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Phenotypic Performance of Quantitative Characters of Wheat (Triticum Aestivum L.) Under Stress Environment

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PHENOTYPIC PERFORMANCE OF QUANTITATIVE CHARACTERS OF WHEAT (*Triticum aestivum* L.) UNDER STRESS ENVIRONMENT

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Submitted by

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Dedicated

To

My Beloved Parents

DECLARATION

I hereby declare that thesis entitled **"Phenotypic Performance of quantitative Characters of Wheat (*Triticum aestivum* L.) Under Stress Environment"** submitted to the Institute of Biological Sciences. Rajshahi University, Rajshahi, Bangladesh for the degree of Doctor of Philosophy is the result of my own investigation and was carried out under the supervision of Professor Dr. M. I. Zuberi, Department of Botany, Rajshahi University, Rajshahi. The thesis contains no material previously published or submitted elsewhere for any other degree.

Most. Nasrim Akhter
Candidate 22.12.11

Certificate

*I have the pleasure to certify that the thesis "**Phenotypic Performance of Quantitative Characters of Wheat (Triticum aestivum) Under Stress Environment**" submitted by Most. Nasrin Akhter to the Institute of Biological Sciences, University of Rajshahi, Rajshahi, Bangladesh in partial fulfillment of the requirements for the degree of Doctor of Philosophy, was carried out by Most. Nasrin Akhter and the data included are original.*

22.12.11

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

BARI	= Bangladesh Agricultural Research Institute
DW	= Dry weight
FAO	= Food and Agriculture Organization
FLA	= Flag leaf area
FW	= Fresh weight
GY	= Grain yield
LLA	= Largest leaf area
LMH	= length of main head
MPO	= Master Plan Organization
NHGM	= Number oh half filled grains in the main head
NHGS	= Number oh half filled grains in the second head
NFM	= Number of florets in the main head
NFGM	= Number of full grains in the main head
NFGS	= Number of full grains in the second head
NFS	= Number of florets in the second head
NL_3	= Number of leaves at 3 weeks
NL_7	=Number of leaves at 7 weeks
NL_H	= Number of leaves at heading
NS	= Number of spike
NT	= Number of tillers per plant at 7 weeks
NT	= Number of tillers per plant at heading
PH_3	= Plant height at 3 weeks

PH_7 = Plant height at 7 weeks

PH_H = Plant height at heading

PH = Plant height at harvest time

SY = Straw yield

TS = Tiller with spike

WHFGM = Weight of half filled grains of the main head

WHFGS = Weight of half filled grains of the second head

WFGM = Weight of full grains of the main head

WFGS = Weight of full grains of the second head

YPP = Yield per plant

HYV = High yielding variety

ABSTRACT

Ten high yielding modern varieties maintained in BARI Farm, Satkhira, Bangladesh (Aghrani, Khanchan, Bejoy, Sufi, Satabdi, Potiva, Akbar, Gourab, Prodip and Barkat) and eight collections of wheat (*Triticum aestivum* L.) from local farmers were grown in two different sites, saline and less-saline soils in the coastal area of Bangladesh (Satkhira district). One of the sites was at Ishwaripur of Shymnagar Upazila with high salinity level (5.3 to 8.5 dS) and another was at Alipur (low salinity level (2.2.0 to 2.8 dS) in Satkhira district during the Rabi Seasons of 2008-09 and 2009-2010 under rain fed conditions.

Juvenile characters scored at four and seven weeks (plants height, number of leaves, number of tillers fresh weight, dry weight), heading time characters (plant height, number of tillers, largest leaf area, flag leaf area) and harvest time characters (plant height, tillers with spike, number of florets, number of full grains, weight of full grains, number of half-filled grains, weight of half-filled grains and yield per plant) were scored and performances were compared, in the more saline and less-saline environments, among the ten high yielding varieties and eight farmers' collection over the two seasons (2008-2010).

Nineteen juvenile and maturity characters scored as indicator of phenotypic variation for growth, flowering and yield expressed high level of variation, but the degree of variability was higher in less saline environment. Salinity was observed to affect some characters and some accessions more than others. Depending on the phenotypic performance of yield, earliness, number of tillers and half filled grains six better

performing lines in the saline environment and two better performing lines from the less-saline environment were identified during the first experiment, and were used for trial during the next year in both saline and less-saline soils for further investigation.

Results indicated that plant growth, number of tillers, number of leaves, leaf area, fertile tillers, number of florets, number of full grains weight of full grains were significantly decreased by salinity stress. Salinity stress also enhanced flowering and maturation. Tiller per plant was more stable in salinity tolerant lines, so is the number of grains in the main head, number of grains in other heads were more susceptible to salinity.

The results also indicated that modern varieties were more susceptible than the local farmers' collection. Out of ten modern varieties, 3 Accessions A_1 (Aghrani), A_6 (Protiva) and A_8 (Gaurab) produced better yield among the 10 lines in the Rabi season 2008-2009 in the saline area. Three Accessions (A_{14}, A_{16} and A_{17}) out of 8 farmers' collections also gave better yield. On the other hand, in the less-saline area, Accessions A_5 (Satabdi), A_7 (Akbar), A_8 (Gaurab) and A_{10} (Barkat) from modern varieties and Accessions A_{12}, A_{14}, A_{15} and A_{17} from farmers' collections were better yielding. The three Accessions (A_8, A_{14}, A_{17}) were good in both the saline and less-saline environments. All these better performing Accessions indicated an efficient combination of juvenile and yield contributing characters, thus producing improved yield. In the Rabi season of 2009-2010, number of fertile tillers had decreased with the increasing salinity level with time and this negative effect of salinity was more prominent in the less-saline environment. The reduced number of grains per spike and smaller grain size resulted from increasing salinity in the less-saline area were responsible for the yield loss.

During the second year, Accession A_{14} and A_{17} were high yield giving in the saline and in the less-saline environments. Accessions A_{10} $A_1$and A_5 had also good combination of yield contributing characters and better performance. Results indicated that effect of salinity became more pronounced late in the season and affected heading and harvest time characters.

In general, the stress factors related to high salinity enhanced the life cycle of wheat - plant growth, flowering and maturation were enhanced. Thus, the number of days to heading and maturity were decreased. Out of eight wheat Accessions, grown in the Rabi season of 2009-2010, A_{10} (Barkat), A_{14} and A_{17} were likely to have salt tolerance based on their relative performance for yield components and grain yield.

These lines were selected for further trial and farmer based selection and also for future genetic analysis.

Chapter One

Introduction

INTRODUCTION

1.1 Environment and agriculture

The economic activities of human beings and the resulting impact on the environment have resulted in reduced resilience and regeneration of environmental resources. Interventions of man in nature, through his diverse and far-reaching scientific and technological capabilities, have transformed the structure and function of the nature and utility ecosystem. The degradation of agricultural ecosystems has given rise to the concept of sustainability (WCDE, 1981, World Bank, 1992, Tisdell, 1994).

In many areas like South-Western Bangladesh, agriculture has already suffered through lack of water and irrigation creating a serious threat to the attempts at attaining self-sufficiency in food production. It has been estimated that, it is theoretically possible to expand irrigated land from 1.9 million hectares (in 1986) to a maximum of 6.9 million hectares (MPO 1986 but serious doubts created particularly because of (a) upstream withdrawal of river water, (b) the unreliability of recharge of ground water, (c) irregularity of rainfall and lack of proper utilization of surface water and (d) dereliction of surface water bodies (USAID 1990).

About eighty percent of the total population of Bangladesh depend, directly or indirectly, on agriculture. Despite the decline in relative importance of the agricultural sector in the national economy since independence, the sector still produces about half of the economy's output and employs nearly three fifths of the civilian labour force (BBS 1986). The crop agriculture alone accounts for about two fifths and rice almost a quarter of the national output (BBS 1991).

1.2 Stress environment and plant response: salinity

Cold, drought and salinity are environmental stress which affect plants in many respects. Plants are very sensitive to these environmental stimuli and undergo changes in physiology and development – known as responses - that acclimate them to their particular surroundings. These responses of a plant, often induce or cause adaptations to and tolerance of environmental stresses. Abiotic stresses, such as drought, salinity, extreme temperatures, are serious threats to agriculture and the natural status of the environment. Due to the wide-spread occurrence of these stress like drought and salinity, they often cause the most fatal economic losses in agriculture. Naturally there are many research works on the effects of these stress factors ranging from a description of the damages to mechanisms of tolerance and selection and breeding. Increased salinization of arable land is expected to have devastating global effects, resulting in 30% land loss within the next 25 years, and up to 50% by the year 2050. Therefore, breeding for drought and salinity stress tolerance in crop plants (for food supply) should be given high research priority in plant improvement. The present research focuses on soil salinity as the stress factor and wheat as the crop of study.

1.3 Wheat in Bangladesh

Wheat is the second most important crop after rice in Bangladesh with versatile uses in making various foods and feeds. Being more nutritive and environment friendly requiring less water and inputs, wheat is grown from irrigated to dry rain fed environments where optimum temperature for the growth (10-20°C, Fischer, 1981) prevails. But the production per unit area of wheat in this country is very low, the average yield in

Bangladesh being only 1930 kg/ha which is lower than the world average. (FAO, 1987). Bangladesh has to import a huge quantity of grain food, mainly wheat to meet the deficit of cereals. In 1989/90 and 1990/91, the average supply of wheat was 2.3 million tons, of which 65% was imported (Ahemd et al 1996).

In recent years, due attention has been given to augment wheat cultivation a number of high yielding varieties of wheat have been released in Bangladesh, with gradual increase in wheat acreage. But these high yielding varieties require adequate irrigation, fertilizer and pesticides for good yield. As a Rabi (winter) crop, wheat faces a number of stress factors like short growing season, drought, higher temperature as well as salinity in the coastal areas. As many of the poor farmers grow wheat using high yielding varieties under rain fed condition without irrigation, poor yield rates are often obtained.

Also the farmers of the coastal region experience very low yield rates due to salinity stress. No variety is known to be selected exclusively for stress environment on low input conditions in Bangladesh. To meet the food demand, it is necessary to increase wheat production either by increasing the yield per unit area or by increasing the wheat cultivated area. In either way, there are widespread problems, for example, salinity limits the realization of yield potential of modern wheat varieties along the coastal region. Alleviation of saline soil the through various methods, such as reclamation, irrigation and drainage are not always economical or practical. Breeding for salt tolerance appears to after a more promising, energy efficient, economical and socially acceptable approach to solving these problems.

About 2.8 million hectares of land of Bangladesh are reported to be salt affected (Karim et al, 1982), which is about one-fifth of the total cultivable land of the country. Water of different sources in saline areas are also saline to different degrees. It is a common practice that only Aman rice is grown in salt-affected area during the monsoon when the salinity decreases due to rain water. But after harvesting of Aman rice farmers generally have to prepare the land when the soil is ready. Often, land preparation needs time and resources, also within a short period the stored moisture in soil becomes inadequate to meet the evapotranspiration (ET) demand of the crop (Karim et al, 1990) and consequently wheat undergoes moisture stress of varying intensities. In salinity affected areas supplementary irrigation is difficult and expensive. The district of Satkhira is one of the South-Western district of Bangladesh which in salinity affected being adjacent to the Bay of Bengal. As a vast area remains fallow due to salinity and shortage of water suitable salinity tolerant wheat variety can be grown as the water requirement of wheat is much less, only one third of rice (Islam, 1975).

1.4 Wheat cultivation in salinity affected coastal soil

The history of wheat cultivation in the Southern part of Bangladesh, coast of the Bay of Bengal, is not well documented. For example, in the coastal district, Satkhira, it is reported that only 9.5 hectares of cultivable land was under wheat in Shyamnagar Upazila and yield per hectare was 1.5 m.t in Rabi season 2008-09 (Upazila Agric. Office,2010 pers.com.)

The main obstacle for growing wheat is salinity and short winter. Fresh water is unobtainable everywhere in this part of the country, the people depend on ponds for drinking and other domestic uses. The farmers who grow wheat in small plots near their courtyard where the pond water is available for limited irrigation. This water scarcity imposes huge reductions in crop yield and is a limitation to crop expansion and the scenarios for global environmental change suggest a future increase in aridity as well as in the frequency of extreme events all over the earth including Bangladesh, (IPCC 2001). Nowadays, approximately 70% of the global available water is employed in agriculture and 40% of the world's food is produced in irrigated soil. More then 10% of the irrigation water comes from aquifers, leading to many aquifers exploited unsustainably (Somerville and Briscoe, 2001).

1.5 Salt tolerance in crops

Salinity affects 7% of the world's land area, which amounts to 930 million ha (Szabolcs 1994; FAO 1989 data). The saline area is increasing; a global study of land use over 45 years found that 6% had became saline (Ghassemi *et al.,* 1995) amounting to 77 million ha. In Australia alone, 2 million ha have become saline since land clearing began a century ago, and another 15 million ha are at risk of becoming saline in the next 50 years (National Land and Water Resources Audit: http://audit,ea,gov.au.) which represents a third of Australia's agricultural area.

Salt tolerance is usually assessed as the percent biomass production in saline versus control conditions over a prolonged period of time. Dramatic differences are found between plant species for salt tolerance, for annual species, particularly for field crops or horticulture crops, the rate of biomass production is more useful, as this usually correlates with yield. It is surprisingly difficult to quantify differences in salt tolerance between closely related species, as the growth reduction depends on the period of time over which the plants have grown in saline conditions. For example, durum wheat has the reputation of being more salt sensitive than bread wheat, and its yield is more affected (Francois *et al.* 1986). Yet, over short periods of time in salinity, there was no differences between durum and bread wheat cultivars, nor between barley and triticale cultivars (Munns R. et al., 1995). This led to consideration of time scale and the different mechanisms that may be important in controlling growth at different periods of time for plants exposed to salinity.

1.6 Research in salinity tolerance in wheat

In many countries including Bangladesh, extensive coastal areas exist where salinity of soil and water is a problem for growing crops. Approaches involving special selection and breeding of crops can be useful here (Paslernak et al., 1985). Wheat, being important source of human nutrition, the incorporation of salt tolerance in this crop deserves more attention. Evidences indicate that cultivars of wheat may serve as a source for salinity tolerance in modern wheat verities (Foster, 1988; Maas and Poss, 1989; Rana, 1986). The fact that biological variation in salt (Na^+ and K^+) contents is important in the genetic basis of salt tolerance in wheat, noted by many workers (Joshi et al., 1979; Shah et al., 1987; Sing et al., 1988; Gorhum, 1988 and Salam, 1993) suggesting a possibility of selecting salt tolerant genotypes with different combination of polygenes.

Research results that under saline condition, genetic variances were significant whereas genotype × environment interaction variance were non-significant for biomass, grain yield and harvest index in wheat (Kelman and Qualset, 1991) also suggest the presence of genetic variation for this trait which are quantitative in nature. 'Between Variety' differences observed in wheat cultivars were related to the differing pattern of dry matter accumulation (Manns and Termaat, 1986) and there is also evidence of genetically controlled selective uptake of salt ions (Erdei and Trivedi, 1983; Salam, 1993).

These results suggest that through selection and hybridization improving salt tolerance in wheat grown in saline soil can be accomplished. Although systematic research to examine genetic variability in wheat (and other cops) are often rare, there always is evidence that there is intra-species variation for salt tolerance in wheat (Ashraf and McNeilly, 1988; Rashid, 1986; Singh et al., 1988). Ahsan (1996) investigating salt tolerance in wheat by selecting genotypes from existing varieties, indicated that improvement in salt tolerance is possible through selection. Ahsan and Wright (1998) demonstrated intra-varietal variations for ion-content, yield and yield components in wheat and indicated a possibility of selection within a variety. Such variability within wheat has also been reported by a number of workers (Rashid, 1986; Shah, 1987; Salam, 1993; Joshi, 1992). Though indicated by Srivastava and Jana (1984) and Kingsbury and Epstien (1984) that salinity variation within existing crop cultivars and selecting promising lines/genotypes, can be rewarding, very few systematic work has been done along this line in Bangladesh.

Another point relevant here is that yield in wheat depends on a number of contributing characters, the development of these occur at different phenological stages (Evans et al., 1975; Kirby, 1988). The salinity levels in the soil too varies with time during the crop season and thus, stress affects the grain yield differently depending on when the stress become effective (Friend, 1965, Langer and Ampong, 1970; Halse and Weir, 1974; Frank et al., 1987). Thus, genetic differences between varieties and genotype environment interaction of individuals towards varying degree of stress can alter opportunity of selection for tolerance within and between wheat varieties.

Therefore, there exists inter-specific and intra-specific (inter-varietal or intra-varietal) variation, within the wheat gene pool when the crop has been grown in a salinity infested area for a long time. It must be possible to identify the character or characters involved in the germplasm, and these character are likely to be genetically controlled so can be used to select and breed for salinity tolerance. There are still large gaps in our knowledge of the genetics of salt-tolerance, although it is now well-established that it is not a simple trait. As salinity tolerance varies throughout the life cycle of the plant, it is necessary to identify and select these genotypes, breeding for salt tolerance is a difficult and lengthy process, necessarily involving a number of stages (Shannon and Noble 1990).

1.7 Approach to select salinity tolerance in wheat

Above discussion suggests that it may be easier to select genes for salt tolerance with small effects which are already in the wheat genomes in the varieties. As bread wheat is hexaploid, there are many duplicate genes in the three sets of paired chromosomes from different sources indicating availability of polygenes. Recently it has been noted that salt tolerance in bread wheat changes with growth stage (El-Hendawing *et al.*, 2005). So, identifying multiple characters showing salinity tolerance at different growth stages can enable identifying, selecting and breeding for salt tolerance through conventional breeding..

So, different researchers working on salinity tolerance in wheat, including this study, plan to identify genotypes which show significantly better performance of growth and development parameters under saline condition. The aim is to select several such genotypes with different genetic ability to tolerate salinity and them hybridize and select for improved salinity tolerance under a breeding program.

Many workers include diverse genotypes from different regions and countries, but such diverse assemblage with different seasonal, physiological and ecological response capability to the experimental site and environment will complicate the expression of salinity tolerance expressed by different juvenile and growth characters as well as yield.

So the present research used improved varieties recommended for that region and local formers' collection which are considered to be locally adapted.

1.8 Cultural solutions: Irrigation, fertilizers and Relay type of multiple cropping

The effects of salinity can be minimized by application of irrigation water and/or manures and fertilizers, the local farmers are known to be poor and were not interested to invest much on a marginal crop like wheat. However, data will be collected from the local BARI farm who use better cultural practices and the results will be compared with the trial data.

Relay cropping is the inter planting of crops in the field prior to harvest the previous crop. Relay type of multiple cropping may be a solution in salinity prone areas. Because in the dry Rabi season, due to lack of rainfall with high evapotranspiration, soil gets more saline gradually and also late harvesting of Aman paddy and late land preparation in traditional cropping become one of the major causes of low yield of wheat crop in the saline area.

So, if the relay cropping is introduced in such areas in wet Aman paddy field, seed germination as well as seedling growth will be hastened and early, rapid growth may prevent the causes of low yield of wheat due to salinity. There are advantages of relay type of multiple cropping:

- There is no need for cultural operation like plaughing and soil preparation.
- Maximum benefit results from minimum cost.
- The soil texture and soil structure reach good condition.

Moreover, delayed sowing increases the chance of the wheat crop to get exposed to salinity more intensely than early sown crop. It has been reported that one day delay sowing decreases 18 kg per acre of wheat production after appropriate time (Bangladesh Agri. Res. Institute, pers.com).

1.9 The present study

In spite of the problems of growing wheat in salinity affected areas, some farmers of Satkhira (salinity affected coastal area of Bangladesh) used to grow wheat for their own consumption ever year. So these varieties grown in saline environment for several years may, through indirect selection, may accumulate genes for salt tolerance in seeds. So, modern varieties from the farm of Bangladesh Agricultural Research Institute (BARI) and collections from local farmers were used.

The objectives of this study were to :

- identify the relative importance of agronomic characters associated with salt tolerance from the phenotypic performance of quantitative characters of wheat (Triticum aestivum) saline stress,

- to screen the different wheat genotypes for their salt tolerance at different growth stages

- Alternative cultural practice, eg. relay cropping whether can sustain wheat cultivation in salinity affected area through screening the performance of quantitative characters under salinity stress.

Chapter Two

Materials And Methods

MATERIALS AND METHODS

2.1 Materials

The materials, Accession 1 to 10 (Aghrani, Kanchan, Bijoy, Sufi, Shatabdi, Protiva, Akbar, Gourob, Prodip and Barkat) modern wheat varieties collected from BARI (Bangladesh Agricultural Research Institute), Jessore and another set, Accession 11 to 18 collected from the local farmers of salinity affected coastal area, Ishwaripur, Bongshipur and Kashimari villages of Shyamnagar Upzila under Satkhira district of Bangladesh were the mayerial for this study. This area is known as highly salinity affected so the farmers collection from this area were included in the experiment. The varieties or identity of A_{11} to A_{18} were unknown to the farmers but were reported derived from seeds of improved varieties released by the BARI and were grown for years.

2.2 Methods

2.2.1 Experimental fields

The experiment was conducted at two different locations of salinity affected areas in the southern district of Satkhira, Bangladesh (Figs 1,2,3 and 4) under farmer field conditions.

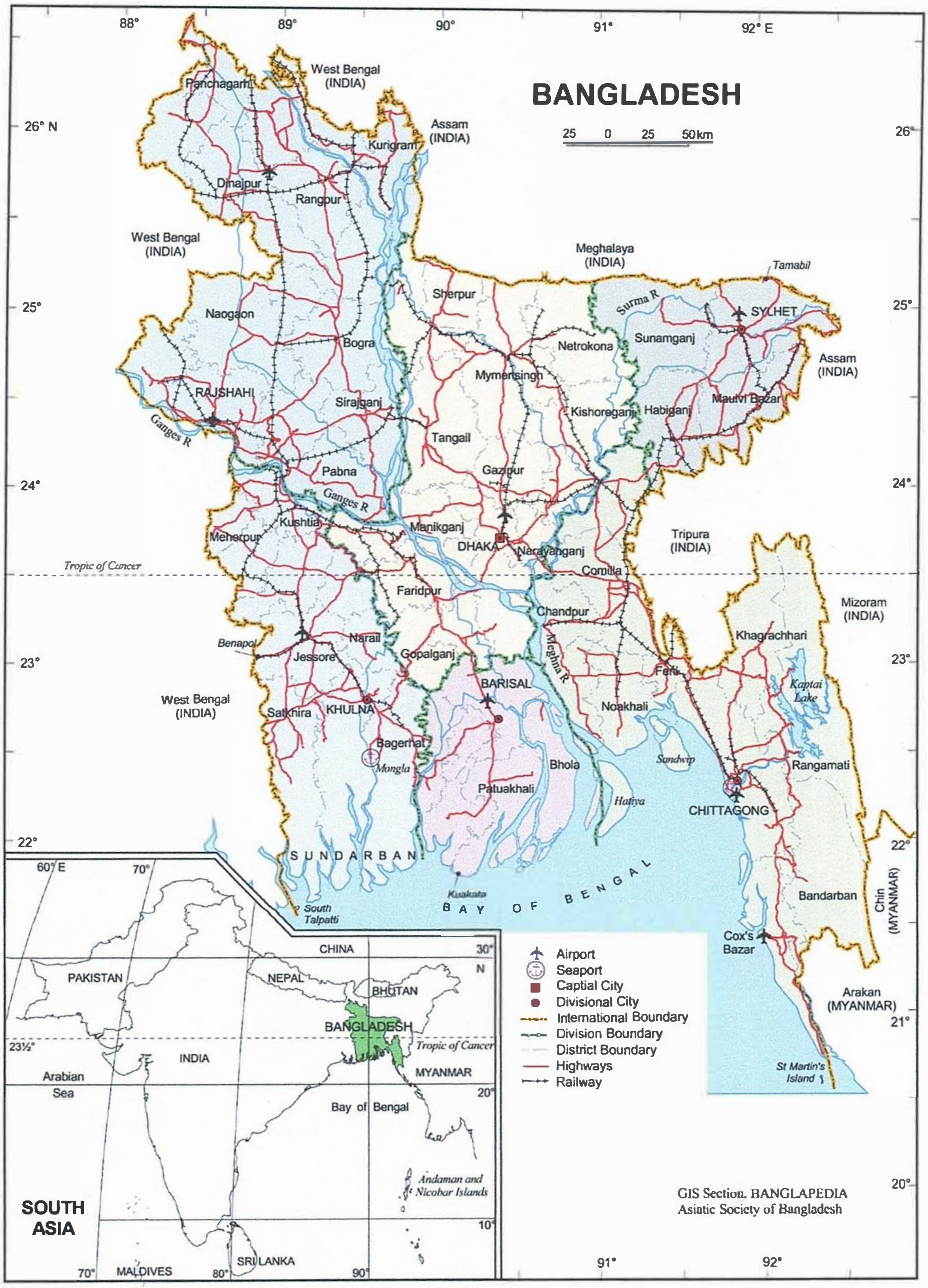

Fig 2.1 Bangladesh: location of the Experiment

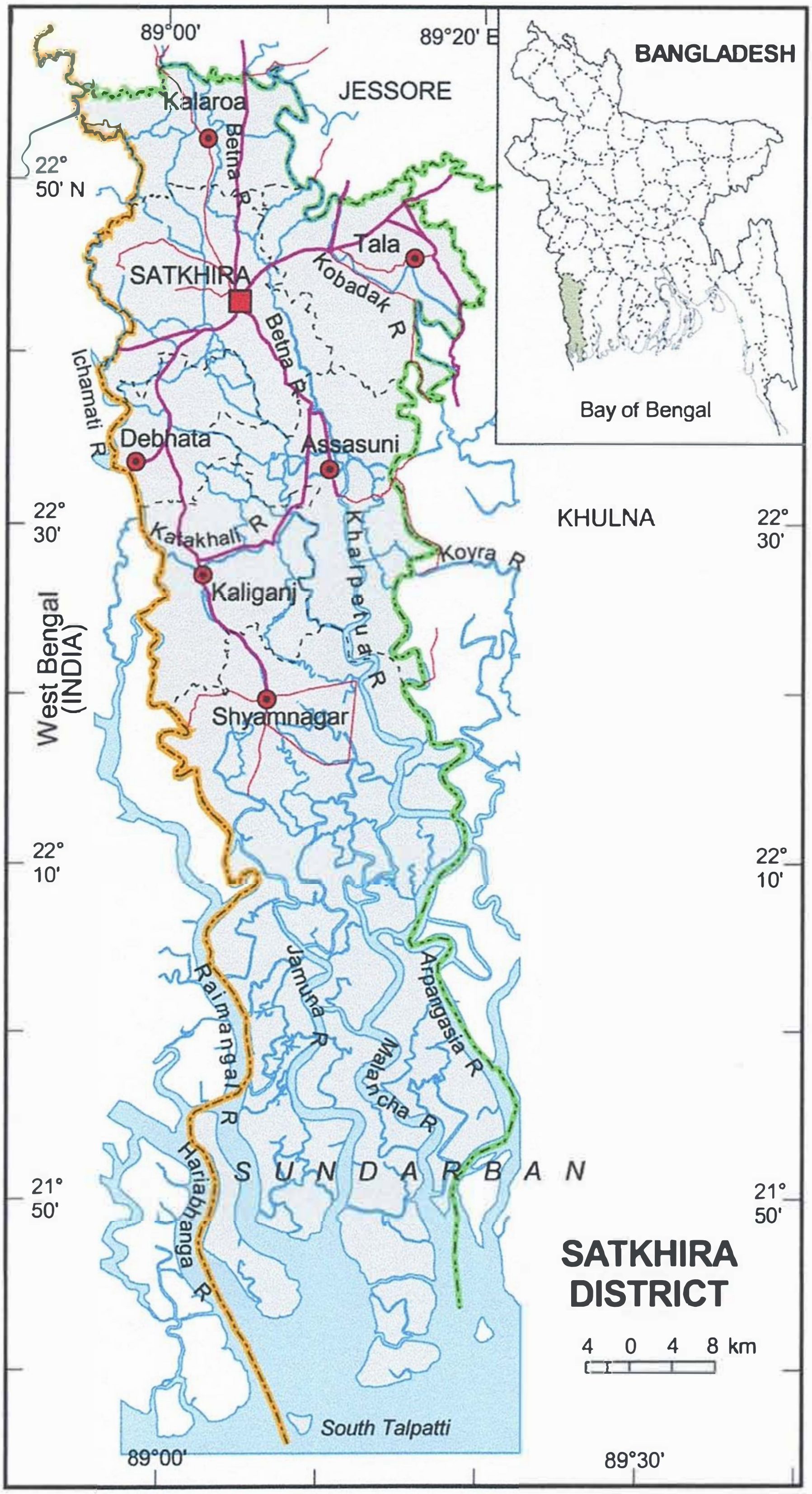

Fig 2.2 Satkhira: location of Experimental area

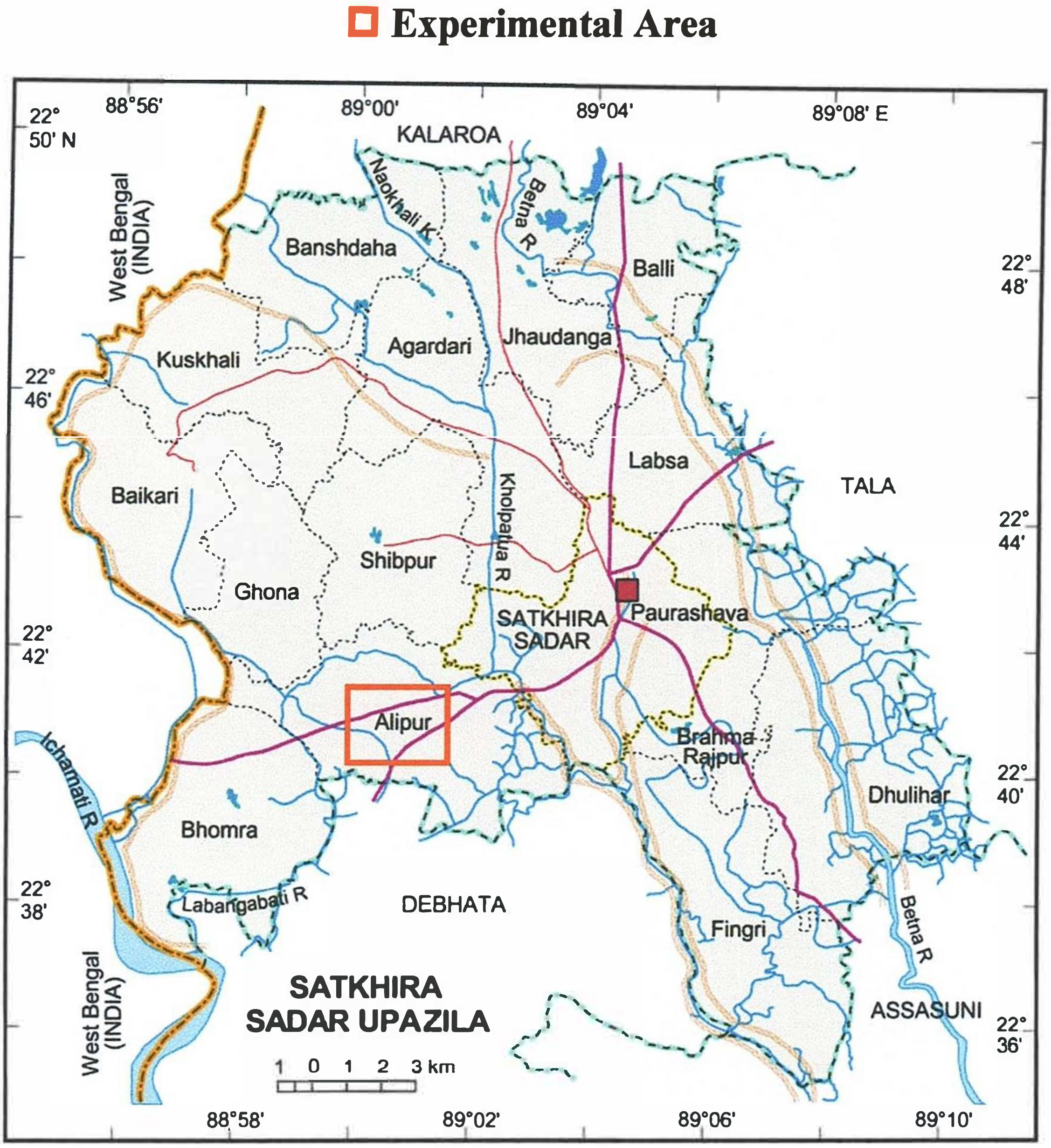

Fig 2.3 Location of the First study area in Satkhira.

