ESWYT-6	169.8 b	157.3 ab	138.7 b	106.6 b	99.72 b
SATYN-3	152.9 c	140.7 cd	83.96 ij	45.87 m	37.87 ij
SATYN-27	124.3 no	120.6 h-k	57.70 m	55.73 j	49.20 f
SATYN-12	140.1 e-i	133.9 ef	93.87 fg	89.26 cd	82.33 c
SATYN-6	140.7 e-h	105.5 o	87.27 h-j	84.71 ef	82.14 c
SATYN-19	127.9 l-o	111.3 m-o	86.90 h-j	53.07 jk	38.53 i
SATYN-16	136.3 g-k	112.4 l-n	77.20 k	70.58 gh	45.73 g
SATYN-25	132.9 h-m	133.6 ef	98.00 ef	73.92 g	0.00 r
WICYT-7	136.7 g-k	70.00 q	57.49 m	38.13 no	9.068 q
WICYT-9	139.1 f-j	50.60 r	31.00 rst	11.07 v	8.836 q
WICYT-28	129.7 k-o	50.83 r	38.87 op	30.42 q-s	13.07 n-p
WICYT-35	143.6 d-g	114.4 k-m	33.23 q-s	24.27 t	15.47 n
WICYT-41	142.2 d-g	126.7 gh	45.67 n	10.47 v	9.928 q
WICYT-15	143.3 d-g	70.51 q	65.73 l	51.27 kl	42.20 h
WICYT-20	132.7 i-m	48.87 r	35.67 pq	27.37 st	21.60 m
WICYT-25	132.8 i-m	126.7 gh	56.40 m	36.75 op	24.85 l
WICYT-26	153.2 c	142.5 cd	41.20 no	36.73 op	26.66 kl
SATYN-2	146.1 c-f	136.6 de	82.87 j	73.00 g	13.27 n-p
SATYN-10	127.1 l-o	85.80 p	35.03 p-r	34.07 pq	28.17 k
SATYN-14	124.3 no	107.7 no	28.27 t	12.53 v	13.80 no
SATYN-20	129.1 k-o	39.60 s	28.80 st	18.14 u	11.40 o-q
BARI GOM 25	149.9 cd	143.6 c	64.00 l	60.47 i	55.61 e
BARI GOM 26	125.6 m-o	118.8 j-l	87.63 hi	55.47 j	50.07 f
BARI GOM 27	129.2 k-o	126.1 g-i	89.47 gh	49.20 lm	35.00 j
BARI GOM 28	167.4 b	153.2 b	134.0 c	104.7 b	97.17 b
BARI GOM 29	122.0 o	119.8 i-k	33.70 qr	29.54 rs	10.47 pq
LSD $_{(0.05)}$	7.90	6.43	4.59	3.84	2.99
CV (%)	4.53	4.51	5.12	5.61	6.34

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

4.3 Root length

The reduction trend of root length was varied significantly among wheat genotypes under different saline solution (Appendix IV and Table 3). Similarly ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes had shown a slower reduction against the increasing of salt concentration. At 0 dSm^{-1} salt solution root length ranges from 164.20 mm in ESWYT-5 to 13.32 mm in SATYN-12 which was statistically similar with SATYN-19; at 5, 10 and 15 dSm^{-1} salt solutions root length ranges from 152.10 mm in ESWYT-5 to 5.13 mm in SATYN-19, 109.30 mm in ESWYT-5 to 3.96 mm in SATYN-19, 69.79 mm in ESWYT-5 to 3.03 mm in SATYN-19 which were statistically at par with SATYN-12 at 15 dSm^{-1}, respectively. Longest root length distinctly was found fromESWYT-5, ESWYT-6 and BARI GOM 28 at 20 dSm^{-1}, on the other hand seedlings of SATYN-22 and SATYN-25 did not survive at the same saline concentration. In conclusion it may be said that ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes could be salt tolerance and SATYN-19, SATYN-12 sensitive to salt in respect of root length. SATYN-22 and SATYN-25 might be very much sensitive to salt at higher salt concentration in the context of root length.

Root length severely affected by salt stress and as a consequence a drastic reduction was observed for salt stress sensitive genotypes. Similar findings also reported by Moud and Maghsoudi (2008), Datta *et al*. (2009), Rahman*et al*. (2008), Tarmatt and Munns (1996) and Dager *et al*. (2004).

Table 3. Effect of different salinity levels on root length of different wheat genotypes at different salt concentrations

Genotypes	Root length (mm) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	129.1 d	87.67 g-i	36.23 l	27.69 o	0.00 s
SATYN-15	120.5 ef	84.47 ij	42.41 ij	50.85 g	34.20 e
SATYN-21	119.6 f	90.40 f-h	65.87 e	58.71 e	27.33 g
SAYYN-17	113.1 gh	109.2 d	62.87 f	53.30 fg	41.84 d
SATYN-23	142.0 c	92.93 f	65.64 e	64.57 bc	28.96 f
ESWYT-5	164.2 a	152.1 a	109.3 a	69.79 a	64.80 a
SATYN-24	82.03 no	120.5 c	65.07 ef	63.37 bc	23.73 ijk
ESWYT-6	160.29 a	150.1 a	95.48 b	65.13 b	63.72 a
SATYN-3	115.7 fg	72.57 l	64.35 ef	28.09 no	29.42 f
SATYN-27	89.13 lm	82.89 j	24.83 o	31.60 lm	18.80 m
SATYN-12	13.32 p	7.83 rs	16.99 q	5.048 s	5.91 q
SATYN-6	114.8 fg	91.67 fg	44.07 i	51.00 g	43.67 c
SATYN-19	14.99 p	5.13 s	3.96 s	3.03 s	4.21 r
SATYN-16	120.4 ef	107.6 d	79.40 c	60.07 de	51.33 b
SATYN-25	121.1 gh	86.60 h-j	56.27 g	62.13 cd	0.00 s
WICYT-7	85.33 mn	25.07 o	13.27 r	32.80 kl	16.73 n
WICYT-9	130.8 d	14.33 p	21.27 p	30.20 mn	26.00 gh
WICYT-28	91.07 kl	9.83 qr	41.80 ijk	24.87 p	19.07 m
WICYT-35	95.00 jk	14.07 pq	29.67 n	43.30 i	25.07 hi
WICYT-41	105.5 i	32.27 n	23.27 op	33.73 kl	14.80 o
WICYT-15	116.4 fg	35.87 n	58.47 g	34.80 k	34.53 e
WICYT-20	112.5 gh	23.53 o	70.87 d	54.87 f	34.47 e
WICYT-25	113.3 gh	90.67 f-h	52.28 h	48.15 h	41.04 d
WICYT-26	107.7 hi	64.00 m	41.47 jk	18.10 q	9.096 p
SATYN-2	128.2 d	67.60 m	42.90 ij	19.65 q	22.93 jkl
SATYN-10	99.27 j	63.67 m	33.80 lm	40.60 j	24.20 ij
SATYN-14	126.7 d	74.00 kl	35.47 l	20.00 q	26.53 gh
SATYN-20	77.53 o	18.07 p	14.28 r	10.07 r	6.520 q
BARI GOM 25	91.13 kl	77.20 k	32.17 m	28.40 no	22.50 kl
BARI GOM 26	128.3 d	99.47 e	58.40 g	24.60 p	22.88 jkl
BARI GOM 27	125.3 de	82.40 j	39.53 k	26.07 op	22.08 l
BARI GOM 28	150.9 b	138.3 b	94.6 b	68.59 a	63.68 a
BARI GOM 29	138.3 c	94.56 f	25.15 o	20.33 q	6.420 q
LSD $_{(0.05)}$	5.66	4.45	2.50	2.46	1.54
CV (%)	4.18	4.96	4.27	5.27	4.81