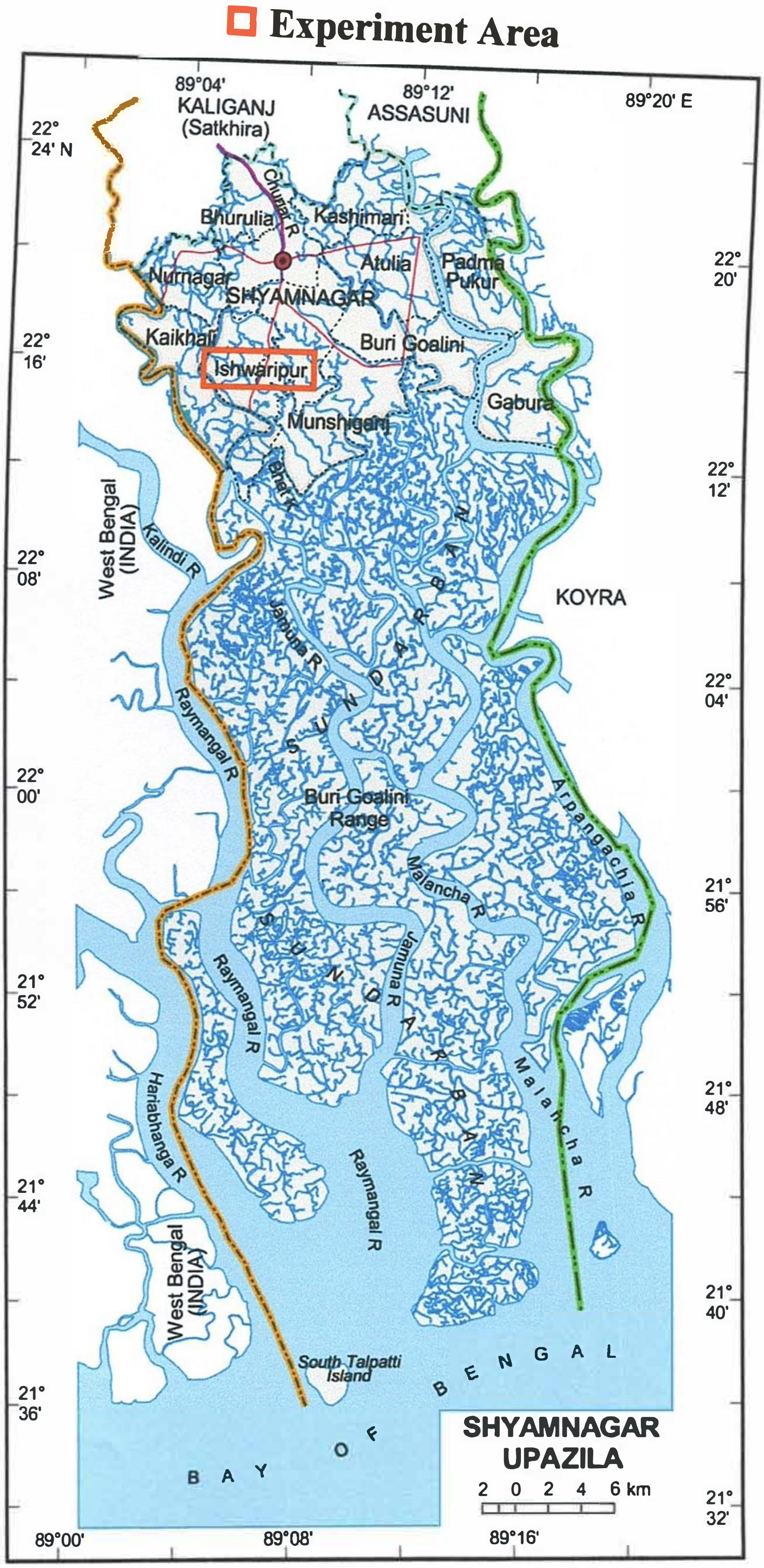

Fig 2.4 Location of the Second Experimental area

One experiment was set at Ishwaripur of Shyamnagar Upazila, known as highly salinity affected area of Satkhira and another experiment was set at Alipur union of Satkhira Sadar which is less salinity affected area a longer distance from the coast. The field experiments were carried out during the Rabi (winter) season of 2008-2009 under rain fed condition. The experimental field was prepared by four ploughings during the month of November, 2008. Necessary manure (cow dung) were added. Both of the experimental fields were divided into 18 plots with an area of 2 sq. m. for each plot. The space between plots was 30 cm and between lines was 10 cm.

2.2.2 Sowing of Seeds

The seed were sown on November 20 and 21, 2008.

The boundary lines were sown with non-experimental seeds. After sowing the fields were irrigated lightly. When seedlings attained a height of 17-18 cm, first weeding was done. During the heading time, the fields were lightly irrigated again with watering cans. The material of A_1-A_{10} and A_{11}-A_{18} were assigned randomly to rows in two blocks.

2.2.3 Relay cropping

A paddy field of 16m length and 10m width was selected near the experimental field of high salinity affected area. The wheat seed of about 0.5 kg was collected from the authorized dealer from Shyamnagar. The seeds were broadcast in the paddy field on November 18, just 18 days before harvesting the paddy. During harvesting the paddy, the stubbles were kept at the height of 15 cm in the field.

2.2.4 Farmers wheat field

Shyamnagar upazila, one of the leading salinity prone areas in Bangladesh, is 50 km. South from Satkhira Sadar to wards leading to the Sundarbans. Only 9.5 hectares of cultivable land were under wheat during the Rabi season of 2008-09 (Upazila Agricultural Office, Shyamnagar). Wheat ware grown only Kashimari, Bhurulia, Nurnagar Shyamnagar Sadar among 12 unions of Shyamnagar Upazila during the Rabi season 2008-2009.

Table 2.1 Area and production of wheat in Shyamnagar Upazila.

Union	Total land (ha)	Variely	Yield /ha (mt)
Bhurulia	5	Kanchan	1.7
Kashmiri	1	Kanchan	1.6
Shyamnagar	1.5	Satabdi, Shourob	1.3
Nurnagar	2.0	Khanchan Satabdi	1.4

Source: Upzila Agricultural office, Shyamnagar.

For collecting data from farmers field in more saline area, 12 fields were randomly selected from Kashimari, Bhurulia and Nurnagar. No area was identified for wheat cultivation after Bongshipur, another 15 Kms south from the Shyamnagar Sadar.

Kashimari, 10 Kms north east, Bhurulia 7 Kms. north and Nurnagar 25 Kms west from Shyamnagar, Sadar. The sampling was conducted among farmers of Kashimari, Bhurulia and Nurnagar and Shyamnagar.

Another 6 fields were randomly selected from less salinity affected area of Alipur and Bhomra from Satkhira Sadar. About 30 mature plants were uprooted randomly from the farmer's fields and harvest time characters were scored as in the experimental fields.

2.2.5 Measurement of Salinity

For measuring salinity of both the experimental fields in the more saline and less-saline areas, about 350 gm soil samples from (a) soil surface (b) 13 cm depth and (c) 25 cm depth, were collected between the months of November, 2008 to April 2009 from different locations from both the experimental fields the sampling dates were.

1. 15, November, soil was collected from middle of the field.
2. 17, December, from the southern side of the fields sail was collected.
3. 14, January, soil was collected from the northern side of the fields.
4. 18, February, from the eastern side sail was collected.
5. 16, March, soil was collected from the western side.
6. 7, April, soil was collected from the middle of the fields.

Procedure:

Electro Conductivity Meter model HI-993310-Hanna, (1344.88) was used to measure electrical conductivity (salinity of soil and water). Solution was made of soil and distilled water at ratio of 1:2, then the solution was stirred well from 10 to 20 minutes, the Anod bar is connected to the main body was put into the solution the reading showed the salt concentration.

2.3 Collecting of morphological Data of wheat

2.3.1 Juvenile stage characters

Twenty plants of each variety from in the experimental fields in the saline and lese saline areas and the relay crop field were selected randomly and were tagged. The following characters were scored from these plants after 3 week (21 days) and 7 week (51 days) of emergence.

Three week characters:

(i) Plant height (PH): Height was measured in cm. from the base of the plant to the tip of the tallest leaf.

(ii) Number of leaves per plant (NL): Number of open leaves per plant was counted.

(iii) Fresh weight (FW): Weight was measured in gm immediately after the collection of plants with an electric balance.

(iv) Dry weight (DW): Weight of the dry seedlings after sun and oven-drying were measured.

Seven week characters:

(i) Plant height (PH): Height was measured in cm from the base of the plant of the tip of the main tiller.

(ii) Number of leaves per plant (NL): Number of leaves per plant was counted.

(iii) Number of tiller per plant (NT): Number of tiller per plant was counted.

2.3.2 Heading time characters.

(i) Plant height (PH): Heights were measured from the base to the tip of the plants in cm.

(ii) Number of tiller per plant (NT): Number of tiller per plant were counted.

(iii) Largest leaf area (LLA): Area of the largest leaf of the same plant was calculated by measuring the length and maximum width in mm.

(iv) Flag leaf area (FLA): The flag leaf area of the same plant was calculated by using the same method.

2.3.3 Harvest time characters.

(i) Plant height: Height was measured from the base to the tip of the plant in cm (PH)

(ii) Number of tiller with spike Number of tillers with spike were counted (TS)

(iii) Number of florets in the main head were counted (NFM)

(iv) Number of florets of other head were counted (NFS)

(v) Number of full grains per main head were counted (NFGM)

(vi) Number of half filled and sterile grain were counted (NHGM)

(vii) Number of full grain in the second head were counted (NFGS)

(viii) Number of half filled sterile grains were counted (NHGS)

(ix) The weight of full grains of the main head after sun during were measured in gm with an electric balance (WFGM)

(x) Weight of half filled grains of main head were measured in gm (WHGM)

(xi) The weight of full grains of the secondhead were measured in gm (WFGS)

(xii) The weight of half filled sterile grains second head were measured in gm with an electric balance (WHGS)

(xiii) Yield per plant was measured in gm (YPP)

Table 2.2 The meteorological data of the district during the study period (2008-2009) was given below:

Month	Rainfall (m.m)	Temperature (°C)		Humidity %		
		Maximum	Minimum	Average	Maximum	Minimum
November '08	Nil	29.26	18.27	79.33	97.33	42
December '08	Nil	26.06	15.03	84.33	98.66	41.33
January '09	Nil	26.36	14.03	81.66	99.33	37.66
February '09	Nil	30.2	16.03	76	98	30
March '09	4.9 (3 days)	31.97	20.7	72.25	97.5	28.5
April '09	11.4 (2 days)	36.05	24.97	73.25	96.75	24.75

Source: Local meteorological department, Satkhira.

2.4 A part of the experiment was repeated during 2009-2010 Rabi season for the 2nd year to compact the character performance over two different years.

Based on the 1st year's result, the better performing 3 Modern Varieties eg., A_1 (Aghrani), A_6 (Protiva), A_8 (Gaurab) and 3 local Accessions A_{14}, A_{16} and A_{17} were used for the second year experiment. Seeds of previous year from plants grown in the saline environment were used for the second year experiment.

Other 2 Accessions, A_5 (Satabdi) and A_{10} (Barkat) which performed better in the less-saline environment during the 1st year were selected for the second years experiment. So, there were 8 entries for the second years' experiment.

2.5 Experimental Field

The experimental fields were set as mentioned (section 2.2.1). at two different locations during the Rabi season of 2009-2010. Both the experimental fields were divided into 8 plots with an area of 3 sq. m. each.

The seeds were sown an November 17 and 19, 2009 and the cultural procedures were the same as mentioned in section 2.2.2.

Relay Cropping for the 2nd year

A paddy field of 16 m length and 13 m width was selected near the experimental field the at high salinity affected areas on November 23, 15 days before harvesting the paddy. During harvesting the paddy, the stubbles were kept at height of 15 cm in the field. One light irrigation was applied while the field had became very dry with watering cm.

2.6 Materials from BARI campus for comparison of performance:

Ten Plants of each of the 12 accessions (Satabdi, BAW 1104, BAW 1059, BAW 1064, BAW 1114, V 01078, BAW 1051, Prodip, BAW 1111, BAW 680, BAW 1103 and Garuda) were randomly collected from the research fields of Bangladesh Agricultural Research Institute, Benerpota, Satkhira during the Rabi Season of 2009-2010 and harvest time characters were scored.

2.7 Measurement of salinity for the 2nd year

The same procedure was applied for measuring electro conductivity of the soil samples as mentioned in the Section 2.2.5.

2.8 Collecting of morphological data of wheat of the 2nd year experiment

Juvenile stage characters, scored at 3 weeks and 7 weeks, heading time characters and harvest time Characters were scored as mentioned in Sections 2.3.1, 2.3.2 and 2.3.3.

Table 2.3 The total rainfall, temperature and humidity during the crop season in Satkhira (2009-2010) in given below:

Month	Rainfall (mm)	Temperature (°C)		Humidity %		
		Maximum	Minimum	Average	Maximum	Minimum
November'09	19.5 (3 days)	30.60	19.30	79.50	96.5	39.75
December'09	Nil	29.92	13.66	79.00	98.25	35.50
January'10	Nil	23.85	11.20	77.25	96.50	35.37
February'10	Nil	27.01	16.0	75.25	97.75	31.25
March'10	Nil	34.58	23.28	71.50	97.75	32.75
April'10	25.2 (2 days)	36.15	27.05	74.25	95.25	41.50

2.9 Statistical analysis

A salt tolerance index was defined as the observation for a character at salinity divided by the average of the performance in less saline field expressed in percentage:

Salinity index (%) = [mean in saline – mean in less saline]/[mean in less saline x 100

Standard statistical analysis of the collected data were made (mean, variance, analysis of variance, LSD and correlation analysis) with the help of statistical package software SPSS.

2.10 View of the experimental fields and the experimental plots

The general view showing the experimental area, the plots and the plants in plots are given in Figs 2.5 to Figs 2.10. Fig 2.5 and 2.6 general view of the area showing fallow and dry nature around the experimental plot, Fig 2.7 the location of plots of the first year field experiment in saline area, Fig 2.8 the plots in less saline area, Fig 2.9 and Fig 2.10 plots in saline and less saline area of second year, Fig 2.11, 2.12 and 2.13 the plots of relay crop.

Fig. 2.5 General view of the area showing fallow and dry nature around the experimental plot

Fig. 2.6 General view of the area showing fallow and dry nature around the experimental plot

Fig. 2.7 The plot in saline area of first year

Fig. 2.8 The plot in less saline area of first year

Fig. 2.11 The plot of relay cropping of first year

Fig. 2.12 The plot of relay cropping of second year

Fig. 2.13 The plot of relay cropping of second year

Chapter Three

Results

RESULTS

The results of the 1st years' experiment are given below

3.1 Salinity levels of the Experimental area

The results of salinity tests are given in Table 3.1.There was clear difference between the more saline and less-saline areas, during the whole year there was a 2 to 3 fold difference. The surface soil was more saline than sub-surface soil, the level of salinity was more or less same all over the year (November to April) in the less saline area but it varied with time in more saline area, more during the dry months (March/April). Extreme salinity (with an ECe $\geq$ 5 dS was usually known to affect crops severely (Richards (1983).

Table 3.1 Salinity levels of soil (dS) from experimental fields of Saline and less saline areas

Month	Saline				Less-saline			
	Surface	13 cm depth	25 cm depth	$\overline{X}$	surface	13 cm depth	25 cm depth	$\overline{X}$
Nov. '08	7.55	5.6	4.88	6.01	4.2	2.42	1.4	2.67
Dec. '08	7.82	5.7	5.12	6.21	3.2	2.2	1.2	2.20
Jan. '09	8.2	6.8	5.23	6.74	3.2	2.4	1.4	2.33
Feb. '09	8.58	6.82	5.3	6.90	3.3	2.5	1.4	2.40
Mar. '09	8.93	7.31	6.12	7.45	3.4	2.5	1.5	2.47
April '09	10.12	7.82	6.85	8.26	3.6	2.5	1.62	2.57
$\overline{X}$	8.53	6.68	5.58		3.48	2.42	1.42	

dS = Deci Semen per meter.

3.2 Juvenile characters scored at 3 weeks

Mean performance and variance of four agronomical characters at the juvenile stages are presented in Tables 3.2 and 3.3.

3.2.1 Plant height at 3 weeks (PH_3) of the modern varieties

Little variation was observed for plant height (19.2cm to 22.9cm) at this stage among the seedlings in the saline area. (Table 3.2). The highest and the lowest values of plant height at 3 weeks were observed for A_{10} and A_2 respectively.

In the less-saline area, the range of plant height at 3 weeks was between 26.4 cm to 32.3 cm. The highest and the lowest values were for A_9 and A_2, the average plant height at 3 weeks was reduced significantly due to salinity (20.46 cm. in saline area and 29.6 cm. in the less-saline area).

Seedlings of Accession A_2 were short both in saline and in less-saline area but the tallest A_{10} in the saline area (22.9 cm) was short (27.9 cm) in the less-saline area.

3.2.2 Number of leaves per plant at 3 weeks (NL_3)

The average number of leaves per plant varied from 3.1 to 3.6 in the saline area. (Table 3.2). Accessions A_{10} and A_7 had the highest and the lowest mean number of leaves, respectively.

In the less-saline area, the average value ranged from 2.9 to 4.0, Accession A_3 had the highest value, whereas A_1 and A_7 had the lowest number of leaves respectively. The average number of leaves (3.3) in both the environments remained the same.

3.2.3 Fresh weight of plants (FW_3)

A narrow range of variation was observed for fresh weight of plants in the saline environment (0.17gm to 0.27gm). The highest and the lowest values were found for Accessions A_8 and A_1 respectively. Other Accessions had more or less-similar number of leaves.

In the less- saline environment, the mean values ranged from 0.24 gm to 0.41 gm. The highest mean value was for the Accession A_8 and the lowest was for Accession A_1. Thus, salinity had reduced mean fresh weight from 0.22 gm. to 0.32 gm. On the basis of fresh weight, the 10 entries can be classified into two groups: low weight (0.24gm to 0.32gm) and high weight (0.33gm to 0.41gm).

3.2.4 Dry weight (DW_3)

In the saline environment, range of variation was observed for dry weight between 0.02gm to 0.05gm. The highest mean value was for Accession A_7 and the lowest was for A_1.

In the less-saline environment, the range was from 0.01gm to 0.06gm. The highest mean value was found for the Accession A_8 and the lowest for A_2.

3.3 Juvenile characters of the Farmers' collection (A_{11} to A_{18})

3.3.1 Plant height at 3 weeks (PH_3)

Variation was observed for plant height in the saline area from 18.8cm to 22.9cm. Accessions A_{14} and A_{18} had the highest value and A_{15} had the lowest value, respectively.

Table 3.2 Mean value and variance (in parenthesis) of juvenile characters of Modern verities 3 weeks after sowing in the saline and the less-saline environment.

Accessions	Saline				Less-saline			
	PH (cm)	NL	FW (gm)	DW (gm)	PH (cm)	NL	FW (gm)	DW (gm)
A_1	22.5 (5.5)	3.2 (0.18)	0.17 (1.2^{-03})	0.02 (6.4^{-05})	28.3 (7.1)	2.9 (0.05)	0.24 (1.2^{-03})	0.03 (1.9^{-03})
A_2	19.2 (7.8)	3.4 (0.02)	0.21 (2.4^{-03})	0.03 (3.6^{-05})	26.4 (8.3)	3.1 (0.18)	0.29 (3.6^{-03})	0.01 (2.4^{-03})
A_3	19.6 (5.1)	3.3 (0.21)	0.24 (1.4^{-03})	0.03 ($1.^{-06}$)	29.7 (8.4)	4 (0.59)	0.33 (3.6^{-03})	0.03 (7.6^{-05})
A_4	19.4 (5.5)	3.4 (0.35)	0.21 (1.4^{-03})	0.03 (2.2^{-04})	28.3 (13.2)	3.2 (0.18)	0.29 (8.4^{-04})	0.02 (6.4^{-05})
A_5	19.5 (10.2)	3.2 (0.23)	0.25 (2.5^{-03})	0.04 (2.2^{-03})	31.9 (13.2)	3.3 (0.21)	0.37 (0.21)	0.05 (8.1^{-05})
A_6	20.4 (5.2)	3.4 (0.25)	0.22 (1.4^{-03})	0.04 ($1.^{-04}$)	28.6 (6.3)	3.4 (0.24)	0.29 (4.3^{-03})	0.03 (6.4^{-05})
A_7	20.6 (12.3)	3.1 (0.09)	0.24 (2.1^{-03})	0.05 (1.4^{-04})	30.2 (5.9)	2.9 (0.05)	0.35 (4.7^{-03})	0.04 (1.4^{-04})
A_8	20.8 (7.3)	3.3 (0.23)	0.27 (1.7^{-03})	0.04 ($1.^{-04}$)	32.1 (18.3)	3.4 (0.24)	0.41 (0.01)	0.06 (6.2^{-04})
A_9	19.7 (4.7)	3.3 (0.21)	0.24 (1.7^{-03})	0.04 (1.7^{-04})	32.3 (12.8)	3.8 (0.33)	0.32 ($6.^{-03}$)	0.03 (1.4^{-04})
A_{10}	22.9 (13.6)	3.6 (0.24)	0.20 (8.0^{-03})	0.04 (1.0^{-03})	27.9 (9.7)	3 (0.15)	0.27 (2.3^{-03})	0.02 (6.0^{-05})
$\overline{X}$	20.46	3.3	0.22	0.04	29.6	3.3	0.32	0.03
LSD 0.05	1.92	0.29	0.04	0.00	2.04	0.32	0.05	0.01

In the less-saline area, the variation in plant height was between 27.6 cm. to 36.3 cm. Accession A_{15} had the highest value and A_{17} had the lowest for plant value respectively.

Thus, salinity had significantly reduced plant height at 3 weeks, the overall means were 21.3 cm for the saline and 30.2 cm for less-saline environment.

3.3.2 Number of leaves per plant. (NL_3)

The average number of leaves per plant varied from 3.2 to 3.7. A_{12} and the Accession A_{18} had the highest value and A_{11} had the lowest value, respectively.

In the less-saline area, the average number of leaves was from 2.9 to 3.8. The tall Accession A_{15} had the highest mean value for leaf number and A_{11} had the lowest mean, respectively.

3.3.3 Fresh weight per plant (FW_3)

Little variation was observed for fresh weight in saline area. (0.21 gm to 0.25 gm) Accession A_{16} and A_{17} had the highest mean value and A_{13} had the lowest value for fresh weight.

In the less-saline environment, variation for fresh weight per plant was observed 0.26 gm to 0.48 gm. Accession A_{15} had the highest mean value and A_{18} had the lowest mean value.

Salinity had reduced fresh weight per plant significantly, overall mean reduced from 0.35 gm to 0.23 gm.

3.3.4 Dry weight at 3 weeks (DW_3)

In the saline area, the variation ranged from 0.03 gm to 0.06 gm. Accession A_{14} showed the highest mean value and A_{16} the lowest mean value for DW.

At the less-saline area, the variation ranged from 0.01 gm to 0.06 gm. Accession A_{15} had the highest mean value and A_{12}, A_{18} had the lowest mean value for dry weight.

Table 3.3 Mean value and variance (in parenthesis) of juvenile characters of 8 Accessions (Farmer's collection) in the saline and the less-saline environment.

Accessions	Saline				Less-saline			
	PH (cm)	NL	FW (gm)	DW (gm)	PH (cm)	NL	FW (gm)	DW (gm)
A_{11}	20.1 (3.9)	3.2 (0.16)	0.24 (1.5^{-03})	0.04 (1.7^{-04})	28.7 (12.2)	2.9 (0.75)	0.38 (6.0^{-03})	0.05 (2.9^{-04})
A_{12}	22.3 (7.8)	3.7 (0.21)	0.22 (1.4^{-04})	0.05 (1.4^{-04})	30.8 (15.7)	3.4 (0.25)	0.27 (2.3^{-03})	0.01 (2.4^{-05})
A_{13}	21.1 (8.7)	3.4 (0.25)	0.21 (1.3^{-03})	0.05 (1.6^{-04})	28.1 (28.9)	3.2 (0.26)	0.32 (.26)	0.02 (7.6^{-05})
A_{14}	22.9 (6.9)	3.5 (0.25)	0.23 (8.0^{-04})	0.06 (5.4^{-04})	30.7 (24.0)	3.3 (0.21)	0.36 (.01)	0.02 (6.1^{-05})
A_{15}	18.8 (5.8)	3.3 (0.31)	0.24 (2.2^{-03})	0.04 (9.6^{-05})	36.3 (13.6)	3.8 (0.13)	0.48 (7.4^{-03})	0.06 (1.2^{-04})
A_{16}	20.7 (4.9)	3.5 (0.23)	0.25 (1.6^{-03})	0.03 (4.9^{-05})	31.2 (15.9)	3.5 (0.25)	0.39 (.01)	0.05 (5.1^{-04})
A_{17}	21.6 (6.9)	3.5 (0.25)	0.25 (2.2^{-03})	0.04 (6.9^{-05})	27.6 (13.5)	3.3 (0.23)	0.31 (4.1^{-03})	0.02 (4.0^{-05})
A_{18}	22.9 (8.9)	3.7 (0.59)	0.23 (8.2^{-04})	0.05 (2.8^{-04})	27.8 (23.9)	3.4 (0.34)	0.26 (4.8^{-04})	0.01 (2.1^{-05})
$\overline{X}$	21.3	3.4	0.23	0.04	30.2	3.3	0.35	0.03
LSD 0.05	1.67	0.34	0.03	0.01	2.73	0.34	0.05	0.01

3.4 Analysis of variance

Since all the accessions were grown in two different environment, an analysis of variance was performed separately (Table 3.4) to test the significance of the Treatment (Salinity) and Between Varieties items.

In all cases except for number of leaves, Between Treatment was highly significant and Between Varieties was significant for plant height and number of leaves at 3 weeks for the Modern Varieties.

For farmers collection (Table 3.4) Between Treatment items was highly significant for the characters PH and FW, but for all other characters Between Varieties was significant for plant height and dry weight.

Table 3.4 ANOVA for 3 weeks characters for the Modern Varieties and Farmers' collection.

Characters	Items	Modern Varieties				Farmers' collections			
		DF	SS	MS	F	DF	SS	MS	F
PH	Between treatment	1	414.97	414.97	121.69**	1	312.41	312.41	41.16**
	Between lines	9	21.20	2.35	2.58**	7	19.07	2.72	2.59*
	T X L	9	30.7	3.41	1.59^{NS}	7	53.18	7.59	7.22**
	Error	380	344.93	0.91		304	320.59	1.05	
NL	Between treatment	1	0.002	0.002	0.026^{NS}	1	0.06	0.06	1.62^{NS}
	Between lines	9	0.710	0.078	1.95*	7	0.42	0.06	1.02^{NS}
	T X L	9	0.698	0.077	1.92*	7	0.26	0.037	0.74^{NS}
	Error	380	17.62	0.04		304	15.38	0.05	
FW	Between treatment	1	0.03	0.03	30.0**	1	0.06	0.06	42.86**
	Between lines	9	0.03	0.003	0.30^{NS}	7	0.02	0.0028	0.28^{NS}
	T X L	9	0.01	0.001	0.10^{NS}	7	0.01	0.0014	0.14^{NS}
	Error	180	2.36	0.01		144	2.08	0.01	
DW	Between treatment	1	0.002	0.002	18.18**	1	0.001	0.001	2.32^{NS}
	Between lines	9	0.000	0.000	0.05^{NS}	7	0.001	0.00014	2.00*
	T X L	9	0.001	0.00011	0.55^{NS}	7	0.003	0.00043	6.14**
	Error	180	0.037	0.0002		144	0.01	0.00007	

*,** indicate significance at 5% and 1 % level respectively.
NS = Non significant

3.5 Juvenile characters scored at 7 weeks.

Mean values and variance of the characters scored at 7 weeks are given Tables 3.5 and 3.6

3.5.1 Plant height at 7 weeks (PH_7) for Modern Varieties

A range of variation for plant height from 39.2 cm to 49.4 cm was observed at 7 weeks in the saline area.

Among better performing Accessions at 3 weeks, A_1 also had the highest mean value for plant height at 7 weeks and A_5 had the lowest value, respectively.

In the less-saline area, the range of variation was observed from 43.1 cm to 61.9 cm. Accession A_4 showed the highest mean PH while A_2 showed the lowest PH. Overall mean values to PH were 44.7 and 54.8 cm for the saline and less saline areas.

3.5.2 Number of leaves per plant at 7 weeks (NL_7)

In the saline area, the average number of leaves per plant ranged between 8.7 to 13.3. Accession A_{10} had the highest NL and A_3, A_4 had the lowest leaf number, respectively.

In the less-saline area, the variation ranged between 9.2 to 16.6. Accession A_4 had the highest value and A_{10} had the lowest value, respectively. All the tall Accessions had higher number of leaves and the short accession had comparatively fewer number of leaves. The salinity in soil had reduced the mean NL from 13.05 to 11.0.

3.5.3 Number of tillers per plant (NT_7)

In the saline environment, the average number of tillers ranged from 1.9 to 3.3. Accession A_{10} had the highest average number of tillers, (3.3) while A_4 had the lowest average number of tiller (1.9).

In the less- saline environment, the range for tiller number was from 2.1 to 3.6. The short Accessions A_5 had the highest mean value and A_2, A_{10} had the lowest mean value. The average number of tiller in the saline soil was 2.5 while that in that in the less-saline soil was 2.8.

3.6 Seven weeks characters of the farmers' collection (A_{11}-A_{18})

3.6.1 Plant height at 7 weeks (PH_7)

In the saline area, the range of plant height was observed from 35.4 cm to 44.8 cm. Accession A_{14} showed the highest PH and A_{15} the lowest value.

In the less-saline environment, the variation for plant height was observed from 45.4 cm to 55.9 cm. Accession A_{16} had the highest value and A_{13} had the lowest value respectively.

The man plant height for the Accession was 42.06cm in the saline soil whereas it was 49.4 cm. in the less-saline soil.

Table 3.5 Mean value and variance (in parenthesis) of 7 weeks characters in the saline and the less-saline experiment. (BARI Collection)

Accessions	Saline			Less-saline		
	PH (cm)	NL	NT	PH (cm)	NL	NT
A_1	49.4 (28.9)	12.8 (16.5)	3.0 (0.5)	57.6 (86.9)	13.6 (6.7)	2.9 (0.45)
A_2	40.9 (31.6)	12.2 (12.5)	2.4 (0.44)	43.1 (6.3)	10.8 (11.1)	2.1 (0.63)
A_3	47.8 (3.8)	8.7 (3.2)	2.1 (0.29)	57.2 (44.5)	15.9 (12)	3.4 (0.74)
A_4	47.0 (13.3)	8.7 (4.8)	1.9 (0.45)	61.9 (38.6)	16.6 (19.5)	2.2 (0.49)
A_5	39.2 (14.3)	9.9 (11.1)	2.1 (0.63)	51.1 (16.9)	9.5 (4.6)	3.6 (1.0)
A_6	41.7 (22.2)	11.6 (7.1)	2.1 (0.39)	51.2 (53.4)	9.7 (5.3)	3.1 (0.79)
A_7	45.1 (26.3)	9.2 (4.9)	2.7 (0.51)	60.6 (56)	14.3 (9.5)	2.4 (0.34)
A_8	45.6 (12.8)	12.8 (8.6)	3 (0.50)	60.2 (20.3)	14.8 (5.8)	3.2 (0.48)
A_9	44.8 (29.9)	10.8 (8.1)	2.9 (0.79)	57.9 (86.4)	13.5 (7.2)	2.8 (0.63)
A_{10}	45.8 (17.5)	13.3 (6.3)	3.3 (0.61)	47.1 (43.4)	11.8 (5.9)	2.1 (0.59)
$\overline{X}$	44.7	11.0	2.5	54.8	13.05	2.8
LSD 0.05	3.11	1.83	0.45	4.27	2.01	0.49

3.6.2 Number of leaves per plant (NL_7)

In the saline environment, the average number of leaves per plant varied from 9.9 to 12.9. Accession A_{14} had the highest NL while A_{13} had the lowest value.

In the less-saline environment, the range for number of leaves was between 9.2 to 15.3. Accession A_{12} showed the highest NL and A_{14} the lowest.

Salinity had reduced NL from 12.6 to 11.0 at this stage.

3.6.3 Number of tiller per plant (NT_7)

The average number of tiller per plant ranged between 2.1 to 3 in the saline area, Accession A_{14} had the highest NT and A_{13} had the lowest value.

Number of tiller per plant in the less-saline environment:

In the less saline environment, the variation ranged between 2.1 to 3.4. Accession A_{12} showed the highest NT and A_{13} the lowest.

Salinity also reduce tiller number from 2.6 to 2.4 at this stage.

Table 3.6 Mean value and variance of 7 weeks characters for farmer's collection (A_{11} to A_{18}) in the saline and the less-saline environments.

	Saline			Less-saline		
	PH (cm)	NL	NT	PH (cm)	NL	NT
A_{11}	42.8 (16.9)	10.1 (7.6)	2.3 (0.41)	46.7 (7.4)	10.4 (6.2)	2.3 (0.72)
A_{12}	44.5 (12.9)	12.1 (12.7)	2.3 (0.73)	48.8 (11.1)	15.3 (4.6)	3.4 (0.35)
A_{13}	39.4 (15.2)	9.9 (6.5)	2.1 (0.04)	45.4 (19.6)	11.5 (9.8)	2.1 (0.49)
A_{14}	44.8 (23.9)	12.9 (9.9)	3 (0.65)	51.3 (9.1)	9.2 (3.7)	2.3 (0.41)
A_{15}	35.4 (25.2)	10.2 (8.3)	2.2 (0.46)	49.8 (8.0)	13.5 (9.4)	2.9 (0.59)
A_{16}	43.7 (16.3)	11.6 (9.9)	2.6 (0.64)	55.9 (40.8)	13 (14.8)	2.8 (0.76)
A_{17}	42.7 (26.7)	10.4 (4.9)	2.6 (0.33)	48.6 (40.4)	12.7 (3.2)	2.6 (0.24)
A_{18}	43.2 (27.4)	11.0 (8.4)	2.3 (0.41)	49.8 (36.7)	14.9 (9.4)	2.8 (0.96)
$\overline{X}$	42.06	11	2.4	49.4	12.6	2.6
LSD 0.05	3.55	1.86	0.45	2.96	1.76	0.48

3.7 Analysis of variance

The results of Analysis of Variance for the seven week characters are was given in Table 3.7

Again, Between Treatment was highly significant for plant height at 7 weeks. Significant variations was observed for the item Between Varieties for plant height.

Table 3.7 ANOVA for 7 weeks characters of wheat modern varieties and farmers' collection.

Characters	Items	Modern Varieties				Farmers' collections			
		DF	SS	MS	F	DF	SS	MS	F
PH	Between treatment	1	503.01	503.01	40.01**	1	223.50	223.50	31.48**
	Between lines	9	339.54	37.73	7.22**	7	90.40	12.91	4.79**
	T X L	9	113.17	12.57	2.40**	7	49.76	7.10	2.63**
	Error	380	1984.13	5.22		304	363.66	2.69	
NL	Between treatment	1	21.01	21.01	3.20^{NS}	1	9.45	9.45	3.22^{NS}
	Between lines	9	25.87	2.87	1.64^{NS}	7	18.84	2.69	0.91^{NS}
	T X L	9	59.08	6.56	3.77**	7	20.52	2.93	1.24^{NS}
	Error	380	662.19	1.74		304	719.34	2.36	
NT	Between treatment	1	0.26	0.26	0.78^{NS}	1	0.20	0.20	1.33^{NS}
	Between lines	9	1.83	0.20	1.81^{NS}	7	0.78	0.11	1.57^{NS}
	T X L	9	3.10	0.34	3.09**	7	1.04	0.15	2.14*
	Error	380	45.43	0.11		304	26.64	0.07	

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

3.8 Characters scored at heading time

Table 3.8 and 3.9 show the mean and variance for characters of wheat in the saline and less-saline areas.

3.8.1 Plant height at heading (PH_H)

Range of variation for plant height was observed from 53.0 cm to 66.53 cm in the saline area. Accession A_1 had the highest mean PH and A_2 had the lowest mean PH, respectively.

In the less-saline area, the variation in plant height at heading was more pronounced from 74.42 cm to 88.74 cm. Accession A_9 had the highest mean PH and A_2 had the lowest.

Salinity has strongly affected this characters at this stage, the means were 63.3 and 80.65 cm for saline and less-saline respectively.

3.8.2 Number of tillers per plant at heading time (NT_H)

In the saline area, the average number of tillers at heading ranged between 2.3 to 3.3. The Accession A_{10} had the highest NT while A_4 had the lowest value respectively. These results are almost same as observed during 7 weeks. All the low number of tiller possessing Accessions, except A_2 and A_6 at 7 weeks, also had low numbers, at heading time (2.3 to 2.7).

In the less-saline area, the variation in NT ranged between 2.3 to 4.0. Accession A_3 and A_8 had the highest NT and A_2 had the lowest value, respectively. The highest performing Accession A_5 had 3.6 tillers at

7 weeks also had mean value 3.7 tillers at heading time. Salinity reduced tiller number from 3.2 to 2.8.

3.8.3 Largest leaf area at heading time (LLA)

In the saline area, variation observed for largest leaf area 18.51 cm^2 to 31.59 cm^2. Accession A_7 had the highest mean leaf area and A_1 had the lowest mean value.

In the less saline area, a wide range of variation was observed from 40.22 cm^2 to 62.27 cm^2 for largest leaf area. The highest and the lowest values for LA were for Accession A_9 and A_2, respectively.

It is noted that salinity had affected leaf area to a great extent, the overall mean has been reduced from 48.54 to 21.94 cm^2.

3.8.4 Flag leaf area at heading (FLA)

In the saline area, a wide range of variation was observed for flag leaf area from 18.42 cm^2 to 40.43 cm^2. The highest and the lowest value for flag leaf area were for Accession A_{10} and A_6 respectively,

In the less- saline area, a wide range of variation for flag leaf area was observed (39.72 cm^2 to 71.31 cm^2). Accession A_9 had the highest value which also had largest LA whereas A_2 had the smallest FLA and LLA. Salinity had affected the flag leaf area, the overall mean in saline area was 26.13 cm^2 and in less-saline area was 54.22 cm^2.

Table 3.8 Mean value and variance of heading time characters of wheat accessions in the saline and the less-saline environments.

Accessions	Saline				Less-saline			
	PH (cm)	NT	LLA (cm^2)	FLA (cm^2)	PH (cm)	NT	LLA (cm^2)	FLA (cm^2)
A_1	66.53 (24.24)	3.25 (0.49)	18.51 (12.89)	25.81 (38.51)	83.35 (46.13)	3.1 (0.38)	43.04 (20.54)	56.37 (105.67)
A_2	53.80 (26.01)	3.1 (0.39)	19.71 (9.94)	24.29 (45.19)	74.42 (12.76)	2.3 (0.41)	40.22 (44.75)	39.79 (26.91)
A_3	62.17 (24.26)	2.6 (0.34)	20.57 (17.98)	24.37 (47.87)	83.95 (74.76)	4.0 (1.6)	56.75 (77.29)	52.08 (102.12)
A_4	53.86 (6.49)	2.3 (0.21)	21.86 (5.28)	22.85 (10.96)	75.10 (21.89)	2.6 (0.35)	51.08 (59.86)	51.61 (71.50)
A_5	62.55 (27.36)	2.5 (0.45)	22.11 (7.58)	25.21 (13.71)	81.43 (65.32)	3.7 (0.59)	55.06 (87.86)	62.82 (89.90)
A_6	61.07 (28.56)	3.0 (0.77)	24.57 (18.08)	18.42 (5.57)	77.25 (14.90)	3.2 (0.39)	42.55 (36.93)	41.06 (123.76)
A_7	63.22 (16.24)	2.4 (0.55)	31.59 (18.72)	33.39 (69.27)	78.55 (27.86)	2.6 (0.24)	47.44 (62.26)	58.56 (83.84)
A_8	62.57 (14.75)	3.2 (0.36)	19.32 (13.43)	19.97 (35.27)	85.17 (70.91)	4.0 (0.94)	41.51 (4.04)	45.72 (41.26)
A_9	62.10 (17.67)	2.6 (0.33)	19.78 (19.19)	26.57 (11.55)	88.74 (36.86)	3.1 (0.43)	62.27 (90.40)	71.31 (177.52)
A_{10}	63.41 (17.83)	3.3 (0.61)	21.41 (11.03)	40.43 (14.15)	78.54 (15.51)	3.0 (0.35)	45.44 (47.91)	62.91 (68.65)
$\overline{X}$	62.3	2.8	21.94	26.13	80.65	3.2	48.54	54.22
LSD 0.05	3.86	0.42	2.33	3.53	4.52	0.47	4.81	6.14

3.9 Heading time characters of farmers' collection (A_{11} to A_{18})

3.9.1. Plant height at heading (PH_H)

In the saline environment, range of variation for PH_H was observed from 55.15 cm to 69.82 cm. (Table 3.6). The highest and the lowest value were for Accession A_{18} and $A_{15.}$ respectively.

In the less-saline area, the range varied from 67.22 cm to 88.74 cm. the highest and the lowest values for PH were for A_{16} and $A_{11.}$ which were amongst the highest and lowest in saline experiment too. The overall mean performances were 64.12 cm and 79.73 cm for the saline and the less-saline area, respectively.

3.9.2 Number of tiller per plant (NT_H)

The average number of tiller per plant was observed from 2.6 to 3.4 at heading in the saline environment. Accession A_{16} had the highest mean value and A_{12} and A_{15} had the lowest mean value, respectively. A_{14} had the mean value of 3.0 and others had more or less similar numbers: (2.6 to 2.9).

In the less-saline environment, this range was from 2.7 to 3.8, So not very different from the saline area. Accession A_{18} showed the highest value and A_{11} the lowest.

3.9.3 Largest leaf area (LLA)

In the saline environment, range of variation for LA was from 18.18 cm^2 to 28.01 cm^2. The highest and the lowest value for LA were for A_{15} and A_{14} respectively.

In the less-saline area, the range was from 40.12 cm^2 to 45.26 cm^2. So in the less-saline area the leaves were significantly larger than those at the saline area. Accession A_{15} had the highest value and A_{11}, A_{18} had the lowest value respectively. Salinity had reduced the overall mean value from 42.23 cm^2 to 23.11 cm^2.

3.9.4 Flag leaf area at heading (FLA)

In the saline environment, the range of variation for FLA was observed from 14.89 cm^2 to 32.49 cm^2. Accession A_{15} had the highest FLA value and A_{18} had the lowest, respectively.

Table 3.9 Mean and variance of heading time characters for local collections (A_{11} to A_{18}) in the saline and the less-saline areas.

Accessions	Saline				Less-saline			
	PH (cm)	NT	LLA (cm^2)	FLA (cm^2)	PH (cm)	NT	LLA (cm^2)	FLA (cm^2)
A_{11}	65.19 (15.27)	2.7 (0.41)	22.77 (6.82)	23.27 (24.37)	67.22 (25.19)	2.7 (0.59)	40.12 (14.97)	46.97 (72.39)
A_{12}	69.12 (11.68)	2.6 (0.44)	24.27 (10.43)	27.84 (13.59)	85.57 (16.31)	3.4 (0.55)	43.38 (34.13)	48.92 (48.19)
A_{13}	61.50 (21.22)	2.7 (0.59)	20.67 (5.61)	21.21 (22.99)	70.55 (31.43)	2.8 (0.36)	41.29 (11.97)	39.89 (49.61)
A_{14}	67.11 (17.18)	3.0 (0.35)	18.18 (9.77)	19.30 (43.0)	77.65 (11.01)	2.8 (0.33)	41.01 (26.09)	43.81 (56.85)
A_{15}	55.15 (36.19)	2.6 (0.53)	28.01 (7.86)	32.49 (8.19)	82.03 (55.12)	3.3 (0.51)	45.26 (19.93)	54.0 (60)
A_{16}	65.42 (41.59)	3.4 (0.84)	23.01 (12.55)	25.16 (38.70)	88.74 (55.32)	3.1 (0.63)	41.87 (16.83)	35.29 (73.41)
A_{17}	59.64 (11.16)	2.9 (0.55)	26.19 (10.88)	30.18 (24.34)	77.37 (79.28)	3.2 (0.39)	44.76 (39.53)	41.02 (80.45)
A_{18}	69.82 (55.55)	2.7 (0.71)	21.81 (13.99)	14.89 (11.95)	88.69 (58.30)	3.8 (1.3)	40.12 (20.21)	37.02 (52.35)
$\overline{X}$	64.12	2.8	23.11	24.29	79.72	3.1	42.23	43.36
LSD 0.05	4.26	0.47	2.49	2.97	4.38	0.49	2.93	5.40

In the less-saline area, FLA ranged from 35.29 cm^2 to 54 cm^2, so salinity had almost halved the FLA of the wheat collections. The highest and the lowest values for FLA were for A_{15} and A_{16}. Flag leaf area in the saline soil was 24.29 cm^2 whereas in the less-saline area it was 43.36 cm^2.

3.10 Analysis of variance

The Variance Analysis of results for heading time characters of variance was given Table 3.10

In all the cases, except number of tillers, 'Between Treatment' item was highly significant for Modern varieties and farmers' collections.

For the characters plant height, largest leaf area and flag leaf area of both modern varieties and farmers' collections, as well as number of tillers for modern varieties between varieties item were significant, indicating genetic contribution to the phenotypic variation for these characters.

Table 3.10 ANOVA for Heading time characters

Characters	Items	Modern Varieties				Farmers' Collections			
		DF	SS	MS	F	DF	SS	MS	F
PH	Between treatment	1	1543.53	1543.53	47.67**	1	980.78	980.78	41.42r**
	Between lines	9	167.53	18.61	10.81**	7	457.99	65.42	68.86**
	T X L	9	291.41	32.38	18.82**	7	165.77	23.68	24.92**
	Error	380	653.92	1.72		304	291.76	0.95	
NT	Between treatment	1	0.57	0.57	2.59^{NS}	1	0.39	0.39	3.00^{NS}
	Between lines	9	2.37	0.26	2.60**	7	0.58	0.08	0.88^{NS}
	T X L	9	2.00	0.22	2.20*	7	0.90	0.13	1.44^{NS}
	Error	380	40.87	0.10		304	29.91	0.09	
LLA	Between treatment	1	3535.93	3535.93	56.51**	1	1461.15	1461.15	214.49**
	Between lines	9	306.59	34.06	39.15**	7	78.66	11.28	9.56**
	Error	9	324.39	36.03	41.41**	7	16.57	2.37	2.01*
	Error	380	329.37	0.87		304	359.11	1.18	
FLA	Between treatment	1	3945.74	3945.74	116.81**	1	1455.03	1455.03	149.85**
	Between lines	9	998.90	110.99	584.15**	7	451.29	64.47	44.46**
	T X L	9	304.18	33.78	177.78**	7	67.99	9.71	6.69**
	Error	380	75.49	0.19		304	442.02	1.45	

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

3.11 Performance of harvest time characters of varieties

The mean and variance for the harvest time characters are showed in Tables 3.11 and 3.12

3.11.1 Plant height at harvest time (PH)

Variation was observed for plant height, between 60.09 cm to 80.05 cm. Accession A_9 showed the highest PH and A_4 showed the lowest value respectively in the saline area.

In the less-saline area, the range varied between 81.21 cm to 98.51 cm, so salinity had significantly lowered the range at PH. The highest and the lowest mean value were for Accessions A_9 and A_4, respectively. Salinity had reduced the overall mean value from 90.97 to 70.64 cm.

3.11.2 Tillers with spike (TS).

A rather narrow range of variation was observed for tillers with spike from 2.2 to 3.0 in the saline environment. A_1, A_6 and A_8 exhibited the highest mean value for TS and A_4 exhibited the lowest value.

In the less-saline area, mean value for tillers with spike varied from 2.3 to 3.9. A_3 exhibited the highest mean TS and A_2 exhibited the lowest. The overall mean values were 2.60 and 3.21 for the saline and the less saline area.

3.11.3 Number of florets in the main head (NFM).

Again a narrow range of variation was observed for number of florets in main head from 15.5 to 17.4 in the saline area.

The highest mean florets was for A_4 and A_5 and the lowest mean value was for A_3 respectively.

In the less-saline area, mean value ranged between 15 to 19.9. A_5 exhibited the highest number of florets and A_4, the lowest.

Salinity in the soil had reduced mean florets from 17.15 to 16.44.

3.11.4 Number of florets in the second head (NFS)

In the saline environment, mean value for number of florets on the second head varied from 9.7 to 14.1. The highest and the lowest values were for Accession A_4 and A_9 respectively.

In the less-saline environment, the range for number of florets was from 12.6 to 17.4. The highest and the lowest value of florets in the second head were for A_5 and A_2 respectively, which were different from saline area. A_1, A_5 and A_{10} and high number of florets (15 to 17) and others had low number of florets (12 to 14). Salinity in the soil had reduced the overall number of florets in the second head from 14.20 to 11.85.

3.11.5 Number of full grains in the main head (NFGM)

In the saline area, the mean number of full grains in the main head was from 25.1 to 35.2. The highest and the lowest NFG were for A_6 and A_7 respectively.

In the less-saline area, the range of NFG was between 30.9 to 49.4. A_{10} had the highest NFG value and A_2 had the lowest value respectively. Effect of salinity on number of fall grains in the main head was remarkable, in saline soil the overall mean was 29.93 wehreas in less-saline soil it was 40.12.

3.11.6 Weight of full grains of the main head (WFGM)

The average weight of full grains of the main head ranged between 0.89 gm to 1.75 gm, in the saline area. The highest and the lowest values of WFG were for A_6 and A_7 respectively.

In the less saline area, the variation ranged between 1.15 gm to 2.89 gm. Accession A_{10} exhibited the highest and A_6 exhibited the lowest value for WFG respectively. Saline had also reduced WFG, in less-saline this mean was 1.74 gm but in saline soil it was 1.29 gm.

3.11.7 Number of half-filled grains in the main head. (NHGM)

In the saline area, variation observed between 2.4 to 6.2, Accession A_7 had the highest number of half-filled grains while A_3 had the lowest value.

In the less-saline area, the variation ranged between 1.0 to 2.3. The Accession A_3 exhibited the highest and A_7 exhibited the lowest value for number of half-filled grains respectively. The number of half-filled grain was higher in saline soil (3.95) whereas it was 1.41 in the less-saline soil.

3.11.8 Weight of half-filled grains of the main head (WHGM).

In the saline area, the average weight of shrunken grains ranged between 0.04 gm to 0.1 gm. Accession A_7 had the highest value and A_3, A_4, A_9 had low values respectively.

In the less-saline area, this range was from 0.02 gm to 0.04 gm, A_1, A_3 and A_8 had the highest and A_2, A_4, A_6, A_9, A_{10} had the lowest value for WHFG respectively.

The average mean value was almost similar (0.02 gm) in the saline and 0.03 gm for the less-saline experiment.

3.11.9 Number of full grains in the second head (NFGS)

The range of variation was observed from 10.9 to 26.5, Accession A_6 had the highest value and A_{10} had the lowest value for NFG.

In the less-saline area, the variation was from 21.2 to 42.2. The highest and the lowest values were for Accessions A_{10} and A_2 respectively.

Overall mean was 18.26 and 28.16 for the saline and the less-saline soils, respectively.

3.11.10 Weight of full grains of the second head (WFGS)

The average weight of full grains of the second head was from 0.56 gm to 1.2 gm in the saline area. The Accession A_4 had the highest and A_2 had the lowest value for WFG respectively.

In the less-saline area, the average for WFG was from 0.75 gm to 1.72 gm, Accession A_5 had the highest and A_4 had the lowest value for WFG respectively. Overall mean for the saline and the less-saline soils were experiment was 0.82 gm and 1.88 gm respectively.

3.11.11 Number of half-filled grains in the second head (NHGS)

In the saline area, mean number of half-filled grains of the second head was from 1.9 to 6.3. The highest and lowest values for NHFG were for A_4 and A_9 respectively.

In the less-saline area, the main value for NHFG was between 1.2 to 2.8, Accession A_{10} showed the highest and A_9 the lowest mean value for NHFG. Salinity had raised the mean NHFG from 1.89 to 3.93.

3.11.12 Weight of half-filled grains of the second head (WHGS)

In the saline area, WHFG varied from 0.02 gm to 0.11 gm Accession A_7 and A_4 had the highest WHFG and A_9 had the lowest.

In the less-saline area, the range was from 0.02 gm to 0.05 gm Accession A_{10} had the highest and A_2 and A_9 had the lowest value for WHFG respectively. Salinity had raised the weight of half-filled grains of the second head from 0.03 gm to 0.07 gm only.

3.11.13 Yield per plant (YPP)

In the saline area, the average yield per plant was from 2.5 gm to 4.2 gm. Accession A_6 showed the highest YPP while A_7 showed the lowest value respectively. A_1, A_6 and A_8 had high yield (3.4 gm to 4.2 gm) and A_2, A_3, A_4, A_5, A_7, A_9 and A_{10} had low yield for YPP (2.5 gm. to 3.3 gm). In the less-saline area, the variation for YPP ranged from 3.11 gm to 6.8 gm, the Accession A_5 exhibited the highest YPP and A_4 exhibited the lowest. A_5, A_7, A_8 and A_{10} had high yield (5.0 gm to 6.8 gm) and A_1, A_2, A_3, A_4. A_6 and A_9 low yield for YPP (3.1 gm to 4.9 gm) Overall mean values for YPP, were 3.16 gm and 4.66 gm for the saline and the less-saline environments.

Table 3.11 Mean and variance (in parenthesis) of harvest time characters for Modern Varieties of wheat in the saline and the less-saline environments.

Accessions	Saline				Less-saline			
	PH (cm)	TS	NFM	NFS	PH (cm)	TS	NFM	NFS
A_1	72.12 (14.59)	3 (0.36)	16.6 (2.9)	13 (1.3)	91.43 (28.5)	3.1 (0.15)	16.8 (4.54)	15 (2.1)
A_2	63.41 (35.87)	2.5 (0.36)	15.8 (2.3)	2.6 (1.4)	86.80 (20.8)	2.3 (0.41)	15.3 (1.43)	12.6 (18.4)
A_3	75.49 (18.20)	2.5 (0.25)	15.5 (1.5)	11.3 (2.6)	95.09 (37.9)	3.9 (1.2)	18 (1.4)	14.5 (2.1)
A_4	60.09 (2.96)	2.2 (0.19)	17.4 (2.5)	14.1 (2.4)	81.21 (24.9)	2.6 (0.34)	15 (1.9)	12.7 (10.1)
A_5	77.35 (31.10)	2.3 (0.31)	17.4 (1.5)	12 (11.1)	96.99 (27.7)	3.8 (0.56)	19.9 (0.75)	17.4 (2.4)
A_6	65.65 (20.74)	3 (0.59)	16.9 (4.4)	13.7 (1.9)	86.91 (20.5)	3.1 (0.29)	16.7 (0.72)	14.5 (0.65)
A_7	69.62 (10.35)	2.3 (0.33)	17.1 (3.6)	11.6 (3.3)	88.13 (34.9)	3.3 (0.38)	18.7 (1.2)	12.7 (0.61)
A_8	75.49 (10.53)	3 (0.25)	16.4 (3.1)	12.7 (2.5)	94.84 (53.1)	3.8 (0.72)	16.6 (0.32)	13.6 (1.6)
A_9	80.05 (14.93)	2.6 (0.33)	15.8 (5.4)	9.7 (2.5)	98.51 (25.1)	3.2 (0.42)	17.2 (3.8)	13.75 (2.5)
A_{10}	67.20 (18.92)	2.7 (0.31)	15.50	10.80 (4.2)	89.8 (16.5)	3.1 (0.35)	17.3 (1.0)	15.3 (2.7)
$\overline{X}$	70.64	2.6	16.44	11.85	90.97	3.21	17.15	14.2
LSD 0.05	3.06	0.36	1.07	1.19	4.99	0.46	0.84	1.33

Continued...

Table 3.11 (Continued)

Mean and variance (in parenthesis) of harvest time characters for Modern Varieties of wheat in the saline and the less-saline environments.

Accessions	Saline				Less-saline			
	NFGM	WFGM (gm)	NHGM	WHGM (gm)	NFGM	WFGM (gm)	NHGM	WHGM (gm)
A_1	31.2 (24.4)	1.4 (0.64)	4.7 (7.0)	0.05 ($2.^{-03}$)	39.5 (14.4)	1.6 (0.04)	1.0 (1.5)	0.04 (6.7^{-04})
A_2	27.2 (42.1)	0.96 (0.04)	2.9 (5.6)	0.05 (1.4^{-03})	30.9 (12.7)	1.3 (0.02)	1.15 (0.65)	0.02 (1.8^{-04})
A_3	30.0 (18.1)	1.34 (0.03)	2.4 (3.3)	0.04 (1.2^{-03})	43.8 (25.9)	1.8 (0.05)	2.3 (1.2)	0.04 (6.1^{-04})
A_4	31.0 (22.5)	1.4 (0.06)	2.6 (3.1)	0.04 (7.8^{-04})	38.3 (8.31)	1.5 (0.01)	1.7 (0.85)	0.02 (2.4^{-04})
A_5	29.2 (19.5)	1.27 (0.04)	4.4 (4.9)	0.05 (8.2^{-04})	44.0 (13.1)	2.11 (0.03)	1.5 (1.9)	0.03 (4.7^{-04})
A_6	35.2 (70.9)	1.75 (0.02)	2.8 (4.8)	0.06 (2.2^{-03})	32.7 (10.9)	1.15 (0.01)	1.3 (0.83)	0.02 (3.1^{-04})
A_7	25.1 (50.6)	0.89 (0.09)	6.2 (41.8)	0.1 (0.01)	40.7 (14.6)	1.6 (0.02)	1.0 (1.4)	0.03 (3.6^{-04})
A_8	32.2 (57.7)	1.3 (0.09)	2.8 (3.7)	0.05 ($1.^{-03}$)	42.6 (7.2)	1.9 (0.02)	1.4 (2.2)	0.04 (1.3^{-03})
A_9	28.1 (37.9)	1.2 (0.1)	5.2 (2.9)	0.04 (3.7^{-04})	39.3 (15.0)	1.51 (0.03)	1.67 (1.1)	0.02 (4.3^{-04})
A_{10}	30.1 (28.0)	1.36 (0.04)	5.5 (3.8)	0.06 (1.1^{-03})	49.4 (17.1)	2.89 (0.02)	1.1 (0.72)	0.02 (2.6^{-04})
$\overline{X}$	29.93	1.29	3.95	0.05	40.12	1.74	1.41	0.03
LSD 0.05	3.87	0.15	1.67	0.03	2.36	0.09	0.73	0.18

Continued...

Table 3.11 (Continued)

Mean and variance (in parenthesis) of harvest time characters for Modern Varieties of wheat in the saline and the less-saline environments.