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

4.4 Fresh weight plant^{-1}

Salinity level had highly significant influence on fresh weight plant^{-1} of different wheat genotypes (Appendix V and Table 4). At no salinity level SATYN-23 gave the best fresh weight plant^{-1} followed by ESWYT-6 and BARI GOM 28 where SATYN-20 gave lowest fresh weight plant^{-1} followed by SATYN-22 and SATYN-15. Fresh weight plant^{-1} reduction showed consistency for ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes along with the expansion of salinity levels. Maximum fresh weight plant^{-1} was reported from ESWYT-5 genotypes followed by ESWYT-6 and BARI GOM 28 at all the NaCl concentrations whereas SATYN-22, SATYN-15, SATYN-21, SATYN-27 and WICYT-26 shown more sensitivity to saline condition and produced lowerfresh weight plant^{-1}where there were no survived seedlings for SATYN-22 and WICYT-7 at 20 dSm^{-1} salt concentration. Therefore, ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes showed promising performance against saline conditions in terms of fresh weight plant^{-1}.

Singh *et al*. (2000) and Moud and Maghsoudi (2008) also found varied sensitivity of wheat genotypes on the basis of seedling growth in their research. Karim *et al*. (1992) emphasized, seedling growth is one of the most important character for screening of salt tolerance at the early growth stage and affect plant weight.

Table 4. Effect of different salinity levels on fresh weight plant^{-1} of different wheat genotypes at different salt concentrations

Treatment	Fresh weight (mg) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	52.81 pq	19.97 o	19.92 p	9.698 t	0.00 s
SATYN-15	53.33 opq	11.63 p	10.84 r	7.612 u	6.388 r
SATYN-21	59.33 lmn	32.52 l	21.48 op	17.83 r	15.36 nop
SAYYN-17	78.92 i	61.49 h	53.00 hi	48.16 fg	32.47 h
SATYN-23	57.00 mno	54.12 i	46.25 j	37.90 kl	21.95 lm
ESWYT-5	126.5 a	95.85 a	93.60 a	73.88 a	61.47 a
SATYN-24	72.10 j	63.45 gh	46.24 j	40.11 j	37.28 fg
ESWYT-6	118.6 b	95.51 ab	88.39 b	69.74 b	58.48 b
SATYN-3	65.42 k	42.81 j	35.51 l	24.54 p	22.00 lm
SATYN-27	55.88 nop	25.52 n	21.60 op	19.55 qr	17.10 no
SATYN-12	70.56 j	60.45 h	35.19 l	26.57 o	25.13 jk
SATYN-6	62.16 kl	61.29 h	52.67 i	49.80 ef	35.41 g
SATYN-19	72.39 j	65.30 g	56.93 fg	44.97 h	42.50 e
SATYN-16	59.90 lm	17.83 o	16.30 q	12.61 s	9.826 q
SATYN-25	59.64 lmn	45.28 j	38.79 k	29.95 n	11.42 q
WICYT-7	100.5 d	86.93 c	55.22 gh	39.69 jk	0.00 s
WICYT-9	85.71 h	81.90 d	57.85 ef	36.61 l	24.45 k
WICYT-28	90.72 fg	82.88 d	52.62 i	47.64 g	20.02 m
WICYT-35	84.91 h	56.07 i	30.87 mn	31.03 mn	26.49 j
WICYT-41	94.82 e	78.38 e	52.79 hi	42.94 i	21.07 lm
WICYT-15	77.10 i	65.80 fg	56.47 fg	40.05 j	28.82 i
WICYT-20	87.67 gh	38.16 k	28.60 n	24.31 p	14.39 p
WICYT-25	51.34 q	42.12 j	37.00 kl	32.97 m	20.63 lm
WICYT-26	93.17 ef	54.76 i	31.53 m	17.98 r	15.14 op
SATYN-2	84.09 h	80.77 de	29.02 n	23.98 p	17.29 n
SATYN-10	86.59 h	87.15 c	23.60 o	24.37 p	16.63 no
SATYN-14	85.56 h	66.50 fg	59.41 e	50.71 e	48.67 d
SATYN-20	37.29 r	28.90 m	22.95 o	21.55 q	14.15 p
BARI GOM 25	64.09 k	53.33 i	37.34 kl	42.28 i	37.83 f
BARI GOM 26	93.93 ef	87.62 c	72.00 d	59.60 d	54.50 c
BARI GOM 27	99.12 d	81.70 de	83.83 c	45.10 h	36.95 fg
BARI GOM 28	111.8 c	92.23 b	86.08 bc	67.28 c	57.66 b
BARI GOM 29	71.14 j	69.05 f	43.87 j	36.63 l	22.20 l
LSD $_{(0.05)}$	4.00	3.36	2.44	2.01	2.00
CV (%)	4.12	4.46	4.3	4.43	6.04

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

4.5 Shoot dry weight

Salinity level had highly significant influence on shoot dry weight of different wheat genotypes (Appendix VI and Table 5). Shoot dry weight reduction shown consistency for ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes along with the expansion of salinity levels. Maximum shoot dry weight was reported from ESWYT-5 genotypes followed by ESWYT-6 and BARI GOM 28 at all the NaCl concentrations whereas SATYN-22 and SATYN-12 shown more sensitivity to saline condition and produced lowest shoot dry weight. Following the previous parameter shoot length, as there were no survived seedlings for SATYN-22 and SATYN-12 at 20 dSm^{-1} salt concentration so there were no shoot dry weights for SATYN-22 and SATYN-12. Therefore, ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes showed promising performance against saline conditions in terms of shoot dry weight.

It has been found that under salt stress condition photosynthetic rate reduced markedly, expense huge energy in salt removal mechanism, reduce transportation of beneficial nutrient, arrest cell division and enlargement decrease shoot length, leaf number and for that consequence reduction of plant growth and accumulation of dry matter occure (Meiri and Poljakoff-Mayber, 1970, Long and Baker, 1986 and Seeman and Sharkey, 1986). Cherian and Reddy (2000) found that salt level 7.50 dSm^{-1}quit detrimental resulting about 60% reduction of dry weight in *Suaedanudiflora*. Decreasing of plant dry matter indicates the increasing of salinity level (Sharma, 2003).

Table 5. Effect of different salinity levels on shoot dry weight of different wheat genotypes at different salt concentrations