Accessions	Saline				Less-saline			
	NFGS	WFGS (gm)	NHGS	WHGS (gm)	NFGS	WFGS (gm)	NHGS	WHGS (gm)
A_1	12.0 (6.15)	0.82 (9.6^{-03})	2.63 (1.6)	0.04 (4.6^{-04})	25.6 (15.1)	1.1 (0.03)	2.15 (1.02)	0.04 (3.9^{-04})
A_2	18.7 (20.7)	0.56 (0.02)	3.8 (8.8)	0.06 (1.2^{-03})	21.2 (59.9)	0.86 (0.09)	1.45 (0.85)	0.02 (2.2^{-04})
A_3	17.2 (8.8)	0.69 (.01)	4.8 (28.1)	0.07 (2.2^{-03})	22.2 (21.6)	0.91 (0.04)	1.7 (1.9)	0.03 (6.5^{-04})
A_4	15.0 (50.6)	1.21 (0.13)	6.3 (31.3)	0.11 (7.9^{-03})	24.8 (59.3)	0.75 (0.06)	1.85 (0.89)	0.03 (2.4^{-04})
A_5	22.4 (65.9)	0.97 (0.12)	3.7 (5.2)	0.06 (1.6^{-03})	38.3 (11.25)	1.7 (0.03)	2.2 (0.86)	0.04 (3.4^{-04})
A_6	26.5 (15.4)	1.1 (0.03)	3.6 (2.9)	0.07 ($9.^{-04}$)	28.6 (4.45)	1.02 (5.6^{-03})	1.65 (1.0)	0.03 (3.7^{-04})
A_7	18.8 (39.7)	0.77 (0.07)	4.3 (4.3)	0.11 (0.03)	21.5 (8.4)	0.76 (9.8^{-03})	2.25 (2.5)	0.03 (5.6^{-04})
A_8	18.6 (16.3)	0.67 (0.02)	3.7 (4.6)	0.06 (1.1)	30.8 (8.6)	1.2 (0.02)	1.6 (0.97)	0.04 (5.9^{-04})
A_9	16.6 (16.9)	0.72 (0.03)	1.9 (3.6)	0.02 (4.6^{-04})	26.4 (19.5)	1.2 (0.04)	1.25 (0.68)	0.02 (2.6^{-04})
A_{10}	10.9 (23.6)	0.67 (0.04)	4.6 (4.7)	0.07 ($1.^{-03}$)	42.2 (19.0)	1.72 (0.02)	2.8 (0.98)	0.05 (3.6^{-04})
$\overline{X}$	17.67	0.82	3.93	0.07	28.16	1.12	1.89	0.03
LSD 0.05	3.37	0.14	1.76	0.10	3.05	0.12	0.69	0.03

Table 3.11 (Continued)

The mean and variance (in parenthesis) of harvest time characters for Modern Varieties of wheat in the saline and the less-saline environments.

Accessions	Saline	Less-Saline
	YPP	YPP
A_1	3.54 (0.50)	4.0 (0.35)
A_2	2.73 (0.36)	3.61 (0.40)
A_3	2.64 (0.37)	4.52 (2.7)
A_4	2.5 (0.85)	3.11 (0.37)
A_5	3.13 (0.54)	6.8 (2.0)
A_6	4.2 (1.4)	4.43 (0.63)
A_7	2.98 (1.7)	5.21 (0.37)
A_8	3.5 (0.76)	5.5 (1.3)
A_9	3.1 (1.0)	4.2 (0.87)
A_{10}	3.3 (0.77)	5.2 (0.82)
$\overline{X}$	3.16	4.66
LSD 0.05	0.57	0.91

3.12 Results of the farmers' collection (A_{11} to A_{18}) in saline and less-saline soils

3.12.1 Plant height (PH)

In the saline area, the average value for final plant height from 63.98 cm to 83.07 cm, the highest and the lowest values were for A_{16} and A_{11} respectively.

In the less-saline area, the average value for PH was from 76.86 cm to 99.27 cm. Accession A_{16} showed the highest PH value and A_{11} the lowest PH at harvest. Overall mean values were 73.32 cm and 88.94 cm for the saline and the less-saline experiment. Salinity had affected the final plant height.

3.12.2 Tiller with spike (TS)

In the saline area, the average number of fertile tiller at harvest time was from 2.4 to 3.2. Accession A_{16} had the highest TS and A_{12} had the lowest respectively.

In the less-saline environment, the variation of TS ranged between 2.7 to 3.9 not so much different from the saline area. A_{14} had the highest mean value and A_{11} the lowest. Salinity also reduced TS from 3.2 to 2.78.

3.12.3 Number of florets in the main head (NFM)

The number of NF varied from 13.2 to 17.4, mean values were observed for NF in the saline area. A_{17} and A_{12} exhibited the highest and the lowest values respectively. Tall Accession A_{14}, A_{16} and medium tall A_{17}, A_{18} and short A_{13} had high number of florets in the main heads (16 to 18). In the less-saline environment, this range was between 16.9 to 19.1, A_{12} and A_{11} had highest and the lowest values for NF respectively. Here again, salinity had reduced the number of florets in the main head from 17.86 to 15.60.

3.12.4 Number of florets in the second head (NFS)

In the saline area, the average number of floret in the second head was from 9.6 to 13.4 The highest and the lowest values for NF were for Accession A_{17} and A_{12} respectively.

In the less-saline area, the range of NF was from 13.3 to 16.4 Accessions A_{16} and A_{18} exhibited the highest and the lowest values for NF respectively. Salinity affected NF, in the less-saline soil NF was 14.84 but in saline area it was 12.21 only.

3.12.5 Number of full grains in the main head (NFGM)

The average mean value for NFG was from 20.6 to 37.2, the highest and the lowest values for NFG were for Accession A_{14} and A_{18} respectively.

In the less-saline area, the mean values were from 27.7 to 50.7 for NFG.

Salinity had affected NFG, The overall mean values reduced from 38.34 to 23.71 due to salinity.

3.12.6 Weight of full grains of the main head (WFGM)

In the saline area, the average weight of full grains of the main head ranged from 0.86 gm to 1.56 gm. Accession A_{14} had the highest value of weight of full grains and A_{18} the lowest.

In the less-saline area, the variation in the weight of full grains of the mean head ranged between 1.2 gm. 2.3 gm. Accessions A_{11}, A_{15}, A_{17} and A_{18} had low WFG (1.20 gm. to 1.78 gm) while A_{12}, A_{13}, A_{14} and A_{16} had high WFG (1.79 gm. to 2.38 gm.).

The overall performance for this character in the saline and the less-saline environment were 1.26 gm and 1.76 gm, respectively.

3.12.7 Number of half-filled grains in the main head (NHGM)

Average number of half-filled grains in the main head ranged from 1.4 to 5.6 in the saline experiment. Accession A_{16} had the highest mean and A_{12} the lowest.

In the less-saline soil, average number of half-filled grains were from 1.1 to 2.6. Accession A_{15} possessed the highest number of half-filled grains while A_{17} and A_{18} had the lowest values, respectively. The number of half-filled grains was higher in the soil (2.1) than in the less-saline soil (1.6).

3.12.8 Weight of half-filled grains of the main head (WHGM)

Average weight of half-filled grains in the main head was 0.03 gm to 0.1 gm. Accession A_{16} had the highest WHFG while Accessions A_{11}, A_{12} head the lowest values, respectively in saline soil.

In the less-saline environment, this variation ranged between 0.02 gm to 0.06 gm. The Accession A_{15} had the highest and A_{14}, A_{18} had the lowest values, respectively.

3.12.9 Number of full grains in the second head (NFGS)

In the saline area, average number of full gains, in the second head was from 10.5 to 23.5. Accession A_{14} had the highest value and A_{18} the lowest.

In the less-saline area, the variation was between 20.6 to 34.1, Accession A_{14} possessed the highest number of full grains whereas value and A_{12} had the lowest. Salinity had strong effect on the number of grains on this second head an saline soil the NHG was 17.52 whereas in less-saline the NHG was 17.52 whereas in less-saline soil it was 25.37.

3.12.10 Weight of full grains of the second head (WFGS)

In the saline area, mean values for weight of full grains of the second heads was from 0.41 gm to 0.89 gm. The Accession A_{14} had the highest weight while A_{18} had the lowest.

In the less-saline area, average value for WFG was from 0.78 gm to 1.4 gm. Accessions A_{12} and A_{16} had the lowest and highest mean weights respectively. Salinity had reduced the average weight of full grains (0.69 gm) in saline soil whereas it was 1.0 gm in less-saline soil.

3.12.11 Number of half-filled grains in the second head (NHGS)

Average mean values for NHG was from 2.1 to 5.4 in the saline area. Accession A_{16} had the highest mean number while A_{18} had the lowest value respectively.

In the less-saline soil NHF ranged from 1.1 to 2.7 Accession A_{15} had the highest NHF and A_{18} had the lowest value respectively. Overall mean values for the saline and the less-saline experiment were 3.8 and 1.77, so salinity had in increased the number of half-filled grains.

3.12.12 Weight at half-filled grains of the second head (WHGS)

In the saline area, average weight for half-filled grains was from 0.04 gm to 0.12 gm. The highest WHG were for Accession A_{16} and lower values in A_{11}, A_{14} and A_{18}.

In the less-saline experiment, mean values for NHG were from 0.02 gm to 0.06 gm. The Accession A_{15} possessed the highest value along with high NHG (0.05 gm 0.07 gm).

Against salinity had significantly increased the weight of half-filled grains (3.8 gm) while in less-saline soil it was 1.77 gm.

3.12.13 Yield per plant (YPP)

The average yield per plant for the Accessions grown in the saline soil was from 2.1 gm to 5.2 gm. The Accession A_{14} had the highest average YPP and A_{18} had the lowest.

In the less saline environment, the average yield per plant was from 3.3 gm to 7.0 gm. Accession A_{14} had the highest YPP and A_{11} had the lowest value, respectively.

The overall mean values for YPP were 3.25 gm in the saline environment and 4.89 gm in the less-saline experiment so salinity had reduced yield.

Table 3.12 Mean and variance (in parenthesis) of harvest time characters for local collections in the saline and the less saline environments.

Accessions	Saline				Less-saline			
	PH (cm)	TS	NFM	NFS	PH (cm)	TS	NFM	NFS
A_{11}	63.98 (11.89)	2.5 (0.25)	15.2 (2.8)	12.1 (2.6)	76.86 (17.5)	2.7 (0.59)	16.9 (1.3)	14.0 (11)
A_{12}	68.98 (5.05)	2.4 (0.55)	13.2 (2.1)	9.6 (5.8)	87.16 (19.9)	3.5 (0.55)	19.1 (2.6)	15.2 (2.4)
A_{13}	66.97 (29.69)	2.7 (0.61)	16.4 (0.65)	13.3 (4.0)	81.53 (25.1)	2.8 (0.32)	17.8 (0.53)	15.0 (1.3)
A_{14}	77.31 (25.33)	3.0 (0.46)	16.6 (3.3)	12.7 (9.7)	94.37 (13.7)	3.9 (0.32)	17.6 (0.53)	15.0 (1.3)
A_{15}	80.22 (19.22)	2.6 (0.44)	13.6 (6.5)	12.2 (12.8)	97.65 (47.33)	3.2 (0.46)	18.8 (1.6)	15.4 (4.9)
A_{16}	83.07 (30.36)	3.2 (0.36)	16.0 (0.79)	11.8 (1.0)	99.27 (37.21)	3.2 (0.62)	18.3 (1.9)	16.4 (1.5)
A_{17}	71.44 (22.06)	2.9 (0.55)	17.4 (1.6)	13.4 (2.9)	84.00 (87.4)	3.3 (0.38)	17.3 (1.7)	14.4 (1.2)
A_{18}	74.64 (38.41)	3.0 (0.59)	16.4 (2.5)	12.6 (2.1)	90.75 (61.3)	2.8 (0.28)	17.3 (1.7)	13.3 (10.7)
$\overline{X}$	73.31	2.78	15.6	12.21	88.94	3.2	17.86	14.84
LSD 0.05	3.05	0.44	0.90	1.29	3.99	0.49	0.78	1.32

Continued...

Table 3.12 Continued

Mean and variance (in parenthesis) of harvest time characters for local collections in the saline and the less saline environments.

Accessions	Saline				Less-saline			
	NFGM	WFGM (gm)	NHGM	WHGM (gm)	NFGM	WFGM (gm)	NHGM	WHGM (gm)
A_{11}	25.8 (34.1)	1.2 (0.06)	2.1 (1.9)	0.03 (5.1^{-04})	32.6 (15.9)	1.3 (0.02)	1.6 (0.84)	0.03 (2.8^{-04})
A_{12}	24.4 (21.7)	1.0 (0.05)	1.4 (1.85)	0.03 (2.8^{-04})	40.7 (30.2)	2.1 (0.08)	1.55 (0.74)	0.04 (4.7^{-04})
A_{13}	30.9 (29.7)	1.3 (0.06)	4.2 (6.4)	0.08 (2.5^{-03})	34 (10.2)	1.8 (0.02)	1.50 (0.24)	0.03 (8.2^{-05})
A_{14}	37.2 (31.6)	1.56 (0.04)	2.8 (2.1)	0.05 (6.2^{-04})	50.7 (5.2)	2.38 (7.8^{-03})	1.2 (0.38)	0.02 (1.3^{-04})
A_{15}	28.2 (21.9)	1.2 (0.04)	3.8 (5.2)	0.06 (1.6^{-03})	38.0 (19.6)	1.7 (0.02)	1.6 (1.0)	0.06 (4.7^{-04})
A_{16}	32.2 (30.6)	1.5 (0.07)	5.6 (12.2)	0.1 (3.3^{-03})	47.0 (35.4)	2.0 (0.07)	2.6 (0.74)	0.03 (2.3^{-04})
A_{17}	34.8 (13.8)	1.46 (0.02)	4.4 (4.9)	0.08 (1.5^{-03})	36.0 (10.9)	1.58 (0.02)	1.1 (0.98)	0.04 (2.7^{-04})
A_{18}	20.6 (12.6)	0.86 (0.02)	3.2 (2.8)	0.07 (1.1^{-03})	27.7 (11.8)	1.2 (0.01)	1.1 (0.38)	0.02 (1.6^{-04})
$\overline{X}$	29.26	1.26	3.44	0.06	38.34	1.76	1.53	0.03
LSD 0.05	4.03	0.14	1.38	0.08	3.64	0.23	0.53	0.01

Continued...

3.13 Analysis of variance

The results of Analysis of Variance (Table 3.13) showed highly significant Between Treatment item for the characters plant height, tillers with spike, number of floret in the second head, number of full grain in the main head, weight of full grain of the main head, number of half-filled grain in the main head, number full grain in the second head, weight of full grain of the second head, number of half-filled grain in the second head and yield per plant for both Modern Varieties and farmers' collection.

Between Treatment was also highly significant for weight of half-filled grain of the main head and weight of half-filled grain of the second head of the Modern Varieties, on the other hand for number of florets in the main head, Between Treatment was non significant.

Between varieties items were also significant for the characters, plant height, number of full grains in the main head, number of florets in the main head, weight of full grains of the main head, number of full grains in the second head, weight of full grains of the second head, and yield per plant for modern varieties and farmers' collections.

For modern varieties, Between varieties item were significant for the characters, tillers with spike and number of florets in the second head of farmers' collections, number of half-filled grains in the main head, weight of half-filled grains of the main head and number of half-filled grains in second head were significant for Between varieties item. For the character, weight of half-filled grains of the second, Between varieties item was non-significant for both modern varieties and farmers' collections.

Table 3.13 Results of ANOVA for Harvest time characters for Modern Varieties and Farmers' Collections

Characters	Items	Modern Varieties				Farmers' Collections			
		DF	SS	MS	F	DF	SS	MS	F
PH	Between treatment	1	1065.33	1065.33	744.98**	1	876.46	976.46	398.39**
	Between lines	9	635.07	70.56	68.50**	7	739.2	105.6	364.14**
	T X L	9	12.91	1.43	1.39^{NS}	7	15.38	2.2	7.58**
	Error	380	393.09	1.03		304	89.04	0.29	
TS	Between treatment	1	1.86	1.86	11.62**	1	0.60	0.60	6.00*
	Between lines	9	1.83	0.20	2.50^{NS}	7	0.99	0.14	1.75^{NS}
	T X L	9	1.44	0.16	2.0*	7	0.72	0.10	1.25^{NS}
	Error	380	31.32	0.08		304	23.35	0.08	
NFM	Between treatment	1	3.36	3.36	2.85^{NS}	1	20.48	20.48	8.83*
	Between lines	9	15.01	1.67	3.41**	7	3.73	0.53	2.21*
	T X L	9	10.66	1.18	2.47**	7	16.25	2.32	9.67**
	Error	380	185.44	0.49		304	71.89	0.24	
NFS	Between treatment	1	25.09	25.09	10.81**	1	27.56	27.56	18.49**
	Between lines	9	17.13	1.90	4.42**	7	5.73	0.82	1.14^{NS}
	T X L	9	20.85	2.32	5.40**	7	10.46	1.49	2.07*
	Error	380	163.10	0.43		304	219.45	0.72	
NFGM	Between treatment	1	519.18	519.18	46.47**	1	296.76	296.76	16.93**
	Between lines	9	235.46	26.16	6.88**	7	491.10	70.16	81.58**
	T X L	9	100.56	11.17	2.94**	7	122.7	17.53	20.38**
	Error	380	1443.90	3.80		304	262.64	0.86	
WFGM	Between treatment	1	1.01	1.01	9.18*	1	0.66	0.66	22.00**
	Between lines	9	1.72	0.19	19.00**	7	1.02	0.14	200**
	T X L	9	0.98	0.11	11.20**	7	0.23	0.03	42.86**
	Error	380	2.59	0.01		304	0.22	0.307	
NHGM	Between treatment	1	30.99	30.99**	24.59**	1	14.54	14.54	14.83**
	Between lines	9	8.41	0.93	0.96^{NS}	7	7.46	1.06	2.65**
	T X L	9	11.37	1.26	1.30^{NS}	7	6.89	0.98	2.45*
	Error	380	368.86	0.97		304	120.39	0.40	

Continued...

Table 3.13 (Continued)

Results of ANOVA for Harvest time characters for Modern Varieties and Farmers' Collections

WHGM	Between treatment	1	0.003	0.003	9.09*	1	0.003	0.003	5.26^{NS}
	Between lines	9	0.001	0.00011	0.37^{NS}	7	0.002	0.00028	2.86**
	T X L	9	0.003	0.00033	1.10^{NS}	7	0.004	0.00057	5.82**
	Error	380	0.11	0.0003		304	0.03	0.000098	
NFGS	Between treatment	1	354.48	354.48	39.83**	1	309.75	309.75	62.57**
	Between lines	9	292.77	32.53	8.34**	7	247.38	35.34	23.40**
	T X L	9	80.11	8.9	2.28*	7	34.66	4.95	3.28**
	Error	380	1482.82	3.90		304	457.88	1.51	
WFGS	Between treatment	1	0.46	0.46	5.11**	1	0.31	0.31	18.23**
	Between lines	9	0.66	0.07	15.22**	7	0.47	0.067	22.33**
	T X L	9	0.83	0.09	19.57**	7	0.12	0.017	5.67**
	Error	380	1.77	0.0046		304	0.99	0.003	
NHGS	Between treatment	1	21.07	21.07	30.98**	1	16.40	16.40	23.42**
	Between lines	9	8.80	0.98	0.84^{NS}	7	6.38	0.91	2.30*
	T X L	9	6.13	0.68	0.58^{NS}	7	4.92	0.70	2.00*
	Error	380	444.38	1.17		304	107.19	0.35	
WHGS	Between treatment	1	0.004	0.004	10*	1	0.003	0.003	4.28^{NS}
	Between lines	9	0.006	0.0007	0.07^{NS}	7	0.002	0.0003	0.60^{NS}
	T X L	9	0.004	0.0004	0.04^{NS}	7	0.005	0.0007	1.40^{NS}
	Error	380	5.17	0.01		304	0.16	0.0005	
YPP	Between treatment	1	9.65	9.65	20.06**	1	10.73	10.73	59.61**
	Between lines	9	7.03	0.78	4.88**	7	18.99	2.71	54.20**
	T X L	9	4.33	0.48	3.00**	7	1.26	0.18	3.60**
	Error	380	60.26	0.16		304	15.35	0.05	

YPP

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

3.14 A cultural solution : relay cropping

The results of salinity and data collection from plants in the relay cropping trial is given table 3.14

3.14.1 3 weeks' characters

Mean values for plant height (PH) was 28.5 cm, for number of leaves (NL) was 4.9, for fresh weight (FW) was 0.50 gm and for dry weight (DW) was 0.07 gm respectively.

3.14.2 7 weeks' characters

The average values for plant height (PH) was 59.9 cm, for number of leaves (NL) was 12 and for number of tillers was (NT) 3.

3.14.2 Heading time characters

At heading time, average values for plant height (PH) 85.29 cm, for number of tiller (NT) was 3.3, for flag leaf area (FLA) was 29.72 cm^2 and for large leaf area (LLA) was 27.35 cm^2 (Table 3.14).

3.14.3 Harvest time characters.

At harvest time, mean values for plant height (PH) was 94.32 cm, for tiller with spike (TS) as 3.6, for number of florets (NFM) was 17.7, for number of florets in the second head (NFS) was 13.3, for number of full grains of main head (NFGM) was 40.12, for number of half-filled grains (NHGM) was 3.9, for number of full grains of second head (NFGS) was 21.5, for weight of full grains of main head (WFGM) was 1.67 gm, for weight of half-filled grains (WHGM) was 0.07, for weight of full grains of second head (WFGS) was 0.94 gm.

The average number of half-filled grains in the second head was 5.05 and weight of half-filled grains of second head was 0.08 gm and yield per plant (YPP) was 5.5 gm.

Table 3.14 Mean value and variance of 3 weeks 7 weeks and harvest time characters for plants for relay cropping trial.

PH(cor)	3 weeks			7 weeks		
	NL	FW (gm)	DW (gm)	PH	NL	NT
28.5 (14.3)	4.9 (.15)	0.50 (7.3^{-03})	0.07 (1.2^{-04})	59.9 (20.7)	12.0 (9)	3.0 (.44)

Mean value and variance of heading time characters.

PH	NT	FLA	LLA
85.29 (83.12)	3.3 (.69)	29.72 (55.67)	27.35 (10.95)

Mean value and variance of harvest time characters of relay crapping.

PH	T S	NFM	NFS	NFGM	WFGM (gm)	NHGM	WHGM (gm)
94.32 (59.47)	3.3 (.64)	17.7 (1)	13.3 (20.4)	40.12 (11.11)	1.67 (.02)	3.9 (2.25)	.09 (5.9^{-04})

NFGS	WFGS (gm)	NHGS	WHGS (gm)	YPP (gm)
21.5 (55.63)	0.94 (.11)	5.05 (4.9)	0.08 (1.3^{-03})	5.5 (.96)

3.15 Mean values and variances of the harvest time characters from plants collected from the farmers' field in the saline and less-saline area are given Table 3.15 and 3.16 Results of sample collected from the saline area given below:

3.15.1 Plant height in the saline area (PH)

The mean value was observed between 84.19 cm to 91.49 cm for the 12 collections from 12 fields. The sample No. 6 had the highest PH and sample 2 had the lowest value.

3.15.2 Tillers with spike per plant (TS)

Average number of tiller with spike per plant ranged between 2.6 to 3.3.

Sample No. 11 had the highest TS and sample 1 had the lowest value.

3.15.3 Number of florets in the main head (NFM)

Average number of florets was observed from 15.7 to 17.7, Sample 6 had the highest NFM and sample 9 had the lowest value other.

3.15.4 Number of florets in the second head (NFS)

Mean value of number of florets of second head was observed from 12.3 to 14.4 Sample No. 6 had the highest values for NF and Sample 5 had the lowest value.

3.15.5 Number of full grains in the main head (NFGM)

Range for number of full grains was observed from 32.75 to 36.10 Sample 6 had the highest mean value and Sample 1 had the lowest mean value.

3.15.6 Weight of full grains of the main head (WFGM)

Mean value of weight of full grains was observed from 1.4 gm to 1.7 gm. Sample 6 had the highest value for weight of full grains and S_1 had the lowest value.

3.15.7 Number of half-filled grains in the main head (NHGM)

Average number of half-filled grains of main head was from 2.2 to 4.3. S_{10} had the highest value for NHFG and S_2 had the lowest value, respectively.

3.15.8 Number of full grains in the second head (NFGS)

Mean value of number of full grains of second head was observed from 17.1 to 23.7. Sample S_6 had the highest value for NFG and S_1 had the lowest value.

3.15.9 Number of half-filled grains in the second head (NHGS)

Average number of half-filled grains of second head was observed from 3.6 to 7.3 Sample S_{10} had the highest value for HFG and S_6 had the lowest value.

3.15.10 Weight of full grains of the second head (WFGS)

Mean value for weight of full grains of second head was observed from 0.60 gm to 1.2 gm. Sample S_6 had the highest value and S_1 had the lowest value.

3.15.11 Weight of half-filled grains of the main head (WHGM)

Mean value for weight of half-filled grains was observed from 0.03 gm to 0.08 gm. The high values for WHF were for S_7, S_{10}, S_{12} and the low values were for S_2, S_8 respectively.

3.15.12 Weight of half-filled grains of the second head (WHGS)

Range of variation of weight of half-filled grains of other was between 0.06 gm to 0.1 gm. The highest value was for sample S_{10} and the low values were for samples S_3, S_6 and S_8.

3.15.13 Yield per plant (YPP)

Average yield per plant was observed from 2.5 gm to 4.56 gm. The highest value for YPP was for samples S_6 and the lowest value was for S_1.

Table 3.15 Mean and variance (in parenthesis) of harvest time characters of the samples collected from the farmers' fields in the saline area.

Sample	PH (cm)	TS	NFM	NFS	NFGM	WFGM (gm)	NHGM
1	87.02 (26.29)	2.65 (.53)	15.8 (.86)	13.05 (1.05)	32.75 (22.19)	1.14 (0.02)	3.6 (8.4)
2	84.19 (17.18)	2.85 (.73)	16.9 (3.09)	13.5 (5.95)	34.8 (35.96)	1.42 (0.06)	2.2 (4.06)
3	87.11 (25.19)	2.8 (.77)	16.2 (1.97)	12.8 (8.83)	33.5 (12.75)	1.33 (0.02)	4.0 (3.54)
4	90.49 (26.54)	2.7 (1.67)	16.7 (.62)	13.6 (1.40)	35.1 (15.58)	1.63 (0.03)	3.75 (2.19)
5	87.24 (49.55)	2.8 (0.65)	16.04 (1.52)	12.3 (13.32)	33.85 (22.49)	1.5 (0.04)	3.0 (1.55)
6	91.16 (30.11)	2.9 0(.74)	17.7 (2.22)	14.4 (8.1)	36.1 (13.99)	1.7 (0.04)	3.3 (1.08)
7	87.86 (58.22)	3.2 (0.69)	16.2 (0.93)	13.4 (2.0)	32.96 (13.39)	1.31 (0.02)	3.44 (1.77)
8	89.31 (25.97)	3 (0.44)	16.8 (1.53)	14 (2.5)	34.71 (17.71)	1.41 (0.03)	2.4 (1.32)
9	89.4 (4.04)	3.2 (0.47)	15.7 (2.5)	12.8 (2.3)	35.1 (20.8)	1.43 (0.03)	3.9 (2.9)
10	87.8 (57.5)	2.8 (0.48)	15.8 (2.18)	13.4 (1.27)	33.08 (18.79)	1.35 (0.03)	4.32 (1.4)
11	90.3 (26.3)	3.3 (0.49)	16.1 (1.43)	12.7 (2.4)	35.1 (21.32)	1.61 (0.05)	3.8 (1.5)
12	88.3 (32.3)	2.9 (0.53)	15.9 (1.25)	12.5 (2.6)	33.2 (18.32)	1.46 (0.06)	3.9 (2.3)
$\bar{x}$	88.34	29.92	16.24	13.25	34.2	1.44	3.4

Continued...

Table 3.15 (Continued)

Mean and variance (in parenthesis) of harvest time characters of the samples collected from the farmers' fields in the saline area.

Sample	WHGM (gm)	NFGS	WFGS (gm)	NHGS	WHGS (gm)	YPP (gm)
1	0.06 (8.8^{-03})	17.1 (36.79)	0.60 (0.05)	5.45 (4.75)	0.07 ($8.^{-03}$)	2.5 (0.75)
2	0.03 (4.2^{-03})	23.0 (55.75)	0.94 (0.09)	4.3 (5.11)	0.07 (1.5^{-03})	3.6 (.62)
3	0.06 (9.6^{-04})	18.5 (46.91)	0.74 (0.07)	3.8 (4.3)	0.06 ($9.^{-04}$)	3.3 (1.05)
4	0.07 (6.3^{-04})	20.1 (25.83)	0.84 (0.04)	5.7 (4.62)	0.09 ($1.^{-03}$)	3.5 (1.4)
5	0.06 (4.5^{-04})	17.92 (31.03)	0.77 (0.06)	4.6 (5.43)	0.08 (1.5^{-03})	3.22 (.86)
6	0.04 (3.5^{-04})	23.7 (32.22)	1.2 (0.04)	3.6 (2.04)	0.06 (5.8^{-04})	4.56 (1.52)
7	0.08 (0.2)	20.44 (7.05)	0.86 (0.01)	4.8 (3.04)	0.07 (6.8^{-04})	3.8 (1.1)
8	0.03 (2.7^{-04})	22.04 (14.46)	0.89 (0.02)	3.7 (1.7)	0.06 (1.9^{-03})	3.4 (.91)
9	0.06 (6.3^{-04})	19.5 (6.8)	0.79 (0.01)	6.4 (2.9)	0.09 (5.3^{-04})	3.5 (.56)
10	0.08 (3.9^{-04})	20.1 (4.5)	0.86 (9.1^{-03})	7.3 (2.1)	0.1 (3.3^{-04})	3.3 (0.72)
11	0.07 (3.2^{-04})	21.2 (13.47)	0.92 (0.03)	7.2 (1.81)	0.08 (1.9^{-03})	3.5 (0.82)
12	0.08 (0.01)	20.4 (19.3)	0.86 (0.03)	6.2 (1.5)	0.09 (3.2^{-04})	3.3 (1.1)
$\bar{x}$	0.06	20.33	0.85	5.25	0.08	3.4

Less-saline area:

3.16 The data from the samples collected from the wheat plant from the farmers' fields in the saline and less-saline areas are given below

3.16.1 Plant height in less saline area (PH)

Mean value for plant height was observed from 94.45 cm to 99.65 cm. Sample S_1 had the highest value and S_6 had the lowest value.

3.16.2 Tillers with spike (TS)

Average number of tiller with spike ranged between 2.8 to 3.8 Sample S_5 showed the highest value and S_4 showed the lowest value.

3.16.3 Number of florets in the main head (NFM)

Average number of florets in the main head was observed from 17.3 to 18.27. Sample S_5 exhibited the highest value and S_6 exhibited the height value.

3.16.4 Number of florets in the second head (NFS)

Average number of florets in the second head was observed from 13.82 to 14.8. S_6 had the highest value and S_4 had the lowest value for NFS.

3.16.5 Number of full grains in the main head (NFGM)

Mean value for number of full grains was observed from 32.7 to 40.23. Sample S_4 had the highest value and S_2 possessed the lowest value for NFG.

3.16.6 Weight of full grains of the main head (WFGM)

Range of variation for WFG was observed from 1.5 gm to 2.5 gm. Sample S_4 had the highest value and S_2 had the lowest value for WFG.

3.16.7 Number of half-filled grains in the main head (NHGM)

For number of half-filled grains of the main head the range was from 2.5 to 3.8 Sample S_3 and S_6 had high values and S_1 had the lowest value for NHFG.

3.16.8 Weight of half-filled grains of the main head (WHGM)

Average weight of half-filled grains was observed from 0.05 gm Sample to 0.1 gm, Sample S_5 and S_6 had high values and S_1 had the lowest value respectively for WHF.