Genotypes	Shoot dry weight (mg) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	6.42 p	5.44 q	3.65 t	2.54 o	0.00 w
SATYN-15	7.46 l-n	7.26 mn	6.49 o	3.76 m	3.11 rs
SATYN-21	7.89 k-m	7.42 lm	7.51 i-k	6.72 f	5.17 i-k
SAYYN-17	7.97 kl	7.55 lm	7.57 h-j	6.83 f	4.90 j-m
SATYN-23	7.55 lmn	6.64 op	4.92 rs	3.98 m	3.53 p-r
ESWYT-5	16.64 a	13.90 a	13.07 a	11.30 a	9.18 a
SATYN-24	6.60 op	5.31 qr	5.11 qr	6.78 f	6.50 de
ESWYT-6	15.73 b	13.25 b	12.46 b	10.46 b	8.53 b
SATYN-3	9.43 i	7.33 mn	5.28 qr	5.23 k	4.47 mn
SATYN-27	7.35 mn	6.74 o	6.53 o	5.56 ij	4.76 k-m
SATYN-12	6.03 p	3.12 t	3.62 t	2.62 o	2.28 uv
SATYN-6	7.70 lm	6.31 op	7.95 e-h	7.80 e	6.31 ef
SATYN-19	7.87 k-m	6.21 p	7.33 j-l	6.91 f	6.28 ef
SATYN-16	8.37 jk	8.13 jk	8.15 ef	6.71 f	4.81 j-m
SATYN-25	7.50 l-n	7.55 lm	6.78 m-o	5.71 hi	0.00 w
WICYT-7	13.47 ef	10.98ef	8.30 e	8.12 d	6.93 cd
WICYT-9	11.85 gh	9.92 g	7.11 k-m	5.35 jk	2.62 tu
WICYT-28	11.46 h	3.81 s	3.43 t	3.15 n	3.37 q-s
WICYT-35	7.06 no	4.84 r	4.61 s	3.87 m	4.21 no
WICYT-41	9.03 i	7.93 kl	7.84 f-i	6.05 g	5.64 gh
WICYT-15	11.95 gh	9.21 h	6.67 no	6.92 f	5.25 h-j
WICYT-20	13.77 de	11.33de	7.59 h-j	5.50 i-k	5.07 i-l
WICYT-25	14.96 c	12.23 c	7.08 l-n	5.94 gh	2.03 v
WICYT-26	12.92 f	11.61 d	7.37 j-l	6.75 f	5.89 fg
SATYN-2	15.09 c	8.82 hi	6.42 o	3.31 n	3.65 pq
SATYN-10	13.73 de	10.72 f	8.01 e-g	6.79 f	5.52 g-i
SATYN-14	14.25 d	11.52 d	8.79 d	6.71 f	5.14 i-k
SATYN-20	12.30 g	8.68 i	5.72 p	4.79 l	4.67 l-n
BARI GOM 25	13.62 e	8.93 hi	5.20 qr	3.11 n	2.97 st
BARI GOM 26	8.94 ij	6.83 no	5.13 qr	4.88 l	3.86 op
BARI GOM 27	11.48 h	8.56 ij	7.72 g-j	7.69 e	7.34 c
BARI GOM 28	15.48 bc	12.63 c	9.87 c	8.85 c	8.31 b
BARI GOM 29	12.31 g	9.76 g	5.49 pq	3.08 n	2.30 uv
LSD $_{(0.05)}$	0.61	0.52	0.41	0.31	0.46
CV (%)	4.53	4.86	4.72	4.24	7.89

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

4.6 Root dry weight

Root dry weight of wheat genotypes severely affected by different salt concentrations (Appendix VII and Table 6) with some exceptions of ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes. Root dry weight ranges from 16.16, 13.65, 11.71 and 10.45 mg in ESWYT-5 to 2.64, 1.58, 1.55 and 1.16 mg in SATYN-19 wheat genotypes at 0, 5, 10 and 15 dSm^{-1} salinity levels, respectively. At 20 dSm^{-1} salinity condition ESWYT-5, ESWYT-6 and BARI GOM 28 produced the maximum root dry weight (8.59, 8.49 and 8.41 mg, respectively) and 0.00 mg root dry weight was found for both SATYN-22 and SATYN-12. In criteria for screening salt tolerance wheat genotype ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes exhibited better tolerance against salt affected conditions in the context of root dry weight.

Dry weight the total absolute mass of a plant is the consequence of plant physiological and biological activity. Under salt stress condition prominent was observed this parameter (Akbarimoghaddam *et al*., 2011, Bhatti *et al*., 2004 and Rumena 2006).

Table 6. Effect of different salinity levels on root dry weight of different wheat genotypes at different salt concentrations

Genotypes	Root dry weight (mg) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	6.39 l	6.44 g	1.61 q	2.80 o	0.00 w
SATYN-15	4.30 r	5.62 j	3.49 m	4.61 g	5.63 f
SATYN-21	4.81 pq	4.95 lm	4.69 j	2.36 p	1.83 tu
SAYYN-17	5.16 op	6.75 f	4.88 ij	4.17 hi	2.77 n
SATYN-23	5.18 op	5.05 k-m	4.21 kl	4.37 h	2.55 op
ESWYT-5	16.16 a	13.65 a	11.71 a	10.45 a	8.59 a
SATYN-24	4.81 pq	5.67 j	5.35 gh	4.02 ij	4.13 i
ESWYT-6	15.37 b	13.70 a	11.60 a	10.09 b	8.48 a
SATYN-3	6.05 lm	4.43 o	3.99 l	4.11 ij	2.37 pq
SATYN-27	5.69 mn	5.77 ij	2.16 p	3.96 i-k	2.11 rs
SATYN-12	3.83 s	3.44 pq	3.10 no	3.57 l-n	5.88 de
SATYN-6	4.67 qr	3.74 p	4.86 ij	3.38 n	3.72 j
SATYN-19	2.64 t	1.58 s	1.55 q	1.16 t	1.15 v
SATYN-16	5.31 no	5.29 k	4.30 k	3.49 mn	3.36 lm
SATYN-25	4.67 qr	5.64 j	5.37 g	3.94 jk	3.52 kl
WICYT-7	3.53 s	2.02 r	5.84 f	2.07 q	0.00 w
WICYT-9	7.45 ij	4.19 o	3.59 m	5.14 f	6.05 cd
WICYT-28	8.79 g	4.49 no	5.97 f	5.71 e	6.07 c
WICYT-35	7.67 ij	5.25 kl	4.41 k	6.95 d	4.09 i
WICYT-41	11.07 e	8.82 b	6.79 d	7.95 c	6.27 b
WICYT-15	8.88 g	6.87 d-f	5.16 gh	5.63 e	5.29 g
WICYT-20	7.78 i	4.75 mn	5.07 hi	4.35 h	1.99 st
WICYT-25	11.85 d	6.85 ef	3.32 mn	2.34 p	1.99 st
WICYT-26	13.05 c	7.16 cd	7.33 c	3.77 kl	3.19 m
SATYN-2	9.68 f	6.10 h	6.35 e	3.62 lm	3.64 jk
SATYN-10	6.85 k	7.28 c	4.74 j	5.24 f	2.65 no
SATYN-14	8.31 h	7.09 c-e	3.03 o	3.02 o	2.51 op
SATYN-20	5.21 o	3.52 pq	2.11 p	1.82 r	1.20 v
BARI GOM 25	5.09 op	6.06 hi	4.20 kl	3.95 i-k	2.28 qr
BARI GOM 26	7.67 ij	6.59 fg	6.57 de	3.52 mn	4.88 h
BARI GOM 27	6.80 k	6.58 fg	3.59 m	1.32 st	1.77 u
BARI GOM 28	15.08 b	12.15 b	10.67 b	10.30 a	8.41 a
BARI GOM 29	7.37 j	3.43 q	1.92 p	1.46 s	1.17 v
LSD $_{(0.05)}$	0.39	0.30	0.28	0.22	0.19
CV (%)	4.2	4.35	4.64	4.17	4.31

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

4.7 Relative water content

Relative water content (RWC) could be the perfect most indicator of plant hydrologic condition as it denotes the physiological consequences of cellular water deficit. Water potential that posses the energy status of plant water which is effective for the transportation of water in the soil-plant-atmosphere chain. A wide range of statistical difference was observed for relative water content of wheat genotypes at different salt concentrations (Appendix VIII and Table 7). The relative water content ranges from 89.80, 90.60, 92.54 and 83.48% in ESWYT-5 to 42.44% in SATYN-20; 24.96% in WICYT-41; 38.21 and 29.28% in WICYT-28 were recorded at 0, 5, 10 and 15 dSm^{-1}, respectively. ESWYT-6 and BARI GOM 28 showed similar trend with ESWYT-5 in most of the salinity level. At highest salt level (20 dSm^{-1}) relative water content ranges from 87.39% in ESWYT-5 to 0% in SATYN-22 and WICYT-7 was found. ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes exhibited much better performance against different salt concentrations for relative water content.

Salt tolerance cultivar may be defined as the capacity of plant to grow under low water potential and thus high relative water content is one of tolerance technique to stress condition (Sinclair and Ludlow, 1985). Sairam *et al*. (2002) reported that under salt stress relative water content higher in salt tolerant cultivar than the sensitive one. In this present piece of work, dry weight of seedling also adversely affected by salt stress. The negative impact was varied among wheat genotypes which indicate different sensitivity of wheat genotypes to salt stress.

Table 7. Effect of different salinity levels on relative water content of different wheat genotypes at different salt concentrations

Genotypes	Relative water content (%) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	85.30 c-f	87.86 ab	85.29 cd	65.48 h	0.00 s
SATYN-15	59.51 l	54.46 m	73.13 h-k	53.5 l	57.29 lm
SATYN-21	83.42 ef	75.40 gh	79.63 e-g	69.02 fg	69.17 fg
SAYYN-17	66.87 k	78.61 e-g	72.17 i-l	78.13 c-e	79.33 bc
SATYN-23	84.89 d-f	75.13 gh	69.66 k-n	53.90 l	64.11 h-j
ESWYT-5	89.80 a	90.60 a	92.54 a	83.48 a	87.39 a
SATYN-24	83.96 ef	80.00 d-f	71.16 j-m	76.52 de	62.22 i-k
ESWYT-6	89.55 ab	90.20 a	92.17 ab	82.21 ab	87.21 a
SATYN-3	72.14 ij	70.46 i	77.01 f-h	54.79 kl	53.92 m
SATYN-27	88.39 a-d	76.87 fg	55.09 r	61.12 i	60.75 j-l
SATYN-12	74.81 hj	81.69 de	73.36 h-k	67.69 f-h	68.92 fg
SATYN-6	78.91 gh	82.06 c-e	75.69 g-i	71.04 f	70.75 ef
SATYN-19	78.47 gh	76.89 fg	74.18 h-j	77.16 de	80.54 b
SATYN-16	76.22 hi	82.42 cd	80.03 ef	58.72 ij	65.53 g-i
SATYN-25	87.18 a-e	87.23 ab	85.88 cd	81.41 a-c	76.12 cd
WICYT-7	82.41 fg	65.16 j	40.03 u	60.08 ij	0.00 s
WICYT-9	86.59 a-f	61.48 k	63.57 op	61.56 i	61.92 i-k
WICYT-28	89.08 a-c	58.53 kl	38.21 u	29.28 o	43.62 p
WICYT-35	85.42 b-f	39.88 o	65.82 n-p	71.19 f	27.86 r
WICYT-41	85.31 c-f	24.96 p	61.70 pq	58.10 i-k	44.80 op
WICYT-15	71.91 j	60.01 k	46.53 st	74.96 e	66.38 gh
WICYT-20	72.23 ij	55.08 lm	87.99 bc	67.09 gh	78.56 bc
WICYT-25	78.73 gh	51.63 m	67.63 m-o	56.57 j-l	59.66 kl
WICYT-26	78.61 gh	58.61 kl	68.71 l-n	35.85 n	46.79 n-p
SATYN-2	72.31 ij	69.32 i	62.21 pq	37.06 n	47.46 no
SATYN-10	86.04 a-f	85.42 bc	50.09 s	54.96 kl	35.51 q
SATYN-14	86.34 a-f	71.05 i	58.75 qr	30.01 o	49.09 n
SATYN-20	42.44 m	44.18 n	44.81 t	46.99 m	35.45 q
BARI GOM 25	78.04 h	78.53 e-g	72.39 i-l	67.81 f-h	73.81 de
BARI GOM 26	78.78 gh	85.39 bc	82.93 de	81.57 ac	72.94 de
BARI GOM 27	76.32 hi	72.56 hi	71.56 i-m	78.91 b-d	74.59 d
BARI GOM 28	89.15 a-c	89.89 a	90.91 ab	81.96 ab	86.64 a
BARI GOM 29	72.94 ij	54.58 m	59.23 qr	67.77 f-h	66.37
LSD $_{(0.05)}$	4.18	3.64	4.24	3.51	3.69
CV (%)	4.22	4.14	4.88	4.42	5.08

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

4.8 Turgid weight

Significant influence was found in terms of turgid weight affected by different salinity level to the selected wheat genotypes (Appendix IX andTable 8). It was found that ESWYT-5 gave the best performance on turgid weight at no salinity level and also all in saline condition followed by ESWYT-6 and BARI GOM 28 whereas SATYN-22, SATYN-15, SATYN-21, SATYN-27 and WICYT-26 showed more sensitivity to saline condition and produced lower turgid weight where there were no survived seedlings was found for SATYN-22 and WICYT-7 at 20 dSm^{-1} salt concentration.

4.9Water saturation deficit

The amount of water vapor which need to be increased in the air to attain a saturation point without disturbing the environmental condition (temperature and pressure). It is opposite to relative water content. Salinity level had highly significant influence on water saturation deficit among different wheat genotypes (Appendix X and Table 9). The result revealed that water saturation deficit ranges from 57.56 in SATYN-20, 75.04 in WICYT-41, 61.72 and 70.72 in WICYT-28 to 10.20, 9.40, 7.46 and 16.52 in ESWYT-5 at 0, 5, 10 and 15 dSm^{-1}, respectively. At 20 dSm^{-1} maximum water saturation deficit 72.14% was observed for WICYT-35 but SATYN-22 and WICYT-7 were prominently sensitive to higher salt concentration. Therefore, ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes exerted better tolerance against salty condition in case of water saturation deficit.

Table 8. Effect of different salinity levels on turgid weightof different wheat genotypes at different salt concentrations

Treatment	Turgid weight (mg) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	61.10 r	62.77 opq	44.93 kl	36.90 s	0.00 s
SATYN-15	88.01 lmn	93.54 hi	74.80 d	64.61 de	48.97 gh
SATYN-21	69.74 p	85.64 jk	70.86 efg	54.29 l	45.64 i
SAYYN-17	87.01 mn	76.52 mn	72.85 def	62.18 efg	50.39 gh
SATYN-23	66.16 pqr	40.01 s	63.44 i	63.20 ef	56.50 f
ESWYT-5	153.3 a	121.0 a	100.4 a	88.57 a	81.71 a
SATYN-24	84.40 n	80.16 lm	63.01 i	49.19 no	33.15 mn
ESWYT-6	147.6 b	119.1 ab	99.94 a	78.29 b	78.89 b
SATYN-3	87.14 mn	81.30 kl	43.77 klm	40.99 qr	37.30 kl
SATYN-27	62.93 qr	66.33 o	51.34 j	46.12 p	31.44 no
SATYN-12	78.40 o	73.45 n	45.95 k	46.69 op	31.55 no
SATYN-6	76.99 o	58.61 q	67.47 h	57.31 ijk	48.18 hi
SATYN-19	90.22 klm	49.65 r	74.63 d	57.41 ijk	61.58 e
SATYN-16	76.65 o	28.87 t	22.94 q	17.77 u	13.76 r
SATYN-25	70.02 p	38.97 s	68.18 gh	61.03 fgh	61.83 e
WICYT-7	66.52 pq	65.63 op	30.48 p	25.82 t	0.00 s
WICYT-9	97.65 hij	95.79 ghi	69.87 fgh	54.84kl	35.11 lm
WICYT-28	100.9 gh	101.5 def	32.98 op	42.37 q	36.28 kl
WICYT-35	96.97 hij	50.85 r	37.54 n	36.36 s	31.46 no
WICYT-41	109.4 f	93.29 i	41.62 m	38.09 rs	26.68 p
WICYT-15	103.5 g	61.51 pq	42.45 lm	50.61 mn	40.50 j
WICYT-20	117.1 de	99.09 efg	63.52 i	58.14 hij	32.52 n
WICYT-25	92.76 jkl	84.54 jkl	51.32 j	52.62 lm	31.74 no
WICYT-26	117.1 de	83.15 jkl	71.01 efg	66.92 d	56.35 f
SATYN-2	112.1 ef	98.58 fg	43.09 klm	37.74 s	29.53 o
SATYN-10	99.07 ghi	98.02 fgh	41.29 m	37.23 s	38.18 jk
SATYN-14	97.77 hij	85.93 j	35.59 no	20.59 u	20.43 q
SATYN-20	76.79 o	49.63 r	31.50 p	47.72 nop	21.30 q
BARI GOM 25	116.9 de	109.6 c	71.00 efg	59.79 ghi	62.25 e
BARI GOM 26	120.6 d	104.8 d	88.10 c	74.72 c	68.36 d
BARI GOM 27	120.1 d	103.4 de	89.98 c	55.16 jkl	51.50 g
BARI GOM 28	128.7 c	115.0 b	95.21 b	76.66 bc	73.99 c
BARI GOM 29	94.99 ijk	83.79 jkl	73.29 de	53.19 lm	25.20 p
LSD $_{(0.05)}$	5.08	4.55	3.08	2.99	2.57
CV (%)	4.23	4.51	4.11	4.61	4.97