3.16.9 Number of full grains in the second head (NFGS)

Average number of full grain in the second head was observed from 24.2 to 26.1 Sample S_5 had the highest value and S_1 had the lowest value for NFG.

3.16.10 Weight of full grains of the second head (WFGS)

Range of variation for weight of full grains was observed from 1.1 gm to 1.35 gm Sample S_6 had the highest value and Sample S_2, S_3 had low values for WFG.

3.16.11 Number of half-filled grains of the second head (NHGS)

Average number of half-filled grains in the second head was observed from 3.2 to 5.3 Samples S_1, S_2, S_4, S_6 had low number (3.2 to 4.2) and S_3, S_5 had high number (4.3 to 5.3) of half-filled grain in the second head.

3.16.12 Weight of half-filled grains of the second head (WHGS)

Average weight for half-filled grains of the second head was observed between .06 gm to .09 gm Sample S_5 exhibited the highest value and S_1, S_2 exhibited low values for WHFG.

3.16.13 Yield per plant (YPP)

Average yield per plant was observed between 4.1 gm to 6.3 gm Samples S_6 had the highest value and S_4 had the lowest value for YPP

Table 3.16 Mean and variances (in parenthesis) of harvest time characters of samples collected from the farmer's fields in less-saline area.

Sample	PH	TS	NFM	NFS	NFGM	WFGM
1	99.65 (12.55)	3.36 (1.03)	18.04 (0.68)	14.12 (4.74)	36.60 (21.32)	2.0 (0.05)
2	95.64 (25.75)	3 (0.69)	17.69 (1.8)	14.3 (2.5)	32.7 (26.8)	1.5 (0.06)
3	98.42 (3.3)	3 (0.35)	17.43 (2.4)	13.87 (4.5)	35.91 (9.2)	1.8 (.02)
4	97.27 (13.7)	2.8 (0.60)	17.54 (1.1)	13.82 (1.2)	40.23 (11.4)	2.6 (0.02)
5	96.34 (19.46)	3.8 (0.60)	17.3 (13.1)	14.13 (10.2)	37.4 (15.8)	2.1 (0.03)
6	94.45 (10.35)	3.4 (0.50)	18.2 (5.0)	14.8 (4.3)	40 (12.1)	1.76 (0.02)
$\bar{x}$	96.96	3.2	17.7	14.2	37.05	1.9

Continued...

Sample	NHGM	WHGM	NFGS	WFGS	NHGS	WHGS	YPP
1	2.5 (1.4)	0.05 (5.3^{-04})	24.2 (21.7)	1.1 (0.05)	3.2 (1.8)	0.06 (5.4^{-04})	5.41 (1.98)
2	3.2 (1.4)	0.06 (5.9^{-04})	24.5 (2.37)	1.1 (0.05)	3.2 (0.95)	0.06 (3.3^{-04})	4.95 (0.99)
3	3.8 (3.2)	0.08 (1.3^{-03})	25.0 (12.5)	1.1 (0.03)	4.4 (1.6)	0.08 (6.2^{-04})	4.43 (0.83)
4	3.8 (1.54)	0.09 (4.6^{-04})	25.4 (21.05)	1.14 (0.04)	3.95 (3.7)	0.07 (1.2^{-08})	4.1 (1.2)
5	3.3 (0.75)	0.1 (2.7^{-04})	26.1 (11.6)	1.3 (0.02)	5.3 (1.9)	0.09 (7.4^{-04})	5.6 (1.6)
6	3.8 (1.34)	0.1 (2.1^{-04})	26 (11.5)	1.35 (0.08)	3.9 (3.5)	0.08 (1.2^{-03})	6.3 (1.5)
$\bar{x}$	3.4	0.08	25.2	1.2	3.99	0.07	5.07

RESULTS OF SECOND YEAR

3.17 Salinity levels of the Experimental area

The results of salinity tests are given in Table 3.17. Again, as in the first year, there was clear difference between the more saline and less-saline areas in the second year too, but the magnitude of the difference has been reduced. Also, during the whole year there was a 2 fold or less difference. The surface soil was more saline than sub-surface soil, the level of salinity was more or less same all over the year (November to April) in the less saline area but it varied with time in more saline area, more during the dry months (March/April).

Table 3 .17 Salinity levels of soil (dS) from experimental fields at saline and less-saline areas for the second year

	More Saline				Less-saline			
	Surface	13 cm depths	25 cm depths	$\overline{X}$	Surface	13 cm depths	25 cm depths	$\overline{X}$
Nov'09	7.12	5.38	4.35	5.28	5.2	3.8	3.1	4.03
Dec'09	7.65	6.32	6.12	6.36	5.32	3.8	3.2	4.11
Jan'10	8.84	6.38	6.29	6.50	5.53	3.6	3.1	4.08
Feb'10	8.79	7.1	5.2	7.03	5.57	3.8	3.2	4.19
Mar'10	9.1	7.8	6.8	7.9	5.81	4.1	3.4	4.44
April'10	10.32	8.1	7.2	8.54	5.89	4.1	3.5	4.49
$\overline{X}$	8.63	6.85	5.99		5.55	3.87	3.27	

3.18 Juvenile characters scored at 3 weeks

Mean value and variance of four agronomical characters at juvenile stage (3 weeks) are presented in Table 3.18

3.18.1 Plant height at 3 weeks (PH_3)

A narrow range of variation was observed for plant height (19.92 cm to 25.38) in the saline environment (Table 3.17). The highest and the lowest values, were observed for Accessions A_1 and A_5 respectively. In the less-saline environment the average value ranged from 29.81 cm to 33.92 cm. Accession A_{14} had the highest and A_{10} had the lowest value, respectively The overall mean value for saline soil was 22.97 cm and in less-saline soil was 32.23 cm. So plant height at 3 weeks reduced due to salinity.

3.18.2 Number of leaves per plant at 3 weeks (NL_3)

In saline area, the average number of leaves at 3 weeks ranged from 3.0 to 3.2. In less-saline area this value ranged from 4.05 to 4.45.

The average number of leaves were 3.08 and 4.2 for saline and less-saline soils, respectively.

3.18.3 Fresh weight of plants (FW_3)

No wide range of variation was observed for fresh weight of plants in saline environment (0.17 gm to 0.25 gm).

Salinity had reduced overall performance the mean was 0.21 gm in saline and 0.35 gm in less-saline environment respectively.

3.18.4 Dry weight (DW_3)

In the saline area, the variation was observed from 0.02 gm to 0.04 gm.

In less-saline area, the range was from 0.03 gm to 0.05 gm.

Table 3.18 Mean values and variances (in parenthesis) of 3 weeks characters of second year at saline and less-saline environment.

Accessions	Saline				Less-saline			
	PH (cm)	NL	FW (gm)	DW	PH (cm)	NL	FW (gm)	DW
A_1	25.38 (7.30)	3.05 (0.05)	0.17 (4.01^{-04})	0.02 (2.4^{-05})	31.54 (7.74)	4.2 (0.16)	0.43 (0.03)	0.04 (0.81^{-4})
A_5	19.92 (4.41)	3.0 (0.0)	0.22 (1.81^{-03})	0.04 (4.4^{-05})	31.32 (9.88)	4.2 (0.16)	0.22 (3.5^{-3})	0.03 (0.1^{-5})
A_6	22.10 (10.17)	3.1 (0.09)	0.23 (1.9^{-03})	0.03 (7.6^{-05})	33.63 (5.85)	4.45 (0.35)	0.43 (4.8^{-3})	0.04 (1.6^{-4})
A_8	25.34 (4.62)	3.0 (0.0)	0.21 (8.8^{-04})	0.03 (2.5^{-05})	33.81 (6.79)	4.05 (0.15)	0.42 (0.01)	0.05 (1.2^{-4})
A_{10}	21.10 (6.98)	3.0 (0.1)	0.17 (1.6^{-03})	0.03 (3.6^{-05})	29.81 (15.10)	4.25 (0.19)	0.30 (0.02)	0.04 (5.2^{-4})
A_{14}	21.69 (4.06)	3.2 (0.16)	0.21 (1.8^{-03})	0.04 (1.2^{-04})	33.92 (13.59)	4.2 (0.16)	0.29 (0.01)	0.04 (2.8^{-4})
A_{16}	25.23 (1.6)	3.2 (0.16)	0.25 (4.7^{-03})	0.04 (6.9^{-05})	33.70 (13.05)	4.35 (0.23)	0.38 (0.02)	0.04 (2.6^{-4})
A_{17}	22.99 (6.90)	3.1 (0.09)	0.19 (4.7^{-03})	0.03 (6.1^{-05})	30.14 (14.38)	4.1 (0.09)	0.37 (0.02)	0.04 (3.6^{-4})
$\overline{X}$	22.97	3.08	0.21	0.03	32.23	4.2	0.35	0.04
LSD 0.05	1.75	0.18	0.03	0.04	2.06	0.27	0.06	0.009

3.19 Analysis of variance

The results Analysis of Variance the Between Treatment item was highly significant in all cases except dry weight per plants. The Between Varieties item was non-significant for all the characters except plant height.(Table 3.19).

Table 3.19 Results of ANOVA for characters for the juvenile characters (3 weeks)

Characters	Items	DF	SS	MS	F
PH	Between treatment	1	343.37	343.37	140.72**
	Between lines	7	35.64	5.09	23.14**
	T X L	7	17.08	2.44	11.09**
	Error	304	67.38	0.22	
NL	Between treatment	1	5.23	5.23	307.6**
	Between lines	7	0.11	0.016	1.60^{NS}
	T X L	7	0.12	0.017	1.70^{NS}
	Error	304	2.03	0.01	
FW	Between treatment	1	0.09	0.09	32.14**
	Between lines	7	0.02	0.0028	1.17^{NS}
	T X L	7	0.02	0.0028	1.17^{NS}
	Error	144	0.35	0.0024	
DW	Between treatment	1	0.0002	0.0002	3.51^{NS}
	Between lines	7	0.0002	0.000028	0.47^{NS}
	T X L	7	0.0004	0.000057	0.95^{NS}
	Error	144	0.009	0.00006	

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

3.20 Juvenile characters scored at 7 weeks

Mean value and variances (in parenthesis) for the characters scored at 7 weeks are give table 3.20

3.20.1 Plant height at 7 weeks (PH_7)

In the saline environment PH ranged from 44.16 cm to 50.50 cm Accession A_1 and A_1 showed the highest value and A_{17} showed the lowest value for PH.

In the less-saline environment, this range was 53.93 cm to 61.05 cm. Like saline environment, A_1 had the highest value for PH. The low values were for and the overall mean value were 47.28 cm and 56.72 cm in the saline and less-saline environment respectively.

3.20.2 Number of leaves per plant at 7 weeks (NL_7)

In saline environment, the range for number of leaves per plant was from 6.00 to 9.35. Accession A_5 had the highest mean value and A_{17} had the lowest.

In less-saline environment, the variation ranged between 9.05 to 11.3 Accession. A_{17} had the highest mean value and A_8 had the lowest mean value for NL, respectively. The over all mean value were 7.41 and 9.97 in the saline and less-saline environment respectively.

3.20.3 Number of tillers per plant (NT_7)

Range for NT_7 was 1.65 to 2.30 in the saline area, Accession A_{10} had high and A_1, A_6 and A_{17} had low mean values respectively.

In less-saline environment, number of tillers per plant was 1.85 to 2.35 Accession A_{14} had the lowest and A_{17} had the highest mean value respectively. The overall mean in the saline and less-saline soils were 1.8 and 2.11 for NT respectively.

Table 3.20 Mean values and variance (in parenthesis) of 7 weeks characters of second year at saline and less-saline environments.

Accessions	Saline			Less-saline		
	PH (cm)	NL	NT	PH (cm)	NL	NT
A_1	50.5 (36.36)	6.9 (2.99)	1.65 (0.22)	61.05 (52.73)	10.35 (13.43)	2.15 (0.73)
A_5	45.48 (102.02)	9.35 (4.33)	2.0 (0.40)	54.29 (35.92)	9.85 (11.23)	1.9 (0.79)
A_6	47.26 (37.55)	6.8 (2.16)	1.65 (0.33)	58.08 (63.82)	10.25 (6.29)	2.15 (0.43)
A_8	47.95 (37.82)	7.25 (2.19)	1.75 (0.29)	57.69 (42.27)	9.05 (4.55)	2.0 (0.30)
A_{10}	47.86 (51.70)	8.55 (3.75)	2.3 (0.51)	54.39 (54.84)	10.45 (16.65)	2.2 (0.96)
A_{14}	48.24 (62.15)	7.25 (3.09)	1.7 (0.21)	53.93 (23.35)	9.3 (7.51)	1.85 (0.43)
A_{16}	46.76 (35.56)	7.15 (1.63)	1.7 (0.21)	59.91 (116.60)	9.25 (8.39)	2.3 (0.61)
A_{17}	44.16 (64.79)	6.00 (2.1)	1.65 (0.53)	54.42 (57.01)	11.3 (2.35)	2.35 (0.33)
$\overline{X}$	47.28	7.41	1.8	56.72	9.97	2.11
LSD 0.05	3.99	1.06	0.37	4.09	1.95	0.48

3.21 Results of Analysis of variance for 7 weeks characters in the second years experiment

The ‘Between Treatment’ items were highly significant in all the cases indicating the strong effect of salinity on the characters. The Between lines Accession items were non-significant.

Table 3.21 ANOVA for 7 weeks characters

Characters	Items	DF	SS	MS	F
PH	Between treatment	1	356.74	356.74	123.44**
	Between lines	7	61.15	8.74	1.01^{NS}
	T X L	7	20.29	2.89	0.33^{NS}
	Error	304	2622.54	8.63	
NL	Between treatment	1	26.39	26.39	25.13**
	Between lines	7	4.48	0.64	0.32^{NS}
	T X L	7	7.37	1.05	0.52^{NS}
	Error	304	610.24	2.01	
NT	Between treatment	1	0.39	0.39	8.12*
	Between lines	7	0.27	0.038	0.48^{NS}
	T X L	7	0.34	0.048	0.60^{NS}
	Error	304	24.48	0.08	

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

3.22 Characters scored at heading time

Table 3.22 shows the mean and variance (in parenthesis) for the characters scored at heading time during the second year trial.

3.22.1 Plant height at heading (PH_H)

For plant height at heading, the range was 52.38 cm to 60.24 cm in the saline area. Accession A_{14} had the highest value and A_{17} hand the lowest value for PH respectively.

In less-saline environment, the variation in plant height at heading was from 70.36 cm to 80.46 cm. Accession A_{16} had the highest and A_6 had the lowest value for PH respectively. Salinity had drastically reduced the overall mean performance from 73.97 cm to 57.16 cm.

3.22.2 Number of tillers per plant (NT_H)

In saline area, the average number of tillers ranged between 1.75 to 2.3, the Accession A_{10} had the highest value and A_{17} had the lowest value for NT respectively.

In less-saline environment, the variation for number of tillers ranged between 2.1 to 2.45, not so different from saline environment. Accession A_{17} had the highest mean value and A_8 had the lowest respectively.

The overall mean were almost the same, 2.03 in saline and 2.26 in less-saline area.

3.22.3 Number of leaves per plant at heading (NL_H)

In saline environment NL, varied from 7.7 to 9.65 at heading. Accession A_{10} had the highest and A_{17} had the lowest value for NL respectively.

In less-saline environment, this range in NL was 8.15 to 9.55, Accessions A_1, A_{10} and A_{17} had high number of leaves at heading (9.88 to 10.75), also had high number of leaves at 7 weeks.

The overall mean value was 8.42 in saline environment and 9.89 in less-saline environment.

3.22.4 Largest Leaf Area (LLA)

In the saline area, mean values for largest leaf area ranged between 18.69 cm^2 to 26.64 cm^2. Accession A_5 had the highest value and A_8 had the lowest value for LLA, respectively.

In less-saline area, range of variation was from 38.67 cm^2 to 49.37 cm^2. Accession A_{10} had the lowest value and A_{16} had the highest value for LLA, respectively. Salinity had reduced overall mean values from 43.14 cm^2 to 23.23 cm^2.

3.22.5 Flag leaf area (FLA)

In saline area, the range for FLA was from 29.16 cm^2 to 37.99 cm^2. The Accession A_{14} had the highest value and A_8 showed the lowest value for FLA respectively.

In less-saline environment, a wide range of variation was observed from 41.14 cm^2 to 63.78 cm^2 for flag leaf area. Accession A_{16} had the highest mean value and A_{14} had the lowest FLA respectively. The overall performance was 33.01 cm^2 for saline and 48.54 cm^2 for less-saline environment.

Table 3.22 Mean value and variance (in parenthesis) heading time characters during the second year trial.

Accessions	Saline					Less-saline				
	PH (cm)	NT	NL	LLA (cm^2)	FLA (cm^2)	PH (cm)	NT	NL	LLA (cm^2)	FLA (cm^2)
A_1	59.50 (32.92)	2.05 (0.18)	8.2 (4.26	20.65 (23.48)	33.30 (48.19)	74.69 (9.56)	2.25 (0.59)	10.0 (9.4)	43.52 (33.11)	47.63 (99.43)
A_5	57.23 (93.37)	2.15 (0.33)	8.85 (4.23)	26.64 (28.70)	33.86 (71.70)	70.57 (16.51)	2.25 (0.59)	9.75 (10.45)	44.27 (35.32)	49.22 (117.85)
A_6	52.72 (25.55)	1.95 (0.25)	8.25 (4.45)	24.14 (30.08)	33.17 (50.28)	70.36 (31.13)	2.15 (0.23)	9.35 (5.63)	41.91 (70.84)	44.25 (82.25)
A_8	57.02 (49.99)	1.95 (0.25)	8.15 (4.53)	18.69 (11.98)	29.16 (38.36)	71.47 (30.44)	2.1 (0.19)	9.70 (7.01)	44.22 (46.18)	53.35 (93.31)
A_{10}	59.31 (30.97)	2.3 (0.51)	9.55 (7.15)	23.77 (19.97)	34.02 (25.91)	77.69 (27.24)	2.35 (1.13)	10.75 (24.2)	38.67 (76.94)	45.69 (74.52)
A_{14}	60.24 (52.29)	2.05 (0.25)	8.68 (4.54)	26.13 (65.23)	37.99 (83.35)	73.61 (16.64)	2.15 (0.33)	9.0 (9.50)	40.83 (48.23)	41.14 (52.82)
A_{16}	58.83 (22.21)	2.05 (0.15)	8.0 (2.0)	19.6 (6.06)	29.85 (22.78)	80.46 (52.96)	2.4 (0.54)	10.25 (8.09)	49.37 (23.08)	63.78 (62.36)
A_{17}	52.38 (53.89)	1.75 (0.49)	7.7 (7.81)	26.23 (22.74)	33.10 (39.00)	72.93 (29.17)	2.45 (0.58)	10.3 (5.91)	42.35 (59.84)	43.30 (74.09)
$\overline{X}$	57.16	2.03	8.42	23.23	33.01	73.97	2.26	9.89	43.14	48.54
LSD 0.05	4.35	0.33	1.37	3.25	4.38	5.21	0.46	2.00	4.76	5.98

3.23 Results of analysis of variance for the heading time character during the second year trial

The results of ANOVA is given in Table 3.23 The Between Treatment items were highly significant. Significant variation was observed for Between Lives Items for plant height and largest leaf area.

Table 3.23 Results of ANOVA for Heading time characters during the second year trial.

Charac ters	Items	DF	SS	MS	F
PH	Between treatment	1	1131.48	1131.48	218.85**
	Between lines	7	117.27	16.75	7.01**
	T X L	7	36.23	5.17	2.16*
	Error	304	726.96	2.39	
NT	Between treatment	1	0.21	0.21	9.13*
	Between lines	7	0.14	0.02	0.28^{NS}
	T X L	7	0.16	0.023	0.32^{NS}
	Error	304	22.55	0.07	
NL	Between treatment	1	8.70	8.70	33.46**
	Between lines	7	2.68	0.37	0.28^{NS}
	T X L	7	1.85	0.26	0.19^{NS}
	Error	304	403.83	1.32	
LLA	Between treatment	1	1575.88	1575.88	100.57**
	Between lines	7	32.29	4.61	3.62**
	T X L	7	109.70	15.67	12.33**
	Error	304	388.35	1.27	
FLA	Between treatment	1	959.61	959.61	21.28**
	Between lines	7	101.19	14.45	1.95^{NS}
	T X L	7	315.69	45.09	6.09**
	Error	304	2250.70	7.40	

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

3.24 Performance of harvest time characters during the second year trial

The mean values and variances (in parenthesis) for harvest time characters are given in Table 3.24

3.24.1 Plant height at harvest time (PH)

In saline environment, plant height ranged from 77.93 cm to 85.23 cm. Access A_{14} showed the highest value and A_{17} the lowest value for PH.

In less-saline area, the range varied between 91.31 cm to 97.31 cm. Access A_1 had the highest value and A_6 possessed the lowest for PH, respectively. Salinity had lowered the overall mean value from 94.33 cm to 81.55 cm.

3.24.2 Tiller with spike (TS)

Narrow range of variation was observed (between 2.0 to 2.3) for TS in the saline area. Accession A_{10} had the highest value and Accessions A_6 A_8 A_{14} A_{16} had low value for TS.

In the less-saline area, this range was from 1.95 to 2.45, not so much different from the saline environment. Accession A_{17} had the highest value and A_{14} had the lowest value for TS respectively.

3.24.3 Number of florets in the main head (NFM)

In the saline area, the range for NFM was 15.20 to 17.35, Accession A_{17} showed the highest value and A_{16} the lowest value for NFM respectively.

In the less-saline environment, number of florets ranged from 16.35 to18.90. Accession A_5 had the highest value and A_{16} had the lowest value for NFM respectively. The overall performance for NFM was 16.23 for saline and 17.57 for less-saline environment.

3.24.4 Number of florets in the second head (NFS)

In the saline area, the average number of florets in the second heads was 10.25 to 12.15 Accession A_1 had the highest value and A_{10} had the lowest value for NFS.

A range of 10.35 to 13.2 was observed for number of florets in the less-saline area. Accession A_{17} had the highest value and A_6 had the lowest NFS respectively. Salinity had reduced NFS from 11.89 to 11.15 a small change.

3.24.5 Number of full grains in the main head (NFGM)

Number of full grains varied from 30.3 of 37.05 in the saline area. Accession A_6 had the highest mean value and A_1 the lowest value for NFGM, respectively.

In less-saline area, a wide range of variation for full gains was observed between 29.75 to 42.00. Accession A_{10} possessed the highest value and A_6 the lowest value for NFG respectively. Salinity had lowered NFG from 36.63 to 34.09, small effect induced.

3.24.6 Weight of full grains of the main head (WFGM)

In the saline area, the average full grain weight ranged from 1.63 gm to 2.12 gm, Accession A_{14} had the highest weight and A_{16} had the lowest weight respectively.

In the less-saline area, the range was from 1.72 gm to 2.39 gm. Accession A_{10} had the highest mean value and A_6 had the lowest mean value for WFGM respectively.

The weight of full grains was 1.91 gm in saline and 2.09 gm in the less saline soil.

3.24.7 Number of half-filled grains in the main head (NHGM)

In the saline area, the range was observed from 0.90 gm to 2.90 gm for NHGM. Accession A_{14} possessed the highest mean value and A_5 possessed the lowest respectively.

In less-saline area, the number varied from 0.55 to 1.6, Accessions A_5, A_{14} had high mean values and A_1, A_6 had low mean values for NHGM respectively.

Saline soil increased the number of half-filled grains from 1.01 gm to 2.15 gm.

3.24.8 Weight of half-filled grains in the main head (WHGM)

In saline area, range of 0.02 gm to 0.05 gm was observed for weight of half-filled grains. Accession A_5 had the lowest value and A_6, A_{14}, A_{17} had high values for WHGM, respectively.

In less-saline area, this range was from 0.0098 gm to 0.03 gm. Accessions A_5 and A_{14} had high mean values and A_1 had low mean value for WHGM respectively.

Salinity had increased WHGM form 0.018 gm to 0.038 gm.

3.24.9 Number of full grains in the second head (NFGS)

A range of 16.40 gm to 20.05 gm was observed for full grains in the saline area, Accession A_5 had the highest mean value and A_8 had the lowest mean value for NFGS respectively.

In the less saline area, this range was from 16.25 to 25.4 Accession A_1 had the lowest value and A_{16} had the highest value for NFGS respectively.

Salinity had reduced NFG from 20.84 gm to 18.29 gm.

3.24.10 Weight of full grains of the second head (WFGS)

Range varied from 0.89 gm to 1.16 gm for weight of full grains in the second head in the saline area. Accession A_{14} had the highest value and A_{16} had the lowest value for WFGS respectively.

In the less-saline environment, average value for weight of full grains was from 0.94 gm to 1.25 gm Accession A_8 had the highest value and A_1 had the lowest value for WFGS respectively.

Salinity had reduced WFGS from 1.12 gm to 1.0 gm.

3.24.11 Number of half-filled grains in the second head (NHGS)

In the saline area, the average value for number of half-filled grains was from 1.15 to 2.25. Accession A_1 had the highest value and A_{17} had the lowest value for NHGS respectively.

In less-saline environment, this range was from 0.35 to 2.30. Accession A_8 had the highest mean value and A_6 had the lowest mean value for NHGS respectively.

The number of half-filled grains was increased due to salinity from 1.42 to 1.7.

3.24.12 Weight of half-filled grains of the second head (WHFS)

The average value for weight of half grains was scored from 0.02 gm to 0.03 gm. A_5 and A_{17} possessed the mean value 0.02 gm and others had the mean value 0.03 gm.

In less-saline environment, the range was from 0.0064 gm to 0.04 gm for weight of half-filled grains. Accession A_6 possessed the lowest mean value and A_8 possessed the highest mean value for WHGS respectively.

Salinity had increased the weight of half-filled grains from 0.023 gm to 0.027 gm.

3.24.13 Yield per plant (YPP)

In saline environment, the average yield was from 2.73 gm to 3.76 gm, Accession A_{10} had the highest mean value and A_{16} had the lowest YPP respectively.

In less-saline environment, the average grain yield was from 2.97 gm to 4.29 gm, Accession A_{10} had the highest mean value and A_6 had the lowest YPP respectively. The overall mean values for YPP were 3.17 gm in the saline experiment and 3.73 in the less-saline experiment.

Table 3.24 Mean values and variance (in parenthesis) parenthesis for harvest time characters of second year in the saline and less-saline environment.

Accessions	Saline				Less-saline			
	PH (cm)	TS	NFM	NFS	PH (cm)	TS	NFM	NFS
A_1	80.88 (53.04)	2.05 (0.15)	16.30 (2.31)	12.15 (9.33)	97.31 (39.80)	2.2 (0.46)	18.0 (2.2)	10.40 (25.14)
A_5	83.15 (28.40)	2.1 (0.19)	15.75 (4.49)	11.35 (9.83)	91.81 (19.17)	2.2 (0.46)	18.9 (5.19)	12.50 (29.25)
A_6	79.93 (23.78)	2.0 (0.2)	16.0 (3.0)	11.3 (15.81)	91.31 (21.81)	2.15 (0.23)	16.75 (3.09)	10.35 (12.23)
A_8	82.59 (15.64)	2.0 (0.2)	15.70 (5.61)	10.55 (15.05)	96.51 (25.12)	2.1 (0.19)	16.95 (2.05)	11.85 (10.43)
A_{10}	82.20 (20.19)	2.3 (0.51)	16.45 (2.65)	10.25 (19.99)	93.48 (96.28)	2.3 (0.91)	18.30 (8.31)	12.05 (31.05)
A_{14}	85.23 (38.96)	2.0 (0.2)	17.10 (2.89)	12.0 (19.00)	95.83 (38.18)	1.95 (0.35)	16.50 (3.05)	11.25 (35.49)
A_{16}	80.50 (25.12)	2.0 (0.2)	15.20 (1.26)	10.60 (13.84)	93.22 (21.29)	2.35 (0.53)	16.35 (1.73)	12.75 (20.69)
A_{17}	77.93 (27.23)	2.05 (0.35)	17.35 (3.93)	11.0 (22.6)	95.18 (19.92)	2.45 (0.55)	17.3 (3.71)	13.2 (13.46)
$\overline{X}$	81.55	2.06	16.23	11.15	94.33	2.21	17.53	11.89
LSD 0.05	3.34	0.32	1.15	3.37	5.69	0.53	1.48	2.99

Continued...

Table 3.24 (Continued)

Mean values and variance (in parenthesis) parenthesis for harvest time characters of second year in the saline and less-saline environment.

Accessions	Saline				Less-saline			
	NFGM	WFGM (gm)	NHGM	WHGM (gm)	NFGM	WFGM (gm)	NHGM	WHGM (gm)
A_1	30.3	1.87	1.85	0.03	33.1	1.99	0.55	9.8^{-03}
	(15.51)	(0.11)	(1.43)	(3.7^{-4})	(15.29)	(0.06)	(0.75)	(2.2^{-4})
A_5	34.35	1.90	0.90	0.02	39.8	2.32	1.6	0.03
	(19.83)	(0.14)	(0.89)	(3.4^{-4})	(10.96)	(0.14)	(3.04)	(8.2^{-4})
A_6	37.05	1.80	2.35	0.05	29.75	1.72	0.55	0.01
	(9.25)	(0.09)	(0.73)	(2.6^{-4})	(12.39)	(0.08)	(0.45)	(1.8^{-4})
A_8	34.10	2.01	1.90	0.03	34.8	2.06	0.95	0.02
	(21.59)	(0.09)	(1.2)	(4.03^{-4})	(13.46)	(0.21)	(0.85)	(3.3^{-4})
A_{10}	36.05	2.03	2.10	0.04	42.0	2.39	1.2	0.02
	(12.15)	(0.05)	(0.69)	(1.8^{-4})	(17.2)	(0.11)	(1.33)	(6.2^{-4})
A_{14}	35.65	2.12	2.90	0.05	39.1	2.26	1.6	0.03
	(20.03)	(0.14)	(10.9)	(2.2^{-4})	(33.79)	(0.11)	(1.44)	(6.2^{-4})
A_{16}	33.95	1.63	2.55	0.04	40.3	2.15	1.0	0.02
	(19.34)	(0.07)	(0.75)	(1.4^{-4})	(22.01)	(0.09)	(1.0)	(3.3^{-4})
A_{17}	31.25	1.93	2.65	0.05	34.2	1.86	0.6	0.01
	(4.39)	(0.02)	(1.93)	(5.19^{-4})	(45.36)	(0.08)	(0.34)	(1.3^{-4})
$\overline{X}$	34.09	1.91	2.15	0.038	36.63	2.09	1.01	0.018
LSD 0.05	2.48	0.91	0.66	0.03	2.93	0.21	0.25	0.01

Table 3.24 (Continued)

Mean values and variance (in parenthesis) parenthesis for harvest time characters of second year in the saline and less-saline environment.