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

Table 9. Effect of different salinity levels on water saturation deficit of different wheat genotypes at different salt concentrations

	Water saturation deficit at different salt concentrations				
Treatment	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	14.70 kl	12.14 q	14.71 r	34.52 k	0.00 s
SATYN-15	40.49 b	45.54 e	26.87 lm	57.30 c	20.67 q
SATYN-21	16.58 hi	24.60 lm	20.37 p	30.98 lm	30.83 n
SAYYN-17	10.20 q	21.39 n	27.83 kl	21.87 o	42.71 g
SATYN-23	15.11 jk	24.87 l	30.34 ij	46.10 e	35.89 kl
ESWYT-5	10.20 q	9.40 r	7.46 t	16.52 q	12.61 r
SATYN-24	16.04 ij	20.00 n	28.84 jk	23.48 no	37.78 i-k
ESWYT-6	10.45 pq	9.80 r	7.83 t	17.79 q	12.79 r
SATYN-3	27.86 d	29.54 ij	22.99 o	45.21 ef	46.06 f
SATYN-27	11.61 op	23.13 m	44.91 d	53.01 d	39.25 hi
SATYN-12	10.45 pq	18.31 o	26.64 lm	32.31 kl	31.08 n
SATYN-6	21.09 g	17.94 o	24.31 no	28.96 m	29.25 n
SATYN-19	21.53 g	23.11 m	25.82 mn	22.84 no	19.46 q
SATYN-16	23.78 f	17.58 o	19.97 p	41.28 g-i	34.47 lm
SATYN-25	12.82 no	12.77 q	14.12 r	18.59 pq	23.88 p
WICYT-7	17.59 h	34.84 h	59.97 a	39.92 h-j	0.00 s
WICYT-9	13.41 mn	38.52 g	36.43 f	38.44 j	38.08 ij
WICYT-28	10.92 pq	56.32 c	61.72 a	70.72 a	56.38 c
WICYT-35	14.58 k-m	60.52 b	55.19 b	28.81 m	72.14 a
WICYT-41	14.69 kl	75.04 a	38.30 f	41.90 gh	55.20 cd
WICYT-15	28.09 d	39.99 fg	53.47 b	25.04 n	33.62 m
WICYT-20	33.13 c	44.92 e	12.01 s	32.91 kl	21.44 q
WICYT-25	25.19 e	55.82 c	32.37 gh	43.43 fg	40.34 h
WICYT-26	21.39 g	41.40 f	31.29 hi	64.15 b	53.21 de
SATYN-2	27.69 d	30.68 i	37.79 f	62.94 b	52.54 e
SATYN-10	13.96 k-n	14.58 p	49.91 c	45.04 ef	64.49 b
SATYN-14	13.66 l-n	28.95 jk	41.25 e	69.99 a	51.91 e
SATYN-20	57.56 a	48.37 d	34.19 g	38.88 ij	36.15 j-l
BARI GOM 25	21.96 g	21.47 n	27.61 k-m	32.19 kl	26.19 o
BARI GOM 26	21.22 g	9.804 r	17.07 q	18.43 q	27.06 o
BARI GOM 27	23.68 f	27.43 k	28.44 j-l	21.09 op	25.41 op
BARI GOM 28	10.85 pq	10.11 r	9.09 t	18.04 q	13.36 r
BARI GOM 29	27.06 d	45.42 e	40.77 e	32.23 kl	33.363 m
LSD $_{(0.05)}$	1.26	1.61	1.95	2.53	2.10
CV (%)	4.83	4.26	5.1	5.49	5.11

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

4.10Water retention capacity

The amount of water useful for crop hold by plant is the water retention capacity. Different salt concentration significantly influenced water retention capacity of wheat genotypes (Appendix XI and Table 10). Highest water retention capacity ranges from 16.40, 24.60, 13.93, 12.06 19.34 in ESWYT-5 to 8.62 in SATYN-22, 5.82 in WICYT-41, 4.92 in SATYN-20, 5.07 in WICYT-41 and 0 in SATYN-22 and WICYT-7 at 0, 5, 10, 15 and 20 dSm^{-1}, respectively.

Under salt stress condition tolerance plant can grow vigorously minimize the salt uptake and maximize potential salt load per unit area by their compartmentalization technique and provide better water use efficiency thus plant growth not hampered (Flower *et al.*, 1988).

4.11Coefficient of velocity

Salinity level significantly influenced the coefficient of velocity of wheat genotypes (Appendix XII and Table 11). Maximum coefficient of velocity ranges from 16.56, 16.68, 16.48 16.78 and 17.33 in ESWYT-5 to 14.52 in BARI GOM 29, 13.98 in SATYN-27, 13.61 in SATYN-22, 13.67 in WICYT-35 and 12.97 in SATYN-15 at 0, 5, 10, 15 and 20 dSm^{-1}, respectively.

Table 10. Effect of different salinity levels on water retention capacity of different wheat genotypes at different salt concentrations

Genotypes	Water retention capacity at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	8.62 p	8.772 q	12.35 bc	8.53 i-k	0.00 t
SATYN-15	12.19 ij	12.45 fg	11.28 de	9.69 f	6.85 pq
SATYN-21	9.70 no	13.13 de	10.73 e-g	7.94 kl	10.24 e-g
SAYYN-17	12.21 ij	11.68 hi	11.84 cd	8.99 g-i	7.81 no
SATYN-23	9.178 op	11.25 ij	9.634 jk	9.05 g-i	7.87 m-o
ESWYT-5	16.40 a	24.60 a	13.93 a	12.06 a	19.34 a
SATYN-24	10.59 m	12.54 e-g	10.61 f-h	8.02 kl	8.43 k-m
ESWYT-6	15.95 a	24.14 a	12.61 b	11.91 a	10.18 e-g
SATYN-3	10.88 lm	13.26 d	8.95 lm	10.34 e	9.06 ij
SATYN-27	10.16 mn	9.982 l-n	9.41 kl	9.25 f-h	6.46 q
SATYN-12	12.92 f-i	9.700 m-o	6.70 p	10.57 de	10.44 d-f
SATYN-6	10.69 lm	11.20 ij	9.58 jk	10.54 de	10.63 de
SATYN-19	10.54 m	10.26 k-m	10.65 f-h	10.78 c-e	7.82 no
SATYN-16	11.38 kl	11.16 ij	10.37 g-i	10.53 de	10.71 de
SATYN-25	12.61 g-i	13.06 d-f	10.09 h-j	8.21 j-l	9.55 hi
WICYT-7	13.09 d-g	9.04 o-q	6.45 pq	9.71 f	0.00 t
WICYT-9	12.25 h-j	17.73 c	5.04 s	7.72 l	8.16 l-n
WICYT-28	13.55 c-f	9.46 n-p	5.78 r	5.23 n	11.33c
WICYT-35	9.444 no	11.01 ij	5.80 r	6.81 m	5.46 r
WICYT-41	13.76 cd	5.82 t	6.94 op	5.07 n	4.79 s
WICYT-15	13.43 c-f	7.022 r	8.26 n	6.83 m	7.36 op
WICYT-20	10.87 lm	6.338 st	8.54 mn	9.19 f-h	6.36 q
WICYT-25	10.84 lm	8.792 pq	5.96 qr	8.74 h-j	8.84 jk
WICYT-26	11.80 jk	12.26 gh	6.62 p	6.32 m	9.03 ij
SATYN-2	11.82 jk	11.22 ij	7.42 o	5.60 n	9.69 gh
SATYN-10	9.28 op	17.18 c	9.66 jk	6.862 m	8.73 j-l
SATYN-14	11.75 jk	6.80 rs	6.47 pq	8.76 h-j	8.27 k-n
SATYN-20	9.538 no	7.22 r	4.92 s	10.8 c-e	9.55 hi
BARI GOM 25	12.97 e-h	13.22 d	11.94 c	11.28 bc	9.68 gh
BARI GOM 26	14.15 bc	10.58 j-l	10.96 ef	9.58 fg	10.04 f-h
BARI GOM 27	12.66 g-i	12.11 gh	9.17 kl	10.99 b-d	10.82 cd
BARI GOM 28	14.87 b	21.23 b	12.11 bc	11.50 ab	15.78 b
BARI GOM 29	13.68 c-e	10.85 jk	10.03 ij	9.65 f	8.14 mn
LSD $_{(0.05)}$	0.75	0.68	0.58	0.60	0.58
CV (%)	5.07	4.69	5.05	5.36	5.47

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

Table 11. Effect of differentsalinity levels on coefficient of velocity of different wheat genotypes at different salt concentrations

Genotyoes	Coefficient of velocity at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	15.89 a-h	14.33 jk	13.61 j	14.73 e-i	13.81 h-k
SATYN-15	15.76 a-i	14.84 g-jk	14.14 g-j	15.01 e-i	12.97 k
SATYN-21	16.04 a-f	15.43 d-i	14.58 d-j	15.57 b-e	13.45 i-k
SAYYN-17	15.35 d-k	15.02 f-j	14.06 h-j	14.43 g-j	14.14 f-i
SATYN-23	15.43 c-k	15.43 d-i	14.13 g-j	14.91 e-i	13.89 g-k
ESWYT-5	16.56 a	16.68 a	16.48 a	16.78 a	17.33 a
SATYN-24	15.26 f-k	15.00 f-k	15.09 c-g	14.76 e-i	14.27 e-i
ESWYT-6	16.53 a	16.63 ab	16.47 a	16.59 a	16.69 ab
SATYN-3	15.64 a-j	14.89 g-k	14.68 d-i	14.17 ij	13.88 g-k
SATYN-27	15.30 e-k	13.98 k	14.13 g-j	14.14 ij	14.59 e-h
SATYN-12	15.77 a-i	14.67 i-k	13.71 ij	14.82 e-i	14.46 e-h
SATYN-6	16.20 a-e	15.52 c-i	14.50 e-j	15.25 c-g	14.92 d-f
SATYN-19	16.07 a-f	14.88 g-k	14.39 f-j	14.37 g-j	14.63 e-h
SATYN-16	15.84 a-h	14.67 i-k	14.70 d-h	14.16 ij	14.18 f-i
SATYN-25	16.01 a-g	15.26 e-j	14.56 e-j	14.21 h-j	14.06 f-j
WICYT-7	16.11 a-f	16.26 a-e	14.74 d-h	14.63 f-i	14.02 f-j
WICYT-9	16.26 a-d	15.61 b-i	16.24 ab	14.63 f-i	16.51 ab
WICYT-28	16.06 a-f	14.90 g-k	16.29 ab	15.09 d-h	16.39 ab
WICYT-35	15.84 a-h	15.79 a-g	14.35 f-j	13.67 j	16.40 ab
WICYT-41	15.07 h-k	16.23 a-e	15.17 c-f	15.98 a-d	14.81 d-g
WICYT-15	16.14 a-f	16.43 a-d	16.22 ab	16.51 a	16.50 ab
WICYT-20	16.21 a-e	16.01 a-f	16.26 ab	16.58 a	16.08 bc
WICYT-25	15.31 e-k	15.00 f-k	15.95 a-c	16.37 ab	16.29 b
WICYT-26	15.47 b-j	15.70 a-h	15.92 a-c	15.99 a-d	15.24 c-e
SATYN-2	16.36 a-c	16.45 a-d	16.46 a	16.22 ab	16.13 bc
SATYN-10	15.85 a-h	16.00 a-f	16.17 ab	16.04 a-c	15.78 b-d
SATYN-14	15.58 b-j	15.40 e-i	15.55 a-d	15.51 b-f	16.09 bc
SATYN-20	15.59 b-j	15.26 e-j	15.43 b-e	16.02 a-c	14.27 e-i
BARI GOM 25	14.89 i-k	14.74 h-k	13.98 h-j	13.68 j	13.15 jk
BARI GOM 26	15.11 g-k	14.92 g-k	14.28 f-j	14.78 e-i	14.72 e-h
BARI GOM 27	14.77 jk	14.62 i-k	14.87 d-h	14.42 g-j	14.36 e-i
BARI GOM 28	16.40 ab	16.50 a-c	16.44 a	16.63 a	16.67 ab
BARI GOM 29	14.52 k	14.84 g-k	14.27 f-j	14.34 h-j	14.49 e-h
LSD $_{(0.05)}$	0.93	1.02	0.97	0.90	0.99
CV (%)	4.72	5.31	5.15	4.7	5.28

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

4.12 Vigour index

Salinity level significantly affected vigour index among different wheat genotypes (Appendix XIII and Table 12). The magnitude of reduction of vigour index was slow in case of ESWYT-5 followed by ESWYT-6 and BARI GOM 28 *i.e.* they hold a consistently decreasing trend but most wheat genotypes exerted rapid reduction of vigour index with the increasing of salinity level. ESWYT-5 scored the maximum vigour index (287.70, 210.5, 155.78 and 164.80 at 5, 10, 15 and 20 dSm^{-1}, respectively) but at control ESWYT-6 scored the maximum vigour index (270.70) which showed similarity with ESWYT-5 and BARI GOM 28 at control, ESWYT-5 at 10, 15 and 20 dSm^{-1},respectively.On the other hand the minimum vigour index were recorded from SATYN-20 68.94, 16.64 at 0, 5 dSm^{-1},respectively; 7.19 and 5.54 at 10 and 15 dSm^{-1} for BARI GOM 29; 0 at 20 $dSm^{-1}$for SATYN-22 and SATYN-25 which were statistically at par with WICYT-7 and SATYN-20 at 10 dSm^{-1}; only SATYN-20 at 15 dSm^{-1}; SATYN-20 and BARI GOM 29 at 20 dSm^{-1}.