Accessions	Saline					Less-saline				
	NFGS	WFGS (gm)	NHGS	WHGS (gm)	YPP (gm)	NFGS	WFGS (gm)	NHGS	WHGS (gm)	YPP (gm)
A_1	19.65	1.02	2.25	0.03	3.08	16.25	0.94	0.70	0.01	3.43
	(24.03)	(0.08)	(0.79)	(1.8^{-4})	(0.38)	(71.49)	(0.22)	(0.61)	(2.3^{-4})	(0.45)
A_5	20.05	1.02	1.50	0.02	3.11	22.9	1.17	1.85	0.03	4.04
	(30.55)	(0.1)	(1.35)	(4.6^{-4})	(0.31)	(114.19)	(0.38)	(3.63)	(1.2^{-3})	(0.43)
A_6	16.70	0.97	1.40	0.03	3.03	17.2	0.99	0.35	6.4^{-03}	2.97
	(50.21)	(0.12)	(0.44)	(2.6^{-4})	(0.37)	(29.56)	(0.10)	(0.33)	(1.1^{-4})	(0.24)
A_8	16.40	0.95	1.90	0.03	2.89	21.9	1.25	2.3	0.04	3.16
	(39.64)	(0.13)	(0.89)	(2.8^{-4})	(0.24)	(37.09)	(0.14)	(1.93)	(8.9^{-4})	(0.23)
A_{10}	18.65	0.99	1.80	0.03	3.76	20.25	1.11	1.5	0.02	4.29
	(65.35)	(0.18)	(0.96)	(2.6^{-4})	(0.89)	(109.49)	(0.32)	(3.85)	(1.0^{-3})	(1.39)
A_{14}	19.45	1.16	1.55	0.03	3.53	21.35	1.22	1.95	0.03	3.85
	(57.65)	(0.21)	(0.75)	(1.9^{-4})	(0.36)	(171.83)	(0.55)	(3.35)	(9.4^{-4})	(1.65)
A_{16}	18.40	0.89	2.05	0.03	2.73	25.4	1.09	1.65	0.03	3.83
	(44.04)	(0.10)	(0.75)	(2.2^{-4})	(0.25)	(111.54)	(0.28)	(1.63)	(6.4^{-4})	(0.60)
A_{17}	17.05	1.04	1.15	0.02	3.27	21.9	1.20	1.05	0.02	3.81
	(55.15)	(0.21)	(0.43)	(1.29^{-4})	(0.60)	(55.09)	(0.15)	(0.75)	(2.4^{-4})	(0.76)
$\overline{X}$	18.29	1.0	1.7	0.027	0.17	20.89	1.12	1.42	0.023	3.73
LSD 0.05	4.32	0.24	0.56	0.02	0.42	5.95	0.33	0.96	0.02	0.55

3.25 Results of Analysis of variance for the characters scored during the second year

The results of Analysis of Variance are given in Table 3.25 for the characters of the second year trial. For all these characters except number of florets in the second had, number of full grains in main had, number of full grain second head, number of half fill grains in the second head, weight of half fill grains of the second had, weight of half fill grains of the main head, the Between Treatment items highly significant indicating large salinity impact for these characters. Between Varieties items were significant for the characters plant height, number of full grains in the main head, weight of full grains of the main head, weight of half-filled grains of the main head and yield per plant.

Table 3.25 Results of ANOVA for Harvest time characters during the second year trial.

Characters	Items	DF	SS	MS	F
PH	Between treatment	1	662.11	662.11	215.67**
	Between lines	7	47.44	6.77	1.93*
	T X L	7	21.48	3.07	0.87^{NS}
	Error	304	1067.73	3.51	
TS	Between treatment	1	0.09	0.09	9.0**
	Between lines	7	0.16	0.02	0.33^{NS}
	T X L	7	0.08	0.01	0.17^{NS}
	Error	304	19.55	0.06	
NFM	Between treatment	1	5.29	5.29	7.78*
	Between lines	7	4.92	0.70	1.19^{NS}
	T X L	7	4.74	0.68	1.15^{NS}
	Error	304	179.20	0.59	
NFS	Between treatment	1	1.66	1.66	1.47^{NS}
	Between lines	7	2.60	0.37	0.11^{NS}
	T X L	7	7.94	1.13	$O.33^{NS}$
	Error	304	1048.45	3.45	

Continued...

Table 3.25 (Continued)

Results of ANOVA for Harvest time characters during the second year trial.

NFGM	Between treatment	1	25.88	25.88	2.08^{NS}
	Between lines	7	78.13	11.16	4.07**
	T X L	7	86.93	12.42	4.53**
	Error	304	833.00	2.74	
WFGM	Between treatment	1	0.13	0.13	6.5*
	Between lines	7	0.36	0.05	2.5*
	T X L	7	0.18	0.02	1.00^{NS}
	Error	304	4.90	0.02	
NHGM	Between treatment	1	5.23	5.23	14.94**
	Between lines	7	1.57	0.22	0.76^{NS}
	T X L	7	2.49	0.35	1.21^{NS}
	Error	304	87.73	0.29	
WHGM	Between treatment	1	0.0016	0.0016	11.43**
	Between lines	7	0.0005	0.00071	11.83**
	T X L	7	0.0010	0.00014	2.33*
	Error	304	0.017	0.00006	
NFGS	Between treatment	1	27.04	27.04	5.06^{NS}
	Between lines	7	38.86	5.55	0.46^{NS}
	T X L	7	37.40	5.34	0.45^{NS}
	Error	304	3630.85	11.94	
WFGS	Between treatment	1	0.06	0.06	10.0**
	Between lines	7	0.08	0.01	0.25^{NS}
	T X L	7	0.04	0.006	0.02^{NS}
	Error	304	11.27	0.04	
NHGS	Between treatment	1	0.31	0.31	1.24^{NS}
	Between lines	7	2.24	0.32	1.28^{NS}
	T X L	7	1.79	0.25	1.00^{NS}
	Error	304	75.36	0.25	
WHGS	Between treatment	1	0.0001	0.0001	1.41^{NS}
	Between lines	7	0.0005	0.000071	0.89^{NS}
	T X L	7	0.0005	0.000071	0.89^{NS}
	Error	304	0.0244	0.00008	
YPP	Between treatment	1	0.99	0.99	14.14**
	Between lines	7	1.71	0.24	2.67**
	T X L	7	0.47	0.07	O.78^{NS}
	Error	304	28.86	0.09	

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

The average value for number of full grains of the main head (NFGM) was 39.35, the mean value for weight of full grains of the main head (WFGM) was 2.62 gm, the mean value for number of half-filled grains in the main head (NHGM) was 2.85, and for weight of half-filled grains (WHGM) it was 0.05 gm.

The mean value for number of full grains of the second head (NFGS), weight of full grains of the second head (WFGS), number of half-filled grains of the second head (NHGS) and weight of half-filled grains of the second head (WHGS) were 19.55, 1.31 gm, 2.35, 0.04 gm respectively.

The average yield per plant (YPP) was 5.47 gm (5.5 gm in first year).

Table 3.26 Mean values and variance of characters scored from samples on relay cropping during the second year trial.

3 weeks' characters

PH (cm)	NL	FW (gm)	DW (gm)
23.6	4.7	0.49	0.06

7 weeks' characters

PH (cm)	NL	NT
57.3	13.85	2.9

Heading time characters

PH (cm)	NT	NL	LLA (cm^2)	FLA (cm^2)
73.66	2.9	12.85	41.21	56.61

Harvest time characters

PH (cm)	TS	NFM	NFS	NFGM	WFGM (gm)	NHGM	WHGM (gm)	NFGS	WFGS (gm)	NHGS	WHGS (gm)	YPP (gm)
97.12	2.7	20.3	13.55	39.35	2.62	2.85	0.05	19.55	1.31	2.35	0.04	5.47

Comparison
Of
Results Over Two Years

COMPARISON OF RESULTS OVER TWO YEARS

3.27 Comparison of two years data of 8 accessions scored at 3 weeks,

Tables 3.27 to 3.28 summarize the performance of the accessions in saline and less-saline soils during the two years.

3.27.1 3 Weeks' Characters

The overall mean values for plant height, number of leaves, fresh weight and dry weight were 21.40 cm, 3.4, 0.23 gm and 0.04 gm respectively in the saline environment in first year. Whereas in the 2nd year the mean values were 22.97 cm, 3.1, 0.21 gm and 0.03 gm for these characters in the same site. There was very little difference between the averages.

Among the 8 Accessions, A_{10}, A_{14} and A_{17} were in better performing for almost all characters scored at 3 weeks in the 1st year. In the 2nd year A_{16} was in top position. Other better performing Accessions were A_6, A_{14} and A_{17}.

On the other hand, in the less saline soil, the overall mean values were 29.79cm, 3.3, 0.33 gm and 0.03 gm in the first year. Accessions A_5, A_8 and A_{16} were better performing. Another better performing Accession was A_{14} in first year. In 2nd year, A_6 and A_{16} had better performance for all characters. A_8 and A_{10} were good for fresh weight and dry weight. The overall mean values were 32.23 cm, 4.2, 0.35 gm and 0.04 gm for plant height, number of leaves, fresh weight and dry weight respectively.

3.27.2 7 Weeks' Characters

Among better performing accessions of 3 weeks Accessions A_{10} and A_{14} also performed better for the characters scored at 7 weeks in the saline environment during 1st year. Other better performing Accessions were A_1 and A_8. The overall mean performance was 44.11 cm for plant height 11.91 for number of leaves and 2.7 for number of tillers.

In 2nd year, the overall mean values were 47.28 cm, 7.4 and 1.8 for these characters. Accession A_{16}, the top performer of 3 weeks in the saline environment failed to retain the top position at 7 weeks. A_5 and A_{10} were good for number of leaves and number of tillers.

In the less-saline environment, during the 1st year, Accession A_8 was better performing for all the characters. Accessions A_1 and A_{16} were good for plant height and number of leaves. Another better performing A_5 at 3 weeks was good only for number of tillers.

Accession A_1 and A_6 had better performance for all characters at 7 weeks in the 2nd year. Accession A_{16}, better performing at 3 weeks was also good for plant height and number of tillers. Accession A_{10} and A_{17} had better position for number of leaves and number of tillers.

3.27.3 Heading Time Characters

In the saline soil, for the first year, the overall mean values were 63.54cm, 3.07, 21.66 cm^2 and 25.56 cm^2 for the characters, plant height, number of tillers, largest leaf area and flag leaf area, respectively.

Accession A_{10} was the best performing Accession for all the characters scored at heading time. Accession A_8 was better for plant height and number of tiller and A_{16} was in better position for plant height, number of tillers and largest leaf area. Another better performing A_{17} had better performance for largest leaf area and flag leaf area.

The overall mean values for these characters scored at heading time for the 2nd year, were 57.15 cm, 2.03, 23.23 cm^2 and 33.01 cm^2 respectively. Accessions A_5 and A_{10} were better for all the characters at heading time, as were at 7 weeks.

Accession A_{14}, was promising during 3 weeks, also better for the characters scored during heading time excepting number of tillers. Another better performing A_{17} was in better position for largest leaf area and flag leaf area during heading time.

In the less-saline environment of the first year, the overall mean values were 81.19 cm for plant height, 3.26 for number of tillers, 44.40cm^2 for largest leaf area and 48.62 cm^2 for flag leaf area, respectively. Accession A_5 had better performance for all the characters in this case. Another better performing Accession A_8 was also better for these characters excepting largest leaf area while Accessions A_1 and A_{10} had greater flag leaf area.

During the second year, in the less-saline environment, the overall mean values were 73.97cm, 2.26, 43.08 cm^2 and 48.58 cm^2, respectively, for the characters plant height, number of tillers, largest leaf area and flag leaf area. Accession A_{16} was better performing for all the characters, so was A_{10} excepting for largest leaf area. Accession A_{17} had better performance for number of tillers and largest leaf area while A_5 also had high largest and flag leaf area.

3.27.4 Harvest Time Characters : Saline soil

In the saline environment during the 1st year, the overall mean values were 73.70 cm for plant height, 2.89 for tiller number, 16.6 for number of florets in the main head, 12.51 for number of floret in the second head, 32.76 for number of full grains in the main head, 1.45 gm for weight of full grains in the main head, 4.12 for number of half-filled grains, 0.06 gm for weight of half-filled grains, 18.49 for number of full grains in the second head, 0.81 gm for weight of full grains of the second head, 3.8 for number of half-filled grains in the second head, 0.06 gm for weight of half-filled grains, in the second head and 3.86 gm for yield per plant.

The high yield (4.2 gm to 5.3gm) giving Accession A_{14} was also better performing for almost all the characters, including weight of half-filled grains of the main head and of the second head. So, was the same rank holder Accession, A_6 with low weight of half-filled grains of the main head.

Another high yield giving Accession A_{17} was good performer excepting weight of full grains of both heads, number of full grains in the second head, with low number of half-filled grains in the main head and weight of half-filled grains of the second head.

Better performing Accessions A_8, A_{10} during the juvenile stage failed to show better results at harvest time when the 8 accessions were grouped on the basis of range of characters these likely.

In the 2nd year, the overall mean value for the characters scored at harvest time were 81.55cm for plant height, 2.06 for TS, 16.23 for NFM, 11.15 for NFS, 34.09 for number of full grains in the main head, 1.91 gm for weight of full grain, 2.15 for number of half-filled grains, 0.04 gm for weight of half-filled grains 18.29 for number of full grains in the second head, 1.00 gm for weight of full grains in the second head, 1.7 for number of half-filled grains in the second head, 0.027 gm for weight of half-filled grains and 3.17 for yield per plant.

The high yield giving Accessions were A_{10}, A_{14} and A_{17}.The Accessions A_{14} and A_{17} which were high yield giving Accessions of two years in the saline area.

Among high number of fertile tiller bearing Accessions (A_5, A_{10}) in 2nd year, A_{10} had high yield but A_5 failed to give reasonable yield. It was very close the to first year performance. (3.13 gm in first year, 3.11 gm in 2nd year). A_{10} was also close to first year yield (3.30gm in first year and 3.76 in 2nd year). Accession A_{14} and A_{17} had also showed better scores of juvenile and heading time characters.

3.27.5 Harvest Time Characters : Less saline soil

In the less-saline soil during the first year, the average mean values of harvest time characters were 92.90 cm, 3.41, 17.56, 15.2, 42.74, 2.13 gm, 1.4, 0.03 gm 31.03, 1.24 gm, 1.96, 0.036 gm and 5.44 gm for plant height, fertile tillers, number of florets in the main head, number of florets in the second head, number of full grain in the main head, weight of full grains, number of half-filled grains, weight of half-filled grains, number of full grains in the second head, weight of full grains in the second head, number of half-filled grains in the second head, weight of half-filled grains in the second head and yield per plant, respectively.

Accessions, A_5, A_{14} and A_{17} were the high yield giving Accessions (5.6gm to 7.1gm) and others had low yield (4.0gm to 5.5 gm) when the eight Accessions were grouped on the basis of yield (4.00 gm to 7.00 gm). Accession, A_5 had better performance for all the characters at harvest time, with weight of half-filled grains of the main head.

Accessions A_{14} and A_{17} were also better performing Accessions for most of the characters at harvest time in the first year. Another better performing Accession during the juvenile stage and heading time, A_8 was low yield giving Accession (4.00gm to 5.5gm).

In the second year experiment in the less-saline environment, Accessions A_5, A_{10}, A_{14}, A_{16} and A_{17} had better performance for yield per plant and had a good character combination for almost all the characters. Accessions A_{10}, A_{16} and A_{17} were also better performing during juvenile and heading time.

Table 3.27 Comparison between two years' mean values and range for all the characters in saline and less saline soils.

	Characters	Environment	First Year		Second Year	
			Mean	Range	Mean	Range
3 weeks	PH	Saline	21.40	19.5-22.9	22.97	19.92-25.38
		Less saline	29.79	27.6-32.1	32.23	29.81-33.92
	NL	Saline	3.4	3.2-3.7	3.1	3.0-3.2
		Less saline	3.30	2.9-3.5	4.2	4.05-4.45
	FW	Saline	0.23	0.17-0.27	0.21	0.17-0.25
		Less saline	0.33	0.24-0.41	0.35	0.22-0.43
	DW	Saline	0.04	0.02-0.06	0.03	0.02-0.04
		Less saline	0.03	0.02-0.06	0.04	0.03-0.05
7 weeks	PH	Saline	44.11	39.2-49.4	47.28	44.16-50.5
		Less saline	52.87	47.1-60.2	56.72	53.93-61.05
	NL	Saline	11.91	9.9-13.3	7.4	6.0-9.35
		Less saline	11.79	9.2-14.8	9.97	9.05-11.3
	NT	Saline	2.7	2.1-3.3	1.8	1.65-2.3
		Less saline	2.8	2.3-3.6	2.1	1.85-2.35
Heading time	PH	Saline	63.54	59.54-67.11	57.15	52.38-60.24
		Less saline	81.19	77.25-88.74	73.97	70.36-80.46
	NT	Saline	3.07	2.5-3.4	2.03	1.75-2.3
		Less saline	3.26	2.8-4.0	2.06	2.1-2.45
	LLA	Saline	21.66	18.18-26.19	23.23	18.69-26.24
		Less saline	44.46	41.01-55.06	43.08	38.67-49.37
	FLA	Saline	25.56	18.42-40.43	33.01	29.16-37.99
		Less saline	48.62	35.29-62.91	48.54	41.14-63.78
Harvest time	PH	Saline	73.70	65.65-83.07	81.85	77.93-85.23
		Less saline	92.90	84.00-92.27	94.33	91.31-97.31
	TS	Saline	2.89	2.3-3.2	2.06	2.0-2.3
		Less saline	3.41	3.1-3.9	2.21	1.95-2.45
	NFM	Saline	16.6	15.50-17.4	16.23	15.20-20.35
		Less saline	17.56	16.6-19.9	17.57	16.35-18.90
	NFS	Saline	12.51	10.80-13.7	11.15	10.25-12.15
		Less saline	15.2	13.6-17.4	11.89	10.35-13.20
	NFGM	Saline	32.76	29.2-37.2	34.09	30.30-37.05
		Less saline	42.74	32.7-50.7	36.63	29.75-42.0
	WFGM	Saline	1.45	1.27-1.75	1.91	1.63-2.12
		Less saline	2.13	1.58-3.38	2.09	1.72-2.39
	NHGM	Saline	4.12	2.8-5.6	2.15	0.90-2.90
		Less saline	1.4	1.0-2.6	1.01	0.55-1.6
	WHGM	Saline	0.06	0.05-0.1	0.04	0.02-0.05
		Less saline	0.03	0.02-0.04	0.02	0.0098-0.03
	NFGS	Saline	18.49	10.9-26.5	18.29	16.4-20.05
		Less saline	31.03	24.0-42.4	20.89	16.25-25.4
	WFGS	Saline	0.81	0.51-1.1	1.0	0.89-1.16
		Less saline	1.24	0.91-1.72	1.12	0.94-1.25
	NHGS	Saline	3.8	2.63-5.4	1.7	1.15-2.25
		Less saline	1.96	2.50-2.8	1.42	0.35-2.3
	WHGS	Saline	0.06	0.04-0.12	0.027	0.02-0.03
		Less saline	0.036	0.02-0.05	0.023	6.4^{-03}-0.04
	YPP	Saline	3.86	3.13-5.2	3.17	2.73-3.76
		Less saline	5.44	4.0-7.0	3.73	2.97-4.29

Table 3.28 Grouping of the Accessions on two years performance for the characters under saline and less-saline soils.

	Characters	Environment	First Year		Second Year	
			(+) genotype	(-) genotype	(+) genotype	(-) genotype
3 weeks	PH	Saline	A_5,A_6,A_8,A_{16}	A_1,A_{10},A_{14},A_{17}	A_1,A_8,A_{16}	$A_5,A_6,A_{10},A_{14},A_{17}$
		Less saline	A_1,A_6,A_{10},A_{17}	A_5,A_8,A_{14},A_{16}	A_6,A_8,A_{14},A_{16}	A_1,A_5,A_{10},A_{17}
	NL	Saline	$A_{10},A_{14},A_{16},A_{17}$	A_1,A_5,A_6,A_8	A_6,A_{14},A_{16},A_{17}	A_1,A_5,A_8,A_{10}
		Less saline	$A_5,A_6,A_8,A_{14},A_{16},A_{17}$	A_1,A_{10}	A_6,A_{16}	$A_1,A_5,A_8,A_{10},A_{14},A_{17}$
	FW	Saline	$A_5, A_6, A_8, A_{14}, A_{16}, A_{17}$	A_1, A_{10}	$A_5, A_6, A_8, A_{14}, A_{16}$	A_1, A_{10}, A_{17}
		Less saline	A_5, A_8, A_{14}, A_{16}	A_1, A_6, A_{10}, A_{17}	$A_1, A_6, A_8, A_{10}, A_{16}, A_{17}$	A_5, A_{14}
	DW	Saline	$A_5, A_6, A_8, A_{10}, A_{14}, A_{17}$	A_1, A_{16}	A_5, A_{14}, A_{16}	$A_1, A_6, A_8, A_{10}, A_{17}$
		Less saline	A_5, A_8, A_{16}	$A_1, A_6, A_{10}, A_{14}, A_{17}$	$A_1, A_6, A_8, A_{10}, A_{14}, A_{16}, A_{17}$	A_5
7 weeks	PH	Saline	$A_5, A_6, A_8, A_{10}, A_{14}, A_{16}, A_{17}$	A_1	A_1, A_{14}	$A_5, A_6, A_8, A_{10}, A_{15}, A_{17}$
		Less saline	$A_5, A_6, A_{10}, A_{14}, A_{16}, A_{17}$	A_1, A_8	A_1, A_6, A_{16}	$A_5, A_8, A_{10}, A_{14}, A_{17}$
	NL	Saline	A_1, A_8, A_{10}, A_{14}	A_5, A_6, A_{16}, A_{17}	A_5, A_{10}	$A_1, A_6, A_8, A_{14}, A_{16}, A_{17}$
		Less saline	A_1, A_8, A_{16}, A_{17}	A_5, A_6, A_{10}, A_{14}	A_1, A_6, A_{10}, A_{17}	A_5, A_8, A_{14}, A_{16}
	NT	Saline	$A_1, A_8, A_{10}, A_{14},$	A_5, A_{16}, A_{17}	A_5, A_{10}	$A_1, A_6, A_8, A_{14}, A_{16}, A_{17}$
		Less saline	A_5, A_6, A_8	$A_1, A_{10}, A_{14}, A_{16}, A_{17}$	$A_1, A_6, A_{10}, A_{10}, A_{17}$	A_5, A_8, A_{14}
Heading time	PH	Saline	$A_5, A_6, A_8, A_{10}, A_{17}$	A_1, A_{14}, A_{16}	$A_1, A_5, A_8, A_{10}, A_{14}, A_{16}$	$A_6, A_7,$
		Less saline	$A_1, A_5, A_6, A_{10}, A_{14}, A_{17}$	A_8, A_{16}	A_1, A_{10}, A_{16}	$A_5, A_6, A_8, A_{14}, A_{17}$
	NT	Saline	$A_1, A_6, A_8, A_{10}, A_{14}, A_{16}$	A_5, A_{17}	A_5, A_{10}	$A_1, A_6, A_8, A_{14}, A_{16}, A_{17}$
		Less saline	A_5, A_8	$A_1, A_6, A_{10}, A_{14}, A_{16}, A_{17}$	A_{10}, A_{16}, A_{17}	$A_1, A_5, A_6, A_8, A_{14}$
	LLA	Saline	$A_5, A_6, A_{10}, A_{16}, A_{17}$	A_1, A_8, A_{14}	$A_5, A_6, A_{10}, A_{14}, A_{17}$	A_1, A_8, A_{16}
		Less saline	A_5	$A_1, A_6, A_8, A_{10}, A_{14}, A_{16}, A_{17}$	$A_1, A_5, A_8, A_{16}, A_{17}$	A_6, A_{10}, A_{14}
	FLA	Saline	A_{10}, A_{17}	$A_1, A_5, A_6, A_8, A_{14}, A_{16}$	$A_1, A_5, A_5, A_{10}, A_{14}, A_{17}$	A_8, A_{16}
		Less saline	A_1, A_5, A_8, A_{10}	$A_6, A_{14}, A_{16}, A_{17}$	A_5, A_{10}, A_{16}	$A_1, A_6, A_8, A_{14}, A_{17}$

Continued....

Table 3.28 (Continued)

Grouping of the Accessions on two years performance for the characters under saline and less-saline soils.

Harvest time	PH	Saline	A_1, A_5, A_6, A_8, A_{10}, A_{14}	A_{16}, A_{17}	A_5, A_8, A_{10}, A_{14}	A_1, A_6, A_{16}, A_{17}
		Less saline	A_1, A_6, A_8, A_{10}, A_{14}, A_{17}	A_5, A_{16}	A_1, A_8, A_{14} A_{17},	A_5, A_6, A_{10}, A_{16}
	TS	Saline	A_1, A_6, A_8, A_{14}, A_{16}, A_{17}	A_5, A_{10}	A_5, A_{10}	A_1, A_6, A_8, A_{14}, A_{16}, A_{17}
		Less saline	A_5, A_8, A_{14}	A_1, A_6, A_{10}, A_{16}, A_{17}	A_1, A_5, A_{10}, A_{16}, A_{17},	A_6, A_8, A_{14}
	NFM	Saline	A_1, A_5, A_6, A_{14}, A_{17}	A_8, A_{10}, A_{16}	A_1, A_{10}, A_{14}, A_{17}	A_5, A_6, A_8, A_{16}
		Less saline	A_5, A_{16}	A_1, A_6, A_8, A_{10}, A_{14}, A_{17}	A_1, A_5, A_{10}	A_6, A_8, A_{14}, A_{16}, A_{17}
	NFS	Saline	A_1, A_5, A_6, A_8, A_{14}, A_{17}	A_{10}, A_{16}	A_1, A_5, A_6, A_{14}	A_8, A_{10}, A_{16}, A_{17}
		Less saline	A_5, A_{16}	A_1, A_6, A_8, A_{10}, A_{14}, A_{17}	A_5, A_8, A_{10}, A_{16}, A_{17}	A_1, A_6, A_{14}
	NFGM	Saline	A_6, A_{14}, A_{17}	A_1, A_5, A_8, A_{10}, A_{16}	A_5, A_6, A_8, A_{10}, A_{14}	A_1, A_{16}, A_{17}
		Less saline	A_1, A_5, A_8, A_{10}, A_{14}, A_{16}	A_6, A_{17}	A_5, A_8, A_{10}, A_{14}, A_{16}, A_{17}	A_1, A_6
	WFGM	Saline	A_6, A_{14}, A_{16}	A_1, A_5, A_8, A_{10}, A_{17}	A_5, A_8, A_{10}, A_{14}, A_{17}	A_1, A_6, A_{16}
		Less saline	A_{10}, A_{14}	A_1, A_5, A_6, A_8, A_{14}, A_{17}	A_5, A_8, A_{10}, A_{14}, A_{16}	A_1, A_6, A_{17}
	NHGM	Saline	A_6, A_8, A_{14}	A_1, A_5, A_{10}, A_{16}, A_{17}	A_1, A_5, A_8	A_6, A_{10}, A_{14}, A_{16}, A_{17},
		Less saline	A_1, A_5, A_6, A_8, A_{10}, A_{14}, A_{17}	A_{16}	A_1, A_6, A_8, A_{16}, A_{17},	A_5, A_{10}, A_{14}
	WHGM	Saline	A_{16}, A_{17}	A_1, A_5, A_6, A_8, A_{10}, A_{14}	A_6, A_8, A_{14}, A_{16}, A_{17},	A_1, A_5, A_8
		Less saline	A_1, A_8, A_{17}	A_5, A_6, A_{10}, A_{14}, A_{16}	A_5, A_{14}	A_1, A_6, A_8, A_{10}, A_{16}, A_{17}
	NFGS	Saline	A_5, A_6, A_8, A_{14}, A_{16}	A_1, A_{10}, A_{17}	A_1, A_5, A_{10}, A_{14}	A_6, A_8, A_{16}, A_{17}
		Less saline	A_5, A_8, A_{10}, A_{14}	A_1, A_6, A_{16}, A_{17},	A_5, A_8, A_{14}, A_{16}, A_{17}	A_1, A_6, A_{10}
	WFGS	Saline	A_1, A_5, A_6, A_{14}, A_{16}	A_8, A_{10}, A_{17}	A_{14}, A_{17}	A_1, A_5, A_6, A_8, A_{10}, A_{16}
		Less saline	A_5, A_8, A_{10}, A_{14},	A_1, A_6, A_{16}, A_{17}	A_5, A_8, A_{10}, A_{14}, A_{17}	A_1, A_6, A_{16}
	NHGS	Saline	A_1, A_5, A_6, A_8, A_{14}, A_{17}	A_{10}, A_{16}	A_5, A_6, A_{14}, A_{17}	A_1, A_8, A_{10}, A_{16}
		Less saline	A_1, A_6, A_8, A_{14}, A_{16}, A_{17}	A_5, A_{10}	A_1, A_6, A_{17}	A_5, A_8, A_{10}, A_{14}, A_{16}
	WHGS	Saline	A_6	A_1, A_5, A_8, A_{10}, A_{14}, A_{16}, A_{17}	A_1, A_6, A_8, A_{10}, A_{14}, A_{16}	A_5, A_{17}
		Less saline	A_1, A_5, A_8, A_{10}, A_{14}	A_6, A_{16}, A_{17}	A_5, A_8, A_{14}, A_{16}	A_1, A_6, A_{10}, A_{17}
	YPP	Saline	A_6, A_{10}, A_{14}, A_{17}	A_1, A_5, A_8, A_{16}	A_{10}, A_{14}, A_{17}	A_1, A_5, A_6, A_8, A_{16}
		Less saline	A_5, A_{14}, A_{17}	A_1, A_6, A_8, A_{10}, A_{16}	A_5, A_{10}, A_{14}, A_{16}, A_{17}	A_1, A_6, A_8

3.29 Results of analysis of Variance for 3 weeks' characters of wheat Accessions

Only Between Years item was significant for number of leaves per plant in the saline environment the three other characters were not significant. But in the less-saline environment, Between years item was highly significant for plant height and number of leaves per plant. Between Varieties items were significant for plant height and dry weight of the saline and less-saline soils.