Table 12. Effect of different salinity levelson vigour indexof different wheat genotypes at different salt concentrations

Genotypes	Vigour index at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	213.7 ij	152.7 gh	39.11 rs	60.41 j	0.00 q
SATYN-15	251.0 b-d	170.7 e	73.32 jk	119.6 c	42.59 i
SATYN-21	223.2 g-i	195.7 d	141.3 d	103.4 e	46.09 h
SAYYN-17	191.8 m	137.1 i	81.85 i	61.02 j	24.69 o
SATYN-23	246.9 c-e	173.5 e	109.2 f	98.76 ef	32.39 kl
ESWYT-5	270.5 a	287.7 a	210.5 a	155.78 a	164.8 a
SATYN-24	179.7 n	195.0 d	124.1 e	113.1 d	82.13 d
ESWYT-6	270.7 a	252.6 b	205.57 a	152.7 a	162.89 a
SATYN-3	167.1 o	103.8 k	46.18 pq	28.62 pq	26.15 no
SATYN-27	163.6 o	133.5 i	39.40 rs	33.58 p	16.61 p
SATYN-12	107.5 q	85.51 lm	68.96 kl	47.17 no	33.35 jkl
SATYN-6	238.6 ef	175.1 e	97.68 gh	93.83 fg	28.37 mn
SATYN-19	127.1 p	115.6 j	77.83 ij	43.04 o	62.47 f
SATYN-16	222.4 hi	196.8 d	137.5 d	92.55 gh	71.54 e
SATYN-25	202.3 k-m	207.9 c	99.30 g	88.15 hi	0.00 q
WICYT-7	207.4 j-l	66.51 o	12.70 u	55.18 kl	14.33 p
WICYT-9	239.9 d-f	53.43 p	36.08 s	59.54 jk	46.87 h
WICYT-28	213.5 i-k	42.32 q	71.71 jk	50.39 l-n	27.87 no
WICYT-35	216.1 ij	23.40 st	47.49 op	86.35 i	36.47 j
WICYT-41	234.0 fg	91.82 l	58.93 mn	100.9 e	31.34 lm
WICYT-15	207.6 j-l	75.67 no	74.44 jk	52.59 lm	48.05 h
WICYT-20	231.5 f-h	47.51 pq	147.9 c	98.35 ef	53.62 g
WICYT-25	120.4 p	32.60 r	43.47 p-r	13.22 s	16.00 p
WICYT-26	240.6 d-f	147.1 h	63.33 lm	45.97 no	96.80 c
SATYN-2	248.8 c-e	161.1 fg	71.60 jk	22.76 r	24.51 o
SATYN-10	216.3 ij	169.2 ef	53.58 no	63.01 j	34.92 jk
SATYN-14	197.9 lm	131.2 i	48.19 op	16.64 s	27.77 no
SATYN-20	68.94 s	16.64 t	7.654 u	6.268 t	1.790 q
BARI GOM 25	91.00 r	81.09 mn	23.52 t	23.74 qr	15.60 p
BARI GOM 26	234.1 fg	189.6 d	92.54 h	48.75 mn	52.66 g
BARI GOM 27	258.0 bc	130.2 i	40.07 qrs	13.74 s	16.49 p
BARI GOM 28	262.0 ab	244.6 b	163.3 b	134.6 b	105.3 b
BARI GOM 29	95.81 r	32.16 rs	7.186 u	5.544 t	1.688 q
LSD $_{(0.05)}$	11.38	9.17	6.40	5.1	3.34
CV (%)	4.51	5.6	6.66	6.58	6.88

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

CHAPTER V

SUMMARY AND CONCLUSION

With a view to screening for salt tolerant wheat genotypes, an experiment was conducted in the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during February to March, 2016. The trial included 33 wheat genotypes *viz*SATYN-22, SATYN-15, SATYN-21, SAYYN-17, SATYN-23, ESWYT-5, SATYN-24, ESWYT-6, SATYN-3, SATYN-27, SATYN-12, SATYN-6, SATYN-19, SATYN-16, SATYN-25, WICYT-7, WICYT-9, WICYT-28, WICYT-35, WICYT-41, WICYT-15, WICYT-20, WICYT-25, WICYT-26, SATYN-2, SATYN-10, SATYN-14, SATYN-20, BARI GOM 25, BARI GOM 26, BARI GOM 27, BARI GOM 28 and BARI GOM 29. Seeds of 33 genotypes were collected from Wheat Research Centre, Nashipur, Dinajpur and Bangladesh Agricultural Research Institute(BARI). The performance of the genotypes was tested under 5 levels of salinity *viz*. Control (No salt), 5, 10, 15 and 20 dSm^{-1}. The experiment was laid out in completely randomized design(CRD) with three replications.

There were significant differences observed among the influence of different levels of salinity in case of almost all the parameters. The salinity performances were evaluated in terms of seed germination, seedling growth, plant survival capacity and plant parameters such as root length, shoot length, dry weight of root and shoot per plant counted at 12 days after seed sowing.

Based on the performance, of these 33 wheat genotypes under 5 salinity level, ESWYT-5, ESWYT-6 and BARI GOM 28 was identified as the most salt tolerant wheat genotypes. All the wheat varieties showed their best performance under the treatment when no salinity was imposed whereas the worst performance was exhibited under the salinity stress of 20 dSm^{-1} NaCl level. All the genotypes were significantly inhibited by each of the salinity level compared to the control (no salinity). However, the inhibition of all parameters due to salinity stress varied among the wheat genotypes used in the study. Germination percentage of all the wheat genoypes was affected by salinity stress. For all the wheat genotypes used in the study, the highest germination percentage was observed under control condition where no salinity stress was imposed. Salinity stress both at 15 dS m^{-1} NaCl and 20 dS m^{-1} NaCl significantly reduced the germination percentage rate for all wheat genotypes. The lowest germination percentage was found from SATYN-20 (9.99%) followed by BARI GOM 29 (10%) and WICYT-25 (10.37%) while the highest germination percentage in ESWYT-5 (88.00%) followed by ESWYT-6 (87.10 %) and BARI GOM 28 (86.67 %). Accordingly, more or less similar trend was found for higher performance on shoot length, root length, fresh weight $plant^{-1,}$ shoot dry weight, root dry weight, relative water content, turgid weight, waterretention capacity, coefficient of velocity and vigour index. Among 33 Wheat genotypes ESWYT-5, ESWYT-6 and BARI GOM 28 gave the best performance where the lower performance was found for shoot length from WICYT-9, root length from SATYN-19, fresh weight from SATYN-15, shoot dry weight from BARI GOM 29, root dry weight from SATYN-19, relative water content from WICYT-35, turgid weight from SATYN-16 and water retention capacity from WICYT-41 at all salinity level. Among the entire genotypes; SATYN-22 and SATYN-25 can’t survive at 20 dS m^{-1} NaCl.

Considering the above results obtaining from the present piece of work it may be concluded that among 33 wheat genotypes ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes are salt tolerance which are attributed to higher germination rate, shoot length, root length, shoot dry weight, root dry weight, relative water content, water retention capacity, coefficient of velocity and vigour index and rest of the wheat genotypes found to be sensitive to salt stress.

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APPENDIX

Appendix 1.Monthly records of temperature, rainfall, and relative humidity of the experiment site during the period of November 2015

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
		Maximum	Minimum	Mean			
2015	November	29.5	18.6	24.0	69.5	0.0	233.2

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

Appendix II. Analysis of variance of the data on germination percentageof wheat genotypes as influenced by different level of salt concentrations

Sources of variation	df	Mean squares of germination percentage at different salt concentration				
		0	50	100	150	200
Treatment	32	1715.67**	1937.64**	2328.34**	2487.48**	2273.88**
Error	132	8.54	10.86	9.76	8.59	5.88

**Significant at 1% level of significance

^{NS} Non significant

Appendix III. Analysis of variance of the data on Shoot length (mm)of wheat genotypes as influenced by different level of salt concentrations

Sources of variation	df	Mean squares of Shoot length (mm) at different salt concentration				
		0	50	100	150	200
Treatment	32	916.095*	5269.236**	5552.164**	4342.238**	4547.769**
Error	132	39.901	26.446	13.443	9.411	5.715

**Significant at 1% level of significance

^{NS} Non significant

Appendix IV. Analysis of variance of the data root length (mm) of wheat genotypes as influenced by different levels of salt concentrations

Sources of variation	df	Mean squares of Root length (mm) at different salt concentration				
		0	50	100	150	200
Treatment	32	4896.303**	8639.827**	2952.874**	1740.205**	1208.676*
Error	132	20.435	12.652	3.987	3.858	1.512

**Significant at 1% level of significance

^{NS} Non significant

Appendix V. Analysis of variance of the data on Fresh weight (mg) of wheat genotypes as influenced by different level of salt concentrations

Sources of variation	df	Mean square of Fresh weight (mg) at different salt concentration				
		0	50	100	150	200
Treatment	32	2143.336**	2861.750**	2356.019**	1403.793*	1332.922**
Error	132	10.231	7.213	3.816	2.580	2.553

**Significant at 1% level of significance
^{NS} Non significant

Appendix VI. Analysis of variance of the data shoot dry weight (mg) of wheat genotypes as influenced by different levels of salt concentrations

Sources of variation	df	Mean squares of Shoot dry weight (mg) at different salt concentration				
		0	50	100	150	200
Treatment	32	53.077**	36.666**	23.265*	22.705*	23.422*
Error	132	0.237	0.171	0.107	0.062	0.137

**Significant at 1% level of significance
^{NS} Non significant

Appendix VII. Analysis of variance of the data on root dry weight (mg) of wheat genotypes as influenced by different levels of salt concentrations

Sources of variation	df	Mean squares of Root dry weight (mg) at different salt concentration				
		0	50	100	150	200
Treatment	32	20.634*	23.867**	12.244*	13.249*	22.423**
Error	132	0.124	0.097	0.083	0.065	0.036

**Significant at 1% level of significance
^{NS} Non significant

Appendix VIII. Analysis of variance of the data on relative water content (%) of wheat genotypes as influenced by different levels of salt concentrations

Sources of variation	df	Mean squares of Relative water content (%) at different salt concentration				
		0	50	100	150	200
Treatment	32	481.439*	1290.128**	1074.961**	1153.897**	2791.958**
Error	132	11.184	8.449	11.478	7.877	8.704

**Significant at 1% level of significance
^{NS} Non significant

Appendix IX. Analysis of variance of the data on turgid weight (mg) of wheat genotypes as influenced by different levels of salt concentrations

Sources of variation	df	Mean squares of turgid weight (mg) at different salt concentration				
		0	50	100	150	200
Treatment	32	2704.775**	2941.309**	2273.014**	1290.989*	2049.821**
Error	132	16.477	13.229	6.058	5.726	4.203

**Significant at 1% level of significance
NS Non significant

Appendix X. Analysis of variance of the data on Water saturation deficit of wheat genotypes as influenced by different levels of salt concentrations

Sources of variation	df	Mean squares of Water saturation deficit at different salt concentration				
		0	50	100	150	200
Treatment	32	481.439*	1381.388**	1074.320**	1205.363**	1613.865**
Error	132	1.016	1.660	2.439	4.092	2.821

**Significant at 1% level of significance
NS Non significant

Appendix XI. Analysis of variance of the data on water retention capacity of wheat genotypes as influenced by different levels of salt concentrations

Sources of variation	df	Mean squares of Water retention capacity at different salt concentration				
		0	50	100	150	200
Treatment	32	16.332*	77.036**	29.795*	18.386*	72.621**
Error	132	0.357	0.294	0.212	0.233	0.215

**Significant at 1% level of significance
NS Non significant

Appendix XII. Analysis of variance of the data on coefficient of velocity of wheat genotypes as influenced by different levels of salt concentrations

Sources of variation	df	Mean squares of Coefficient of velocity at different salt concentration				
		0	50	100	150	200
Treatment	32	42.327**	34.853*	83.24**	56.832*	72.349**
Error	132	1.349	2.712	4.316	3.119	5.422

**Significant at 1% level of significance
NS Non significant

Appendix XIII. Analysis of variance of the data on vigour index of wheat genotypes as influenced by different levels of salt concentrations

Sources of variation	df	Mean squares of vigour index at different salt concentration				
		0	50	100	150	200
Treatment	32	1946.534**	2478.267**	2158.359**	1536.244**	1456.238*
Error	132	12.455	8.637	4.219	3.662	5.217

**Significant at 1% level of significance

NS Non significant

Appendix XIV: Pictures of salinity effect at seedling stage in wheat

Plate 1: Experimental set up in the laboratory

Plate 2. Seedling growth of wheat at 0, 5, 10, 15 and 20 dS m^{-1}NaCl concentration respectively from left side to right

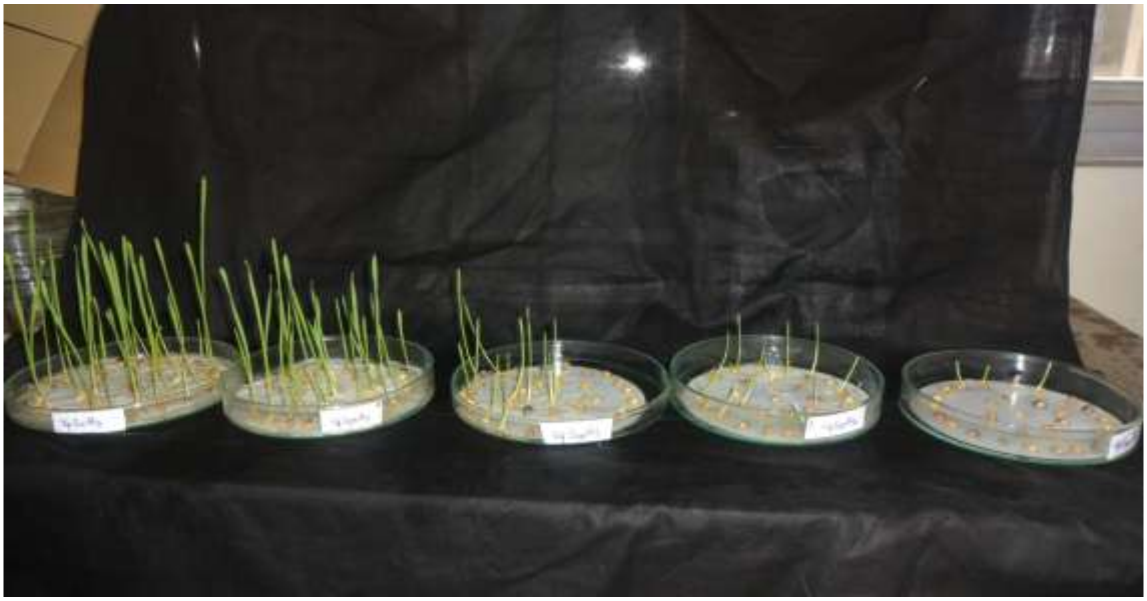

Plate 3: Salinity effect of wheat showing in the petri dish at different salinity levels