Table 3.29 Results of Analysis of variance of wheat Accessions over two years in saline and less saline environment

Characters	Items	Saline				Less-Saline			
		DF	SS	MS	F	DF	SS	MS	F
PH	Between years	1	2.69	9.69	3.34 NS	1	24.14	24.14	12.70**
	Between lines	7	23.06	3.29	3.13**	7	31.70	4.23	2.10*
	Y X L	7	20.40	2.9	2.67**	7	13.52	1.9	0.95 NS
	Error	304	319.74	1.05		304	610.97	2.01	
NL	Between years	1	0.48	0.48	48.0**	1	3.71	3.71	123.67**
	Between lines	7	0.19	0.027	0.90 NS	7	0.20	0.028	0.22 NS
	Y X L	7	0.09	0.01	0.33 NS	7	0.21	0.03	0.23 NS
	Error	304	9.22	0.03		304	39.81	0.13	
FW	Between years	1	0.00	0.00	0 NS	1	0.002	0.002	0.33 NS
	Between lines	7	0.00	0.00	0 NS	7	0.026	0.0037	0.46 NS
	Y X L	7	0.01	0.0014	1.75 NS	7	0.042	0.006	0.75 NS
	Error	144	0.12	0.0008		144	1.23	0.008	
DW	Between years	1	0.000	0.000	0	1	0.0001	0.0001	2.32 NS
	Between lines	7	0.001	0.00014	2.00*	7	0.0011	0.00016	4.00**
	Y X L	7	0.001	0.00014	2.00*	7	0.0003	0.000043	1.08 NS
	Error	144	0.01	0.00007		144	0.018	0.00006	

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

3.30 Results of Analysis of Variance for 7 weeks of wheat

In saline environment, the 'Between Years' item was highly significant for PH, NL and NT, but in less-saline soil 'Between Years' item was highly significant for PH and NT only, NL showed no difference. Between lines item was non significant for all characters except for PH in the less-saline soil and number of tillers in the saline soil.

Table 3.30 Results of Analysis of variance for 7 weeks characters over two years in the saline and less saline environment

Characters	Items	Saline				Less-Saline			
		DF	SS	MS	F	DF	SS	MS	F
PH	Between year	1	40.04	40.04	22.88**	1	59.14	59.14	12.27**
	Between lines	7	78.64	11.03	1.72^{NS}	7	67.59	23.94	3.04**
	Y X L	7	12.29	1.75	0.26^{NS}	7	33.73	4.82	0.61^{NS}
	Error	304	1935.96	6.37		304	2391.63	7.87	
NL	Between year	1	81.23	81.23	56.40**	1	13.15	13.15	5.18^{NS}
	Between lines	7	8.74	1.24	1.59^{NS}	7	17.19	2.45	1.99^{NS}
	Y X L	7	10.07	1.44	1.85^{NS}	7	17.8	2.54	2.07*
	Error	304	237.89	0.78		304	373.26	1.23	
NT	Between year	1	3.33	3.33	34.69**	1	2.04	2.04	12.75**
	Between lines	7	1.08	0.15	2.50*	7	0.78	0.11	1.22^{NS}
	Y X L	7	0.67	0.096	1.60^{NS}	7	1.11	0.16	1.78^{NS}
	Error	304	19.25	0.06		304	28.62	0.09	

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

3.31 Results of Analysis of Variance for heading time characters of wheat

For plant height the Between Years item was highly significant in both saline and less-saline soils, but the Between lines item was significant for saline soils only. For NT and FLA Between Years item was significant but Between lines item was not.

Table 3.31 Results of Analysis of Variance for Heading time characters scored over two years at saline and less saline environments.

Characters	Items	Saline				Less-Saline			
		DF	SS	MS	F	DF	SS	MS	F
PH	Between years	1	163.01	163.01	185.24***	1	208.23	208.23	24.88**
	Between lines	7	107.24	15.32	2.86**	7	157.29	22.47	4.33**
	Y X L	7	6.19	0.88	0.16 NS	7	58.57	8.37	1.61 NS
	Error	304	1627.07	5.35		304	1578.11	5.19	
NT	Between years	1	4.30	4.30	89.58***	1	4.00	4.00	4.0 NS
	Between lines	7	0.42	0.06	1.00 NS	7	0.48	0.07	0.88 NS
	Y X L	7	0.34	0.048	0.80 NS	7	0.71	0.10	1.25 NS
	Error	304	18.85	0.06		304	23.44	0.08	
LLA	Between years	1	9.85	9.85	1.59 NS	1	7.02	7.02	0.44 NS
	Between lines	7	85.99	12.28	1.02 NS	7	108.39	15.48	2.21*
	Y X L	7	43.19	6.17	0.51 NS	7	109.36	15.62	2.23**
	Error	304	3676.55	12.09		304	2331.68	7.01	
FLA	Between years	1	221.79	221.79	7.47*	1	0.03	0.03	0.0003 NS
	Between lines	7	207.25	29.61	6.26**	7	563.99	80.57	7.24**
	Y X L	7	207.79	29.68	6.27**	7	591.61	84.51	7.59**
	Error	304	1438.04	4.73		304	3382.40	11.13	

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

3.32 Results of Analysis of Variance for harvest time characters of wheat accessions

The Between Years item was highly significant for plant height, tillers with spike, number of florets in second head, weight of full grains, number of half-filled grains in the main head, weight of half-filled grains, number of half-filled grains in the second head, weight of half-filled grains of the second head and yield per plant. Between lines was non-significant for all these characters in the saline environment except plant height, weight of half-filled grains of the main head, number of full grains in the second head, weight of full grains and yield per plant.

In the less saline environment, the Between Years item was highly significant for tillers with spike, number of florets in the second head, number of full grains in the main head, weight of half-filled grains of the main head, number of full grains in the second head, weight of half-filled grains of the second head and yield per plant. Between lines item was significant for all these characters plant height, number of florets in the main head, number of full grains in the main head, number of full grains in the second head, weight of full grains of the second head, weight of half-filled grains of the second head and yield per plant.

Table 3.32 Results Analysis of Variance for harvest time characters of wheat accession over two years in saline and less saline environments.

Characters	Items	Saline				Less-Saline			
		DF	SS	MS	F	DF	SS	MS	F
PH	Between years	1	245.70	245.70	14.77**	1	17.39	17.36	1.08^{NS}
	Between lines	7	150.23	21.46	7.18**	7	106.27	15.18	2.64**
	Y X L	7	116.42	16.63	5.56**	7	112.49	16.07	2.79**
	Error	304	908.62	2.99		304	1744.98	5.74	
TS	Between years	1	2.72	2.72	45.33**	1	5.76	5.76	52.36**
	Between lines	7	0.18	0.026	0.52^{NS}	7	0.29	0.04	0.67^{NS}
	Y X L	7	0.42	0.06	1.20^{NS}	7	0.77	0.11	1.83^{NS}
	Error	304	14.85	0.05		304	17.92	0.02	
NFM	Between years	1	0.55	0.55	1.62^{NS}	1	0.001	0.001	0.002^{NS}
	Between lines	7	4.26	0.61	1.22^{NS}	7	9.920	1.42	3.38**
	Y X L	7	2.41	0.34	0.68^{NS}	7	3.770	0.53	1.26^{NS}
	Error	304	153.19	0.50		304	129.07	0.42	
NFS	Between years	1	7.43	7.43	22.51**	1	43.89	43.89	51.03**
	Between lines	7	7.16	1.02	0.57^{NS}	7	11.52	1.64	0.82^{NS}
	Y X L	7	2.33	0.33	0.18^{NS}	7	6.00	0.86	0.4^{NS}
	Error	304	543.26	1.79		304	607.75	1.99	
NFGM	Between years	1	7.02	7.02	1.33^{NS}	1	149.15	149.15	31.07**
	Between lines	7	53.30	7.61	1.78^{NS}	7	378.06	54.01	37.77**
	Y X L	7	36.89	5.27	1.23^{NS}	7	33.64	4.80	3.36**
	Error	304	1297.86	4.27		304	435.46	1.43	
WFGM	Between years	1	0.85	0.85	28.33**	1	0.01	0.01	0.077^{NS}
	Between lines	7	0.12	0.017	0.85^{NS}	7	2.54	0.36	0.95^{NS}
	Y X L	7	0.21	0.03	1.50^{NS}	7	0.91	0.13	0.34^{NS}
	Error	304	4.67	0.02		304	3.46	0.38	
NHGM	Between years	1	15.60	15.60	15.44**	1	0.62	0.62	3.26^{NS}
	Between lines	7	5.49	0.78	1.26^{NS}	7	1.80	0.26	1.30^{NS}
	Y X L	7	7.06	1.01	1.63^{NS}	7	1.36	0.19	0.95^{NS}
	Error	304	188.57	0.62		304	60.79	0.20	

Continued....

Table 3.32 (Continued)

Results Analysis of Variance for harvest time characters of wheat accession over two years in saline and less saline environments.

WHGM	Between years	1	0.002	0.002	14.28**	1	0.0010	0.001	35.71**
	Between lines	7	0.002	0.00028	2.80**	7	0.0008	0.00011	1.10^{NS}
	Y X L	7	0.001	0.00014	1.4^{NS}	7	0.0002	0.000028	0.28^{NS}
	Error	304	0.045	0.0001		304	0.019	0.0001	
NFGS	Between years	1	0.15	0.15	0.008^{NS}	1	409.56	409.56	15.74**
	Between lines	7	118.25	16.89	2.97**	7	194.63	27.80	4.46**
	Y X L	7	129.05	18.43	3.24**	7	182.1	26.01	4.17**
	Error	304	1729.81	5.69		304	1984.94	6.23	
WFGS	Between years	1	0.15	0.15	5.36^{NS}	1	0.05	0.05	1.06^{NS}
	Between lines	7	0.15	0.021	2.10*	7	0.43	0.06	3.00**
	Y X L	7	0.20	0.028	2.80*	7	0.33	0.047	2.35*
	Error	304	4.54	0.01		304	7.27	0.02	
NHGS	Between years	1	17.71	17.71	45.41**	1	1.18	1.18	3.93^{NS}
	Between lines	7	3.24	0.46	1.48^{NS}	7	2.32	0.33	1.32^{NS}
	Y X L	7	2.72	0.39	1.26^{NS}	7	2.1	0.30	1.20^{NS}
	Error	304	95.54	0.31		304	76.54	0.25	
WHGS	Between years	1	0.005	0.005	17.86**	1	0.001	0.001	35.71**
	Between lines	7	0.003	0.00043	0.04^{NS}	7	0.0008	0.00011	18.33**
	Y X L	7	0.002	0.00028	0.03^{NS}	7	0.0002	0.000028	4.67**
	Error	304	4.03	0.01		304	0.002		
YPP	Between years	1	1.87	1.87	8.5*	1	11.73	11.73	28.61**
	Between lines	7	2.29	0.32	4.00**	7	6.19	0.88	9.78**
	Y X L	7	1.59	0.22	2.75**	7	2.91	0.41	4.55**
	Error	304	25.53	0.08		304	28.38	0.09	

*,** indicate significance at 5% and 1 % level respectively. NS = Non significant

3.33 The performance of wheat varieties in the BARI campus of Satkhira Mean and variance of harvest time characters of the 12 varieties at BARI Satkhira campus are given Table 3.30

3.33.1 Plant height (PH)

Mean value for plant height at harvest time was between 87.1 cm to 98.42 cm. the variety BAW 680 had the highest PH and BAW 1051 had the lowest value, respectively.

Satabdi, BAW 1059, 1064, 1103, 1111 V-01078 and Prodip were short (87 cm to 92 cm) and BAW 980, 1103, 1104, 1114 and Garuda were tall (93cm to 98cm).

3.33.2 Tiller with Spike (TS)

BAW 1059 had the highest number (2.9) tillers whereas BAW 1104 had the lowest number of tillers, (1.9). Satabdi, BAW 680, 1051, 1064, 1111, 1114, Prodip and Garuda had low TS (1.9 to 2.4) whereas (VO1078, BAW 1103 had high number TS (2.5 to 2.9) when the 12 entries were grouped into two.

3.33.3. Number of Florets in the Main Head (NFM)

Average number of florets ranged from 15.3 to 20.7; BAW 1104 had the highest NFM and BAW 1111 had the lowest value, respectively. Satabdi, BAW 680, 1051, 1064, 1103, 1114, V-01078, and Garuda had low florets (15 to 17) and BAW 1059, Prodip had high florets.

3.33.4 Number of Florets in the Second Head (NFS)

BAW 1059 had the highest mean value 14.8 and BAW 1111 had the lowest mean value, varieties BAW 680, 1103, 1104 and Prodip had low number florets (9.0 to 11.00) whereas Satabdi, BAW 1051, 1064, 1114, V-01078, and Garuda had high number (12.00 to 14.00) florets.

3.33.5 Number of Full Grains in the Main Head (NFGM)

A range of 38.80 to 55.00 was observed for the number of full grains in the main heads. Garuda had the highest NFG and BAW 1103 had the lowest value respectively. Satabdi, V-01078, BAW 1103, 1111 had fewer full grains (38.00 to 43.00), but BAW 1051, 1059, 1104, 1114 Prodip had medium number of full grains (44.00 to 49.00) BAW 680, 1064 and Garuda had more full grains (50.00 to 55.00).

3.33.6 Weight of full grains of the main head (WFGM)

The entry BAW 1104 had the highest weight of full grains of the main head (3.42 gm), and BAW 1103 had the lowest value (2.14gm) respectively. Satabdi, BAW 680, 1051, 1059, 1111, V-01078 and Garuda had low grain weight (2.17 gm to 2.78 gm) and BAW 1064, 1114 and Prodip had high (2.79gm to 3.43) weight of full grains.

3.33.7 Number of half-filled grains in the main head (NHGM)

The entry V-01078 had the highest mean value of number of half-filled grains in the main head (6.8) and Prodip had the lowest value of half-filled grains (0.4), respectively. Satabdi, V-01078, BAW 1051 and Garuda had high number half-filled grains. BAW 680, 1064, 1103 had intermediate and BAW 1059, 1104, 1111, 1114, Prodip had low number of half-filled grains.

3.33.8 Weight of half-filled grains of the main head (WHGM)

The lowest value for weight of half-filled grains was 0.0082 gm exhibited by Prodip, and Satabdi had the highest value of 0.14 gm. V-01078, BAW 1051 also had high weight of half-filled grains of the main head.

3.33.9 Number full grains in the second head (NFGS)

Mean value ranging from 19.6 to 34.4 was observed for full grains in the second head, and Garuda had the highest mean value, while V-01078 had the lowest, respectively. Satabdi, BAW 680, 1051, 1059, Prodip, BAW-1103, 1104, 111 had low number of full grains (19.6 to 27.50) and BAW 1064, 1114 had high number of full grains (27.6 to 34.5).

3.33.10 Weight of full grains of the second Heads (WFGS)

The entry, BAW 1059 had the highest weight of full grains and V-01078 had the lowest value, whale and the range was 1.04gm to 1.83gm. Satabdi, BAW-680, 1051, 1103, 1111, Prodip had low full grain weight (1.04 gm to 1.43 gm) and BAW 1064, 1104, 1114 and Garuda had high full grain weight (1.44 gm to 1.83 gm).

3.33.11 Number of half-filled grains in the second head (NHGS)

The lowest value of number of half-filled grains was 0.3 and the highest mean value was 6.6. V-01078 had the highest value and BAW 1059 and Prodip had the lowest mean value of number of half-filled grains respectively.

Satabdi, BAW 1051, BAW 680 and Garuda had high half-filled grains.

3.33.12 Weight of half-filled grains of the second heads (WHGS)

The lowest value weight of half-filled grains was 0.005 gm and the highest mean value was 0.07gm. The highest mean value was for V-01078 and the lowest for Prodip respectively.

3.33.13 Yield per plant (YPP)

The best performing entry BAW 1059 had the highest yield per plant (5.4 gm). Another good performer BAW 1064 had the second highest (5.00 gm) and BAW 1111 had the lowest value (3.45gm).

Table 3.33 Mean value and variance (in parenthesis) of harvest time characters of 12 varieties grown in the BARI, Satkhira campus.

	Characters							
Variety	PH	TS	NFM	NFS	NFGM	WFGM (gm)	NHGM	WHGM (gm)
SATABDI	92.98 (25.43)	2.2 (0.36)	16.7 (4.01)	12.1 (20.09)	43.7 (46.61)	2.42 (0.07)	6.7 (16.21)	0.14 (0.01)
BAW 1104	96.96 (7.71)	1.9 (0.29)	20.7 (1.41)	11.1 (55.49)	49.7 (64.41)	3.42 (0.51)	0.8 (1.16)	0.02 (5.27^{-04})
BAW 1059	92.94 (19.59)	2.9 (0.29)	18.5 (1.05)	14.8 (0.56)	46.5 (26.85)	2.73 (0.19)	0.9 (0.69)	0.02 (3.26)
BAW 1064	91.16 (28.93)	2.3 (0.21)	16.7 (2.21)	14.2 (2.96)	52.6 (40.24)	3.09 (0.19)	1.6 (1.44)	0.04 (8.1^{-04})
BAW 1114	94.98 (11.39)	2.2 (0.16)	16.6 (0.84)	13.2 (3.36)	47.5 (9.65)	2.93 (0.26)	0.6 (0.84)	0.01 (3.37^{-04})
V 01078	89.81 (38.74)	2.6 (0.64)	16.5 (1.85)	12.7 (1.21)	41.7 (25.41)	2.57 (0.16)	6.8 (15.96)	0.10 (4.14^{-03})
BAW 1051	87.10 (22.39)	2.10 (0.29)	17.6 (1.44)	12.3 (19.21)	48.6 (71.64)	2.66 (0.21)	5.5 (17.25)	0.10 (4.7^{-03})
PRODIP	91.7 (34.02)	2.0 (0.4)	18.1 (0.69)	11.6 (34.84)	47.8 (43.56)	3.10 (0.18)	0.4 (0.24)	8.2^{-03} (1.0^{-04})
BAW 1111	92.58 (18.41)	2.3 (0.41)	15.3 (0.61)	9.6 (10.84)	43.6 (40.64)	2.46 (0.07)	0.9 (1.09)	0.02 (3.6^{-04})
BAW 680	98.42 (16.13)	2.4 (0.44)	17.9 (1.29)	11.5 (21.45)	54.3 (12.81)	2.71 (0.08)	1.7 (1.01)	0.03 (2.8^{-04})
BAW 1103	91.73 (13.76)	2.5 (0.45)	15.9 (1.49)	11.4 (2.44)	38.8 (19.56)	2.14 (0.03)	2.1 (1.29)	0.04 (2.85^{-04})
GARUDA	94.66 (5.91)	2.4 (0.24)	16.0 (0.6)	12.5 (2.05)	55.0 (28.0)	2.62 (0.03)	3.5 (1.85)	0.06 (4.94^{-04})

Continued...

Table 3.33 (Continued)

Mean value and variance (in parenthesis) of harvest time characters of 12 varieties grown in the BARI, Satkhira campus.

Variety	NFGS	WFGS (gm)	NHGS	WHGS (gm)	YPP (gm)
SATABDI	24.4 (104.84)	1.37 (0.32)	2.9 (5.89)	0.05 (1.92)	3.86 (0.49)
BAW 1104	25.7 (200.61)	1.52 (0.69)	1.8 (12.16)	0.04 (4.4^{-03})	4.20 (0.56)
BAW 1059	27.5 (73.05)	1.83 (0.13)	0.3 (0.21)	5.7^{-03} (7.6^{-05})	5.40 (1.65)
BAW 1064	33.0 (48.2)	1.82 (0.11)	1.5 (2.25)	0.03 (1.34^{-03})	5.00 (2.05)
BAW 1114	29.5 (50.45)	1.74 (0.17)	1.1 (1.09)	0.02 (4.85^{-04})	4.20 (0.68)
V 01078	19.6 (56.04)	1.04	6.6 (20.84)	0.07 (1.63^{-03})	4.40 (4.4)
BAW 1051	26.8 (100.76)	1.38 (0.29)	2.5 (6.05)	0.04 (1.3^{-03})	4.00 (0.50)
PRODIP	22.0 (138.0)	1.26 (0.52)	0.3 (0.41)	5.5^{-03} (1.3^{-04})	3.98 (0.91)
BAW 1111	19.7 (64.61)	1.13 (0.24)	1.6 (0.84)	0.03 (3.01^{-04})	3.45 (0.57)
BAW 680	23.1 (93.49)	1.07 (0.24)	3.0 (7.4)	0.06 (3.6^{-03})	4.00 (1.10)
BAW 1103	24.5 (25.85)	1.33 (0.12)	1.7 (1.61)	0.03 (4.3^{-04})	3.46 (0.52)
GARUDA	34.4 (34.24)	1.53 (0.13)	2.4 (1.04)	0.04 (2.96^{-04})	4.20 (0.33)

3.34 Correlation Analysis

The correlation co-efficient was calculated for different pairs of characters using Accession means of plants grown in the saline and less-saline soils, and are presented in Tables 3.34, 3.35, 3.36, 3.37

3.34.1 Results of correlation analysis on pair-wise Accession mean grown in Saline and less-saline soils (1st year)

Among 3-week characters, fresh weight showed positive significant correlation for the Modern Varieties (Table 3.34). But the dry weight showed for the farmers' collection showed negative significant correlation.

For the 7 weeks data, plant height showed positive significant correlation for Modern Varieties.

For heading time characters, plant height was positively correlated among the Accession means in saline and less-saline environment for the Modern Varieties. Largest leaf area was also positively correlated for farmers' collection in saline and less-saline data.

For Modern Varieties only plant height was positive correlated at heading time. Largest leaf area showed positive correlation for farmers collections.

For harvest time data, number of full grains in the main head showed significant positive correlation for farmers' collection while number of full grains in the second head, weight of full grains of the second head and yield per plant was positively correlated for farmers' collections only.

Table 3.34 Correlation coefficients of several pair wise Accession means of saline and less-saline data are presented in Table 3.34 (first year).

Period	Saline vs less-saline means of characters	Modern Varieties	Farmers Collection
3 Weeks	PH vs PH	-0.20^{NS}	-0.58^{NS}
	NL vs NL	0.02^{NS}	0.25^{NS}
	FW vs FW	0.96**	0.44^{NS}
	DW vs DW	0.43^{NS}	-0.69*
7 Weeks	PH vs PH	0.61*	0.29^{NS}
	NT vs NT	-0.26	-0.15^{NS}
	NL vs NL	-0.41^{NS}	-0.052^{NS}
Heading time	PH vs PH	0.64*	0.31^{NS}
	LLA vs LLA	-0.035^{NS}	0.82**
	FLA vs FLA	0.59^{NS}	0.58^{NS}
Harvest time	PH vs PH	0.98**	0.97**
	TS vs TS	0.14^{NS}	0.17^{NS}
	NFM vs NFM	0.16^{NS}	-0.43^{NS}
	NFS vs NFS	0.26^{NS}	-0.30^{NS}
	NFGM vs NFGM	-0.098^{NS}	0.69*
	WFGM vs WGFM	0.19^{NS}	0.58^{NS}
	NHGM vs NHGM	0.53^{NS}	0.46^{NS}
	WHGM vs WHGM	-0.014^{NS}	-0.08^{NS}
	NFGS vs NFGS	-0.093^{NS}	0.68**
	WFGS vs WFGS	-0.12^{NS}	0.66**
	NHGS vs NHGS	0.32^{NS}	0.18^{NS}
	WHGS vs WHGS	0.08^{NS}	-0.33^{NS}
	YPP vs YPP	0.27^{NS}	0.84**

*,** Indicate Significance at 5% and 1% level respectively. NS = Non-significant.

3.35 Correlation between pair-wise combination of different characters from Accessions grown in saline and less-saline soils

For Modern Varieties plant height showed positive correlation for both in saline and less-saline environment.

In less-saline environment the Modern Varieties for BARI and farmers' collections fertile tillers (tiller with spike) was positively correlated with yield per plant, but in the saline area, only positive correlation existed for Modern Varieties.

Number of florets in the main head was positively correlated with yield per plant only for Modern Varieties in the less-saline soil. For both Modern and farmers' collections, number of full grains was positively correlated with yield per plant in saline environment. On the other hand, positive correlation existed only for farmers collections in the less-saline environment.

For farmers' collections, weight of full grains in the main head was significantly positive correlated with yield in the both saline and less-saline soil.

Significant correlation was also observed between number of florets in the main head and number of florets in the second head.

Table 3.35 Correlation coefficients between pair wise combination of different character for Modern Varieties and farmers' collections for first year.

Character Combination	Modern Varieties	Farmers' Collection
FLA vs YPP in saline soil	-0.19^{NS}	0.13^{NS}
FLA vs YPP in less-saline soil	0.33^{NS}	0.30^{NS}
PH(Heading vs PH (Harvest) in saline soil	0.66*	0.42^{NS}
PH(Heading vs PH (Harvest) in less-saline soil	0.78**	0.53^{NS}
PH (Harvest) vs YPP in saline soil	0.12^{NS}	0.42^{NS}
PH (Harvest) vs YPP in less-saline soil	0.58^{NS}	0.53^{NS}
TS vs YPP in saline soil	0.82**	0.49^{NS}
TS vs YPP in less-saline soil	0.74**	0.96**
NFM vs YPP in saline soil	0.12^{NS}	0.09^{NS}
NFM vs YPP in less-saline soil	0.84**	0.36^{NS}
NFGM vs YPP in saline soil	0.64*	0.87**
NFGM vs YPP in less-saline soil	0.58	0.75**
WFGM vs YPP in saline soil	0.61*	0.81**
WFGM vs YPP in less-saline soil	0.59^{NS}	0.75*
NFM vs NFGM in saline soil	0.12^{NS}	-0.7^{NS}
NFM vs NFGM in less-saline soil	0.55^{NS}	0.39^{NS}
NFM vs NFS in saline soil	0.43^{NS}	0.37^{NS}
NFM vs NFS in less-saline soil	0.22^{NS}	0.71**
NHGS vs WHGS in saline soil	0.57^{NS}	0.97**
NHGS vs WHGS in less-saline soil	0.82*	0.91**

*, ** Indicate Significance at 5% and 1% level respectively. NS = Non-significant.

3.36 Correlation coefficient between pair-wise combination of different characters scored from plants grown in saline and less-saline soil for the second year

The correlation coefficients are given in Table 3.36

No significant correlation was observed between the saline and less-saline environment except for flag leaf area. Flag leaf area showed negative correlation, opposite relation of FLA in saline and less-saline soil.

Table 3.36 Correlation coefficient of pair-wise data saline vs less-saline soil combinations.

Character	Saline vs less-saline	Correlation coefficient
3 Weeks	PH vs PH	0.36^{NS}
	NL vs NL	0.38^{NS}
	FW vs FW	0.003^{NS}
	DW vs DW	-0.38^{NS}
7 Weeks	PH vs PH	0.54^{NS}
	NL vs NL	-0.26^{NS}
	NT vs NT	-0.11^{NS}
Heading time	PH vs PH	0.53^{NS}
	NT vs NT	-0.06^{NS}
	NL vs NL	0.19^{NS}
	LLA vs LLA	-0.53^{NS}
	FLA vs FLA	-0.78*
Harvest time	PH vs PH	0.12^{NS}
	TS vs TS	0.32^{NS}
	NFM vs NFM	0.02^{NS}
	NFS vs NFS	-0.58^{NS}
	NFGM vs NFGM	0.21^{NS}
	WFGM vs WFGM	0.36^{NS}
	NHGM vs NHGM	-0.24^{NS}
	WHGM vs WHGM	-0.32^{NS}
	NFGS vs NFGS	0.025^{NS}
	WFGS vs WFGS	0.28^{NS}
	NHGS vs NHGS	0.13^{NS}
	WHGS vs WHGS	-0.09^{NS}
	YPP vs YPP	0.58^{NS}

*, ** Indicate Significance at 5% and 1% level respectively. NS = Non-significant.

3.37 Association between different agronomic characters in saline and less-saline soils

The correlation coefficients are given in Table 3.37

Significant positive correlation was observed between flag leaf area and yield in saline area but not for less-saline soils. Plant height heading time showed positive correlation with plant height at harvest in the saline area.

Positive correlation was observed between tiller with spike (TS) and yield per plant, (YPP). Also positive correlation between number of florets in the main head and yield per plant was found in the saline environment.

In less-saline environment, number of full grains in the main heads was positively correlated with yield per plant. Weight of full grain of the main head showed positive correlation with yield per plant in the saline and less-saline environment.

Table 3.37 Correlation coefficient between pair-wise combination of different characters of Accessions grown in saline and less-saline soils.

Character Combination	Correlation coefficient
FLA vs YPP in saline soil	0.75*
FLA vs YPP in less-saline soil	-0.02^{NS}
PH(Heading) vs PH (Harvest) in saline soil	0.72*
PH(Heading) vs PH (Harvest) in less-saline soil	0.08^{NS}
PH (Harvest) vs YPP in saline soil	0.32^{NS}
PH (Harvest) vs YPP in less-saline soil	-0.14^{NS}
TS vs YPP in saline soil	0.70*
TS vs YPP in less-saline soil	0.33^{NS}
NFM vs YPP in saline soil	0.71*
NFM vs YPP in less-saline soil	0.45^{NS}
NFGM vs YPP in saline soil	0.26^{NS}
NFGM vs YPP in less-saline soil	0.88**
WFGM vs YPP in saline soil	0.74*
WFGM vs YPP in less-saline soil	0.79*
NFM vs NFGM in saline soil	-0.19^{NS}
NFM vs NFGM in less-saline soil	0.25^{NS}
NFM vs NFS in saline soil	0.34^{NS}
NFM vs NFS in less-saline soil	0.10^{NS}
NHGS vs WHGS in saline soil	0.13
NHGS vs WHGS in less-saline soil	0.94**

*, ** Indicate Significance at 5% and 1% level respectively. NS = Non-significant.

3.38 Results of data collected on days to Heading and Maturity of wheat Accession grown in the saline and less-saline soil for two years

In the saline soils, the Accessions A_1, A_2, A_6, flowered in 55 days after sowing, A_3, A_7 and A_9 took 57 days, whereas A_4, A_5, A_8 and A_{10} flowered 56, 59, 58 and 54 days respectively. A_5 took the highest number of days for flowering and A_{10} took the lowest, Varieties grown in the saline area.

In the less-saline area, A_4 flowered 55 days after sowing and A_5 flowered after 66 days. Accession A_2, A_6, A_7, A_8, took 63 days, A_3 and A_9 65 days, A_1 59 days and A_{10} 64 days to heading.

For the Local Farmers' collections, in the saline area, Accession A_{11} flowered early, only in 52 days whereas A_{17} and A_{18} flowered in 59 days after sowing and A_{12}, $A_{15.}$ A_{16} required 58 days.

During the second year in the saline environment, Accessions A_5, A_6, A_{14} flowered within 56 days, A_8, A_{10} and A_{17} needed 58 days whereas A_1 took 57 days and A_{16} took 60 days.

In the less-saline area, Accessions A_5, A_6, A_8, A_{17} 60 days, A_{10}, A_{14} and A_{16} required 63 days and A_1 took 61 days to heading.

A_{10} took the shortest time to mature (94 days) in the saline environment and 101 days in the less-saline environment, A_6, A_8 and A_{16} required 96 days to mature while for A_1, A_5 A_{14} and A_{17} needed 96 to 100 days in the saline environment.

In the less-saline environment, Accessions A_1, A_6 took 103 days to mature. A_{16} needed the shortest time (99 days) to mature, A_5 and A_{14} matured within 102 days whereas 100 days was needed for A_{17}.

Table 3.38 Days to Heading of wheat varieties grown in saline and less-saline soils during first year

Source	Variety	Saline	Less-saline
Modern Varieties	A_1	55	59
	A_2	55	63
	A_3	57	65
	A_4	56	55
	A_5	59	66
	A_6	55	63
	A_7	57	63
	A_8	58	63
	A_9	57	65
	A_{10}	54	64
	$\overline{X}$	56.4	62
Farmers' collection	A_{11}	52	64
	A_{12}	58	65
	A_{13}	57	64
	A_{14}	57	64
	A_{15}	58	64
	A_{16}	58	62
	A_{17}	59	63
	A_{18}	59	62
	$\overline{X}$	57.25	63.5

Table 3.39 The days to heading and maturity for wheat varieties grown in saline and less-saline soils during the second years

Accessions	Days to heading		Days to maturity	
	Saline	Less-saline	Saline	Less-saline
A_1 (Aghrani)	57	61	100	103
A_5 (Satabdi)	56	60	98	102
A_6 (Protiva)	56	60	96	103
A_8 (Gourab)	58	60	96	103
A_{10} (Barkat)	58	63	94	101
A_{14}	56	63	95	102
A_{16}	60	63	96	99
A_{17}	58	60	97	100
$\bar{X}$	57.37	61.25	96.5	101.67

3.40 Salinity index

The effect of salinity was measured in terms of character scores in more saline and less saline fields expressed, the important results were as follows:

Plant height reduced by 30%, 16% and 20% during 3 week, 7 weeks and heading and 14 % at harvesting, number of tillers by 14 % at 7 weeks, leaf area and flag leaf area, 45 and 31 % during heading, other characters were not much affected.

Leaf number was reduced by 23 %, fresh weight and dry weight were reduced by 40% and 25 % at 3 weeks.

During harvest, most drastically affected characters were number and weight of full grains in the main head were reduced by 10% and 21 %, number of full grains in second head by 12%, and yield was reduced by 15%. On the contrary, the number of half filled grains were increased by 99% due to salinity.

Chapter Four

Follow up study on selected Lines during 2010-2011

Follow up study on the selected lines during 2010-2011

4.1 Introduction

The wheat lines which performed better in saline environments were reported in the previous Chapters. A set of the selected lines were handed over to the Bangladesh Agricultural Research Institute (BARI) Satkhira, station for further trial. The Accessions delivered were A1 A5 A8 A10 A14 and A16. The results of the field trial is given in this Chapter. It is expected that the results will provide further information about the salinity tolerance of the material. Also a sample of bulked seeds from these Accessions were given to local farmer who will plant these in the salinity affected fields for three years keeping seeds every time. These seeds will be collected after three years and another trial will be planned.

4.2 Materials and Methods

The six Accessions were the materials, sown in rows in a plot for the trail, the soil of the BARI site was tested for salinity (Table 6.1). Ten randomly selected plants belonging to each Accession were used for collecting maturity time data on the following characters:

(i) Plant height was measured from the base to the tip of the plant in cm (PH)

(ii) Total number of tiller were counted (NT)

(iii) Number of spikes per square meter were counted (NS)

(iv) Length of main head was measured in cm (LMH)

(v) Number of florets in the main head were counted. (NFM)

(vi) Number of full grains in the main head were counted. (NFGM)

(vii) The weight of full grains of the main head were measured in gm after sun drying with an electric balance. (WFGM)

(viii) Grain yield per plot were measured in kg (GY)

(ix) Grain yield per ha were calculated by measuring grain yield per plot (GY/ha)

(x) Straw yield per plot were measured in kg (SY)

(xi) Weight of 1000 grains were measured in gm (Wt. of 1000 grains)

The methods used for field preparation and data collection are already described in Chapter 3. A light irrigation was applied during the booting stage, which was the standard procedure in the Research Station.

Table 4.1 Results of salinity test made in 2010-11 in RARI Station, Satkhira

Stage of the Crop	Soil conductivity (dS)
Sowing stage	9.28
Germination stage	9.47
Seedling stage	11.31
Vegetative stage	12.18
Booting stage	9.45 (Irrigation was applied)
Panicle stage	10.87
Milking stage	11.20
Maturity stage	13.41
Harvesting stage	14.36

4.3 Results

4.3.1 Soil salinity

The salinity of the soil in the BARI Satkhira Station was higher than the site of the original experiments (dS 5.3 to 8.2 in 2010). This higher levels may represent an increasing trend in the salinity build up in the entire area as the salinity levels determined in the years , for example, mean surface soil salinity was 8.5 in April 2009, 8.6 during 2010.

4.3.2 Crop duration

The crop required 55 to 64 days to head and 101 to 107 days to mature (Table 6.2). The time required for the crop to mature is comparable to the other years (2009, 2010) with same material was 56 to 58 days for heading and 94 to 100 days for maturing (Section 3.38 and Table 3.39).

Table 4.2 Days to heading and total life cycle of 6 Accessions (2010-11 data in BARI trial)

Accessions	Days to heading	Total life cycle
A1	55	103
A5	62	105
A8	57	101
A10	57	101
A14	64	107
A16	64	107

4.3.3 Morphological and yield characters

The performance of the morphological characters scored by the BARI researchers were obtained and are summarized in Table 6.3. For plant height, number of tillers, number of florets and grains of the main head the means were between 79cm to 90cm, 7-8, 15 to 18 and 49 to 55 respectively. These averages are comparable with the performance of the Accessions in saline soils observed in the main experiments (Section 3.23). Grain yield per plant varied between 2.08 to 2.54 gm (Table 6.3), this range is lower than the second year range for this character in the main experiment (2.73 to 3.76 gm).

The estimates for other yield parameters are rough because of the small plot size but indicate an economically acceptable performance.

The Accession A_{10} had highest number of grains and highest yield per plant indicating its superiority in performing in the saline environment, it was the best performer in both saline and less saline soils in the second year (Table 3.24).

Table 4.2 Mean and Variance in [parentheses] of harvest time characters of 6 Accessions of wheat in 2010-11 trial in BARI

Accessions	PH (cm)	NT	NS / sq.m	LMH (cm)	NFM	NFGM	WFGM (gm)	GY/ Plot (kg)	GY/ ha (mt)	SY/ Plot (kg)	Wt. of1000 grains (gm)
A1 mean variance	87 (40.70)	7 (6.69)	574	9 (1.20)	18 (2.24)	55 (20.16)	2.30 (0.09)	0.62	3.10	0.67	41.42 (0.34)
A5 mean variance	85 (22.89)	7 (4.00)	644	10 (1.09)	17 (3.36)	50 (30.24)	2.39 (0.890	0.70	3.50	0.74	47.85 (0.16)
A8 mean variance	79 (32.20)	7 (4.69)	567	11 (0.49)	15 (2.44)	49 (32.04)	2.33 (0.02)	0.65	3.25	0.68	47.50 (0.56)
A10 mean variance	90 (29.45)	7 (7.49)	602	10 (1.01)	18 (3.20)	54 (28.80)	2.54 (0.04)	0.62	3.10	0.69	46.98 (0.83)
A14 mean variance	85 (53.49)	8 (3.81)	648	10 (0.76)	17 (4.16)	52 (37.44)	2.08 (0.06)	0.42	2.10	0.75	40.02 (0.63)
A16 mean variance	84 (52.25)	7 (4.89)	595	10 (1.36)	18 (3.84)	53 (34.56)	2.11 (0.03)	0.40	2.00	0.60	39.83 (0.22)

Chapter Five

Discussion

DISCUSSION

5.1 Salinity the problem and response of wheat in the experimental fields

Among the major factors reducing plant growth and productivity worldwide, salinity is one affecting about 7% of the world's total land area (Flowers et al. 1997). The percentage of cultivated land affected by salt is even greater, include more than 23% of the cultivated land , furthermore, there is also a dangerous trend of a 10% per year increase in the saline area throughout the world (Ponnamieruma,1984). About 2.8 million hectares of land of Bangladesh are reported to be salt affected (Karim et al, 1982), which is about one-fifth of the total cultivable land of the country. The experimental fields involved in this study showed clear difference between the more saline and less-saline areas in the level of salinity, during the whole year there was a 2 to 3 fold difference. The surface soil was more saline than sub-surface soil, the level of salinity was low (2.2 to 2.6 dS) and remained more or less same all over the wheat season (November to April) in the less saline area but it was high (6 to 8 dS) and varied with time in the more saline area, increasing during the dry months (March/April). High salinity (with an ECe > 5 dS) was usually known to affect crops severely (Richards (1983). The weather data during the experimental period indicated almost no rainfall during the crop season (November to April) during both years thus the salinity was less varying and not minimized.

It was noted that genes for salinity tolerance with small effects may be present in improved varieties and local farmers land races (Erdei and Trivedi, 1989; Salam, 1993; Ashraf and McNeilly, 1988; Rashid, 1986;

Singh et al., 1988; Ahsan 1996). The present research was undertaken of find out genetic variation for salinity tolerance through screening a large number of modern varieties and local farmers' collection through phenotypic performance of quantitative characters. It has also been suggested that genes operate at different physiological and phenological stages for salinity tolerance (Evans et al., 1975; Kirby, 1988; Friend, 1965, Langer and Ampong, 1970; Halse and Weir, 1974; Frank et al., 1987).

That the variation in the saline condition in the study was effective in influencing the growth and productivity of wheat has been indicated by the changed performance of all of studied traits. Data showed that most of the characters like plant height, fresh and dry weight, leaf area, flag leaf area, number of fertile tiller, number of spikelet per spike, grain per spike, weight grain per plant, grain weight and yield per plant were reduced by salinity and wide phenotypic differences were observed for most of these components. A number of studies on salinity tolerance of wheat reported similar character response under salinity stress (Akram et al. 2002, El-Hendawya et al. 2005, Kamkar et al. 2004)

Therefore, it can be accepted that the experimental set up satisfied the basic need of the research, provision of salinity differences necessary for expression of salinity tolerance in the material. This is expected to help to identify the growth stage when productivity is most limited by salinity, assess whether this can be overcome by agronomic or other means (eg. cultural) and to develop a procedure to screen at this stage, related as closely as possible to the prevailing field conditions. The 10 wheat varieties cultivated in the southern districts of Bangladesh along the coast of the Bay of Bengal released by BARI were collected and eight collections were made from Shymnagar Upzila through local farmers of Satkhira district known to have high salinity.

Two experimental sites were selected one of Ishwaripur of Shymnagar Upzila which is known as high salinity affected zone and another at Alipur of Satkhira sadar which is likely to be less salinity affected. Experimental measurements of soil salinity at different times of the two sites demonstrated that Ishwaripur in fact had more salinity (7.55 to 10.12 dS/m) and Alipur less salinity (3.2 to 4.2 dS/m) in the surface soil.

5.2 Efficiency of the screening method

A number of factors may be responsible for the low success in improving salt tolerance of wheat genotypes like (1) lack of effective evaluation methods for salt tolerance to screen the genotypes in breeding programs, (2) low selection efficiency using overall agronomic parameters, and (3) a complex phenomenon involving morphological, physiological and biochemical parameters among genotypes (Zeng et al., 2002). Compared with conventional techniques that score and rank salt tolerance genotypes based on single parameter, some success has already been realized by using multiple agronomic parameters simultaneously at different growth stages (Shannon, 1997; Zeng et al., 2002). Because there is variation of salt tolerance among the agronomical parameters and also among the different growth stages for wheat plants, the sensitive parameters, which can be single or multiple parameters, must be identified at different growth stages

As reported by Mass and Grieve (1994) salt tolerance of crops may vary with their growth stage, especially, cereals are the most sensitive to salinity during their vegetative (juvenile) and early reproductive stages, and less sensitive during flowering and grain filling stages (Mass and Poss, 1989) information at one stage may not be efficient. Also, a difference may occur in the salt tolerance among genotypes at different growth stages, Kingsbury and Epstein (1984) found that individual lines of spring wheat showed differing tolerance during their life cycle. This indicates that the salt tolerance of different wheat genotypes should be evaluated at different growth stages. As salt tolerance of wheat is known to change with growth stage. Identifying the multiple parameters associated with salt tolerance during different growth stages is important for evaluating wheat genotypes and improving their salt tolerance. It is known that due to the problems of field screening, much of the research on salt tolerance has been carried out in controlled environments. In this screening a fairly uniform field was used with to have reduced error variation, increased detection of varietal differences, and to cope with the heterogeneity of salinity, if any. The phenotypic expression of various quantitative characters were scored at different stages of crop growth to include widest possible salinity response. All the characters expressed indication of salinity stress when the character performance were compared between the two sites, differing in salinity levels. It has been known to the plant breeders that seed yield is a complex trait depending on a large number of morpho-physiological characters. The expression of the relevant genes and development of these characters occur at different phenological stages (Evans et al., 1975; Kirby, 1988). As salinity levels in saline soil changes with time due to evapo-transpiration the effect of salinity differs affecting these characters expressing at different times and sensitive at different stages to this stress. So, stress due to salinity can affect the characters and seed yield depending on the effectiveness of the stress (Friend 1965; Langer and Ampong, 1970; Halse and Weir, 1974; and Frank et al., 1987).

Therefore, genetic differences between the Accessions in response to salinity and developmental variation on effectiveness of the stress makes the situation complicated. Experiments and breeds should consider this aspect of this issue.

Hence, we deliberately included modern varieties developed and released by BARI and grown in the southern regional station for years and the local farmers collection (of uncertain origin) to minimize the genotype-environmental interaction and effect of heterogeneous collection of genotypes complicating the morpho-physiological expression apart from the factor of our interest, salinity stress. In general, the present results indicated that performance of all characters, at every stage, were reduced in the more saline soil condition. However, all the varieties and collections did not respond equally to this salinity stress, some were more susceptible to salinity stress while others were less susceptible. Thus, variation in tolerance to salinity stress has been successfully demonstrated and it is indicated that genotypes are likely to be more tolerant to salinity stress.

Taking these points into account, the present study involved a large number of juvenile, heading and harvest time characters, in all 24 quantitative traits (plant height, leaf number, leaf area, fresh weight, dry weight, tiller number, flag leaf area, spikelet number, grain number, grain weight and yield per plant) to measure the response to salinity of a large number of genotypes (18 Accessions) from the elite varieties and collections from farmer's fields.

5.3 Response of juvenile morphological characters to salinity

Vegetative growth of wheat plants is characterized by leaf appearance and the tillering, accompanied by growth on the tillers. At the vegetative growth stage, therefore, the three agronomic parameters (i.e. leaf number, tiller number and leaf area per plant) were used to detect the impact of salinity. Other juvenile characters scored were plant height, leaf area, fresh and dry weight measured at three and seven weeks after emergence.

A summary table given below gives the phenotypic expression which indicate positive response under salinity stress eg. indicate tolerance to salinity. The direction of phenotype likely to response to salinity stress positively, thus contributing to better yield or indicate by '+' but not so were indicated by '-'. The three week characters were not considered as salinity stress was not operative at the early stage.

PH	Plant height	Tall (-)	Short (+)	Medium (+)
NL_7	Number of leaves at 7 weeks	high+	low-	
NT_H	Number of tillers at heading	high+	low-	
LLA	Largest leaf area	high+	low-	medium +
FLA	Flag leaf area	high+	low-	medium +
TS	Tiller with spike	high+	low-	
NFM	Number of florets in the main head	high+	low-	
NFS	Number of florets in the second head	high+	low-	
NFGM	Number of full grains in the main head	high+	low-	
WFGM	Weight of full grains in the main head	high+	low-	
NFGS	Number of full grains in the second head	high+	low-	medium+
WFGS	Weight of full grains in the second head	high+	low-	
NHGM	Number of half filled grains in the main head	high-	low+	medium-
NHGS	Number of half filled grains in the second head,	high-	low+	medium-
YPP	Yield per plant	high+	low-	

Using yield as the final indicator of enhanced performance under salinity stress three HYV wheat varieties A_1 A_6 & A_8 were identified as better yielding while the three lowest yielder, A_2, A_3 & A_4 were poor performer. The difference between the better and poorer performing varieties regarding yield was statistically significant (t=5.15, df=38, p=***).

When the phenotypic expression of these better and poor performing varieties were tabulated and compared following above concept, it was demonstrated that the direction of expression of these characters agree with the yield performance (table below).

Summary table of modern varieties in the saline soil during the first year.

Characters	**High yield Accessions**			**Low yield Accessions**		
	A_1	**A_6**	**A_8**	**A_2**	**A_3**	**A_4**
ypp	high	high	high	low	low	low
PH	medium	short	tall	short	tall	short
NL_7	high	high	high	high	low	low
NT_H	high	high	high	high	low	low
LLA	low	medium	low	low	low	low
FLA	low	low	low	medium	medium	medium
TS	high	high	high	low	low	low
NFM	high	high	high	low	low	high
NFS	high	high	high	high	low	low
NFGM	high	high	high	low	low	high
WFGM	high	high	low	low	low	high
NFGS	low	high	medium	medium	medium	low
WFGS	medium	high	low	low	low	high
NHGM	high	low	low	low	low	low
NHGS	low	medium	medium	medium	medium	high
Total traits showing tolerance	11	13	9	7	3	7

Similar comparison of the performance of the 10 varieties in less salinity infested area indicated that four varieties (A_5, A_7, A_8 & A_{10}) gave higher yield whereas, other four (A_1, A_2, A_4 & A_9) performed poor in the less-saline soils(table below)

Summary Table of modern varieties in less-saline area during the 1st year

Characters	**High yield Accessions**				**Low yield Accessions**			
	A_5	A_7	A_8	A_{10}	A_1	A_2	A_4	A_9
ypp	high	high	high	high	low	low	low	low
PH	tall	medium	tall	medium	medium	short	short	tall
NL_7	low	high	high	low	high	low	high	high
NT_H	high	low	high	low	low	low	low	low
LLA	Medium	low	low	low	low	low	medium	high
FLA	high	medium	low	high	medium	low	medium	high
TS	high	high	high	low	low	low	low	high
NFM	high	high	low	low	low	low	low	low
NFS	high	low	low	high	high	low	low	low
NFGM	high	high	high	high	low	low	low	low
WFGM	high	high	low	high	low	low	low	low
NFGS	high	low	medium	high	low	low	low	low
WFGS	high	low	medium	high	medium	low	low	medium
NHGM	low	low	low	low	low	low	high	high
NHGS	medium	medium	low	high	medium	low	medium	low
Total traits showing tolerance	12	9	9	9	6	3	4	6

On the average, during both the experiments, plant height was reduced by 27 to 30 percent, leaf number by about 25 %, tiller by 14 to 36 %, fresh and dry weight by 30 to 40 % during the vegetative period. As detected from the heading time data, both area of the largest leaf and the flag leaf were reduced by 52 % and 50% during the first year and by 45 % and

31% during the second year, while tiller number was reduced by 36 % and 6% during the first and second years respectively. In a trial of thirteen wheat genotypes from Egypt, Germany, Australia and India, El-Hendawya (2005) reported significant decrease of tiller number, leaf number and leaf area at vegetative stage with increasing salinity.

The effect of salinity on tiller number and spikelet number, which both initiate during early growth stages, are known to have a greater influence on final grain yield than on yield components in the later stages (Mass et al., 1983; Mass and Poss, 1989). In fact, results indicated that on the average, grain yield was reduced by 29.3 and 15.0 % in the two years, the number and weight of full grains in the main head were reduced by 23.5 and 33.0 % respectively. El-Hendawya (2005) reported that spikelet number on the main stem decreased much more with salinity than spike length, grain number and 1000-grain weight at maturity. Another character detected contributing to low yield in saline environment was the increase in the number (and weight) of half-filled grains (by 150 to 200%). In saline condition, more in the second and to lesser extent in the main head, many grains were half-filled eg were failing to develop due to stress, thus reducing yield.

As wheat breeding efforts mainly target improving the grain yield, so the evaluation of final grain yield and growth parameters determining grain yield are important. Grain yield of wheat is known to be determined by the yield components like number of spikes per plant, spikelet number, grain number and grain weight. Again, the number of spikes is highly correlated with the number of tillers.

These results indicated a fairly strong negative impact on the vegetative characters, the impact on yield characters and the responses of the different genotypes, are now followed to see the response to salinity.

5.4 Accessions responding to salinity showing tolerance

One of the purpose of this study is to use the character responses to evaluate genotypes for salt tolerance and understand the mechanism of this tolerance. The general trend was, the values of the agronomic characters decreased with increasing salinity. However, salt tolerant genotypes were less sensitive for number of tillers, like in the First year experiment, A1 and A10 having similar number of tillers both in the saline and less saline soils, while sensitive genotypes like A3 and A5 showed a greater reduction in tiller number (e.g. by about 35%) than tolerant ones (e.g.by about 6.1%). The yield reductions were 11% (A1) and 36% (A10) for the tolerant and 41% and 54% for the sensitive Accessions for the First year experiment. The ranks of yield were little changed during the Second year experiment, Accessions A10 and A1were both top ranking in saline and less saline environments. The results also show a wide variation among genotypes. The study of El-Hendawya (2005) reported that grain yield per plant was reduced by an average 22% for the most tolerant genotypes, whereas it was reduced by an average 61% for the least tolerant genotypes .

As reported by Steppuhn et al., (2005) salinity affect more tiller number than leaf number or leaf areas which was also observed in these experiments. Tiller number at seven weeks and harvest low in 10 out of 16 comparisons and 8 out of 16 in reportedly. Whereas largest leaf area was low in 6 out of 16 comparisons in the saline sail both years considered together. They also reported that spikelet number of the main tillers was decreased with salinity, in the present experiment number of tiller was lowered in 10 out of 16 comparison during harvest. Number of spike bearing tiller was affected, 8 were lowered

This may indicate that tiller number and their behavior under salinity can be used as a simple and non-destructive measurement to evaluate wheat genotypes in breeding programs. Nicolas et al. (1994) found that salt stress during tiller emergence can inhibit their formation and can cause their abortion at later stages. When salinity levels are greater than 7.5 dSm−1, most of the secondary tillers of moderately tolerant genotypes were eliminated, and the number of primary tillers for salt sensitive wheat genotypes was greatly reduced. Paradkis (1940) found that high-tillering varieties of wheat had greater grain yield on poor soil than low-tillering ones, whereas low-tillering varieties on rich soil produced as much as or more than the high-tillering ones, like Accession A!0 of the present study having only 2 to 3 tillers on all environments but with higher yield. Therefore, increasing the salinity tolerance in wheat may require stability or an increase in the capacity of tillering under stress as stressed by Islam and Sedgley (1981).

Other yield components showed different responses to salinity, for example, number of fertile tiller showed little variation under saline condition, so are the number of fertile florets and fertile grains. But the number of shriveled grains in the main head varied widely, more half-filled grains under salinity (150 to 200 %), indicating failure of these to accumulate enough weight.

It is well documented that salinity affects in the formation and viability of reproductive organs in cereal, reducing the numbers of florets per ear and alters the time of flowering and maturity (Munns and Rawson, 1999). It is known that wheat genotypes respond differentially to salinity, which necessitates the identification of high yielding stable varieties under saline conditions. The agronomic and physiological traits may be important, not only to be used as quick and easy screening criteria if they are closely associated to grain yield (Noble and Rogers, 1992; Munns and James, 2003) but also improves the salt tolerance.

5.5 Diversity in the accessions for salinity response

A very wide differences in response to salinity was observed among the accessions between environments (saline and less saline) and also between years. When considered individual characters the development in either saline or less saline environment resulted in identical phenotypic performance, there being small variation. However, characters like number of leaves, tillers and spikelet per plant were more sensitive at vegetative stage and more varying. This suggested that evaluation for salt tolerance among genotypes can be based on the diversity in tiller and spikelet numbers. When the developmental pattern of genotypes is so different between growth stages, assessment of the actual salt tolerance of the genotypes may be more rewarding on a combination of criterion to evaluate the salt tolerance (Munns et al., 2000).

Salinity stress resulted in over all shortening of the development time by 5 to 6 days and maturing time by 5 days as expected for crops under physiological stress. Also the Accessions exhibited some differences in their response for these characters the better responding genotypes requiring shorter period to mature in salinity affected environment. Apart from the year wise comparison, the saline environment were affected as expected if salinity is a functional stress factor in the experiment. For example the expression of growth characters were rapid in saline soil for example the 10 Modern Varieties flowered early in saline soil ($\overline{X}$ = 56.4 days) whereas in the less-saline soil they flowered about 5 days later ($\overline{X}$ = 62.00 days. These findings are in agreement with Nizamuddin and Marshal (1988) who observed that on an average water deficit significantly accelerate heading by about eight (8) days. Some trend was observed for farmers' collection as well as performances during the second year. Also the half-filled grains and tillers without grains were higher in the salinity soil but characters like number of tillers, fertile tiller, flag leaf area were lowered in saline soil. All other facts confirm that salinity was an effective stress in saline soil here and there is difference in salinity between the two sites not only evident by instrumental measurement but by the characters of wheat.

The results of correlation analyses also suggested characters show different patterns in saline and in less saline environments like Flag Leaf Area and Yield Per Plant showing positive correlation in saline soil but not in less saline soil, likewise plant height at early and harvest stages and tiller per plant with yield showing correlation in saline but not in less saline environments. Thus, association of characters tend to change with stress which indicated that selection on one or few characters, one growth stage or one environment, one or few characters will be difficult. The results in this study indicate that the grouping among genotypes based on characters for salt tolerance based on the different growth stages and years was more close to identifying genotypes for tolerance.

Consistent response to salinity at different growth stages was observed in A10, A1 and A5 from the elite collection and A14 and A17, the characteristics of these genotypes were stable number of tillers, higher grains in the main head and higher grain yield compared with other genotypes.

5.6 Prospect of relay cropping and farmer's selection for salinity tolerance

It is expected that supplement of irrigation water and manures / fertilizers are expected to reduce the negative impacts of salinity, the yield data in BARI Farm trial indicated higher yields (5.4 to 3.5 g per plant) while the tiller number ranged from 1.9 to 2.9. It is usual practice to give irrigation and fertilizers as required but in the present experiment the existing farmers' practices were followed, giving no irrigation and inorganic fertilizers. The data collected from the local farmers' fields also indicated comparable results (number of tillers per plant ranging from 2.2 to 3.3 in saline and 2.8 to 3.8 in less saline, and 2.5 to 4.5 g yield per plant in the saline to 4.1 to 6.3 g in less saline area). These results suggest that the performance in the wheat grown in the farmer's field are not very different in performance and that they may are adjusting to the salinity and drought stresses existing in their environment. This is suggestive to the presence of polygenic variations among these which may serve as a source for salinity tolerance in modern wheat verities (Foster, 1988; Maas and Poss, 1989; Rana, 1986).

The results from the relay cropping experiment also suggest comparable performance for yield components and yield (tillers 3.3 and yield per plant 5.5 g per plant) thus indicating that inter planting of wheat in the rice fields prior to harvest (relay cropping) can be a sustainable solution in salinity prone areas. Because in the dry Rabi season, lack of rainfall and high evapo-transpiration, the soil gets more saline with the mid and end of the season thus wheat facing more stress during the critical grain filling period. Also often due to late withdrawal of monsoon resulting in late harvesting of Aman paddy and time required for land preparation in traditional cropping become the major causes of no wheat crop or very late sowing resulting in low yield in the saline area. It was evident from the discussed so far that for a successful development of salinity tolerant genotype, one must have genetic variation and these are proved to be present in the inter-varietal and intra-varietal wheat lines. (Foster, 1988; Moas and Pan, 1989; Rana, 1986). Other genetic analysis (Kalman and Qualset, 1991; Erdei and Trivedi, 1989; Salam, 1993; Ashraf and Mc. Meilly, 1988; Rashid, 1986; Sing et al., 1988) also indicated inter-variety variation in salinity tolerance. Ahsan, 1996; Ahsan and wright, 1998 demonstrated possibilities of selection within a variety from physiological and genetical analysis.

No selection for salinity tolerant genotypes have to be identified and Mendelian Analysis be done following biometrical tools for identification of genes from segregating generations, Hence, researchers need to focus and there is a large gap in this knowledge of genetic background of salt tolerance. For selection yield is often used for selection of salinity tolerance under salt-stress but this is often unreliable and not repeatable. So, other characters which contribute and influence yield is proved to the helpful. Further research along this line is needed.

5.7 Trial of selected accession in BARI farm and future plan

Salinity is a major problem for expanding crop production and is also an increasing problem in irrigated areas world-wide for salt accumulation in soil. Although much effort has been put into the development of salt-tolerant wheat there has been little impact in farmers' fields. Many efforts have been made to improve salt-tolerance in wheat, but successful results from the laboratory have not yet been translated into the field. For sustainable development, it is important, because breeding crops for improved salt-tolerance and other remedial measures, will enable us to reduce the social and economic disadvantages of the population, particularly the poor and women, of salinity affected areas, and improve living standards and health.

Keeping this in mind the present experiment was planned to conduct selection for salinity tolerance in farmers' field condition in the naturally salinity affected soils in the coastal districts of Bangladesh. It is well known that field experiments in saline soils are made difficult by high spatial and temporal variability which lead to very high environmental components to the variation and make it difficult to detect differences between genotypes. For this, a large number of less heterogeneous genotypes were selected, these crop varieties were known to be grown in the area for a longer period, therefore will be expected to exhibit no other major environmental interactions apart from salinity effects.

The second point is that the seeds of the selected accessions which did exhibit tolerance were handed over to local BARI Farm for cultivation and maintenance for future (described in Chapter 6). The ultimate aim is when enough seed produced a type of 'Farmer-managed trials' with no formal design either within a farm or across farmers will be used to identify farmer-acceptable cultivars, like that of rice and chickpea adopted in India (Joshi and Witcombe1996). It was concluded that the lack of adoption of new cultivars in their case was because resource-poor farmers had not been recommended or exposed to the most appropriate cultivars under the existing variety recommendation and popularization system, and that adoption rates would be improved by increased farmer participation, especially the systematic testing in zonal trials of locally-popular cultivars. This type of more liberal release system, and a more open system of providing seeds of new cultivars to the farmers was also aimed to breed acceptable varieties with the minimum resource use, and to use farmers' knowledge in the breeding programme (Sthapit *et al* 1996).

Conclusion

CONCLUSION

One of the major problems in increasing production of wheat is salinity in the coastal regions, with global climate change this problem will be more acute in future. Although much effort has been paid to develop salinity tolerant wheat, there has been little success as salinity tolerance is likely to be a polygenic trait, its expression is influenced by a diverse genetic, physiological and developmental interaction both in the plants and in the plant-environment interaction. In the present research, attempts made to identify salinity tolerance in cultivars from both elite and farmers' materials (ten high yielding modern varieties, Aghrani, Khanchan, Bejoy, Sufi, Satabdi, Potiva, Akbar, Gourab, Prodip, Barkat, and eight local collections of wheat (*Triticum aestivum* L.) grown in farmer field conditions in the salinity affected coastal area of Bangladesh. Plants identified both from the modern varieties and from farmers' collection which performed significantly better in high salinity soils, indicated by both seed yield and response to the salinity stress by the morpho-physiological characters scored at various developmental stages. The seeds of these accessions exhibiting improved salinity tolerance have been handed over to the local agricultural researchers and identified farmers for further trial, selection and breeding.

Chapter Six

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