COMPARATIVE ECO- PHYSIOLOGY OF TWO CULTIVARS OF WHEAT (*TRITICUM AESTIVUM* CV. BARI 26 AND CV. PRADIP) IN RELATION TO SOIL MOISTURE AND SALINITY

M.Phil. THESIS

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DHAKA-1000, BANGLADESH

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CERTIFICATE

This is to certify that the research work embodying the result of the thesis entitled "COMPARATIVE ECO-PHYSIOLOGY OF TWO CULTIVARS OF WHEAT (*TRITICUM AESTIVUM* CV. BARI 26 AND CV. PRADIP) IN RELATION TO SOIL MOISTURE AND SALINITY" was carried out by the author herself in the Plant Ecology and Environment Laboratory, Department of Botany, University of Dhaka, under my supervision and the style and contents of this thesis is suitable for the fulfillment of The Degree of Master of Philosophy in Botany.

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DEDICATED TO

MY BELOVED PARENTS, HUSBAND AND MY CHILDREN

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SHAMIMA HAFIZ

ABSTRACT

Experiment has been done with two cultivars of wheat cv Bari 24 and Bari 26 in relation to salinity and soil moisture to study the growth, yield and water relations. Salinity experiment was done in the laboratory in Petri dishes. Two cultivars of wheat, *Triticum asetivum* (cv. Bari-24 (Pradip) and cv. Bari- 26) were grown in the different concentrations of sodium chloride solution and the seedling growth was observed. Shoot and root length of the seedlings of both cultivars of wheat showed a significant (P= 0.05) decrease at the highest salinity treatment but at the lowest salinity treatment i.e. at 0.05 M NaCl both shoot and root length increased. It is suggested that the growth of both cultivars of wheat seedling is favoured by low NaCl salinity.

Seeds of two cultivars of *Triticum aestivum* (cv. Bari- 24 and cv. Bari- 26) were grown in the field under wet (watering everyday) and dry (watered once in a week) treatments.

Six harvests were done with an interval of 7 days. Growth analysis from successive harvest of plants showed that early pattern of growth was influenced by moderate restriction in the availability of soil water and was associated with marked shift in the allocation of growth resources in favour of root development.

Plant height, total dry weight, shoot and root dry weight, relative growth rate, and root: shoot ratio were analyzed after every harvest. In wet treatment, the number of lateral roots showed luxurious growth from those of dry treatment. Root and shoot length of both cultivars was significantly (P= 0.05) higher than dry treatment. Apart from total dry weight, the root and shoot dry weights were also higher in wet treatment than that of dry treatment. Relative growth rate (RGR) did not show significant difference between wet and dry treatments. Root/ Shoot ratio of both cultivars in all treatments from 3rd harvest onward showed an increasing tendency.

Spike length and weight were maximum in cv. Bari 24 under wet condition and minimum was in cv. Bari 26. The maximum value of Flag leaf area was found in cv. Bari-26 in wet treatment and lowest was in cv. Bari 24 in dry condition. The area of flag leaf did not show any significant difference (P= 0.05) between the treatments but an increasing tendency of flag leaf area was noted under wet condition.

Tissue water relations in wet and dry treatments were examined in leaf material collected from the field, with a view to obtaining comparative data on the mechanism of adaptation to drought. The relative water content was significantly (P=0.05) lower in cv. Bari 24 under wet condition than dry treatment and was highest in cv. Bari 26 in dry treatment plants. Wet treatment plants showed the maximum rate of loss of water, while dry treatment plants showed the lowest.

The plants of these two cultivars of wheat showed a significant difference in their growth and yield in relation to soil moisture.

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Cultivar Bari-24

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CHAPTER-1

GENERAL INTRODUCTION

To plant life salinity is an inimical factor of the environment. The poor growth of some crop plants in saline condition is a physiological problem of considerable ecological interest and is considered in this investigation in relation to germination, seedling growth; growth measurements and tissue water relation and its ecological significance. At present a substantial amount of information is available about factors responsible for excess of salinity in many parts of the world. Such factors include frequency of tidal inundation; soil characteristics, water table, depth of salt deposit and temperature.

Millions of hectares of lands throughout the world are too saline to produce economic crop yields and more land becomes non-productive each year because of salt accumulation (Waisel 1972). Salinity problems in agriculture are usually confined to arid and semiarid regions where rainfall is not sufficient to transport salts from the plant root zone. Such areas comprise 25% of the earth’s surface (Thorne and Peterson 1954).They also reported that extensive areas are present in Asia. Soil salinity problem also occurs on non-irrigated crop lands (Carter *et al.* 1964). The actual total area of salt affected soils throughout the world is not known. A survey indicated that irrigated area of 103 countries totaled 203 million hectares (Anonymous 1970). If 25% of this land is saline, then there are large areas of salt affected soils. Therefore, the salinity problem in agriculture is extensive and important (Carter 1975).

The total areas in the countries so far mapped, Australia (Northcote and Skene 1972) and Europe (Szaboles 1974) is vast (some 3×10^6 km^2) . While maps of the saline land in the remaining areas of the world have as yet not been completed; estimates indicate there to be at least another million Km^2 (Mudie 1974) without including the areas of many of the major deserts.

Many plant species are sensitive to salinity during germination (Carter 1975). Experiment to see the effect of different concentrations of NaCl salinity on the seedling growth of two cultivars of wheat was done. Saline conditions drastically change the root environment, aeration, and osmotic potential of the soil solution and the normal equilibrium of the dissolved ions. To some extent plants can adapt to the low osmotic potentials prevailing in saline soils by absorbing ions. Although there are multiple salts that constitute salinity, NaCl has been considered as the primary constituent which produces salinity effect (Flower *et al.* 1977) and in the present investigation the work on salinity has been done using NaCl.

The problems of secondary salinization are most serious, it usually represents loss of productive land. For example, in areas such as Punjab in India, 25% of the 51000 Km^2 of agricultural land had been seriously affected by salinity up to 1960, while some 10% had been lost from agriculture and land was going out of use at the rate of 400 Km^2 per year (Raheja 1966). Such losses are due primary to irrigation; water is used during the farming season, and water supplies are often of poor quality. As a result evapo-transpiration leads to the concentration in the soil of salts added during irrigation. Casey (1972) in an extensive review has judged the spread of salinity in irrigated lands to be so severe that he has questioned the long term viability of such irrigated lands. In this context the study of salt tolerance should be considered.

Salinisation of soil is common in arid and semiarid regions where the amount of rainfall is insufficient for substantial leaching. High concentrations of salts have detrimental effects on plant growth (Bernstein 1962, Taiz & Zeiger 2006, Ramoliya *et al*. 2004). Plant species differ in their sensitivity or tolerance to salts (Marschner 1986, 1995). There is evidence that organs, tissues and cells at different developmental stages of plants exhibit varying degrees of tolerance to environmental conditions (Munns 1993). It is reported that soil salinity suppresses shoot growth more than the root growth (Maas & Hoffman 1977; Munns 2002, Ramoliya *et al*. 2004). However, fewer studies on the effect of soil salinity on root growth have been conducted (Munns 2002).

The high salt content lowers osmotic potential of soil water and consequently affects the availability of soil water to plants. The salt-induced water deficit is one of the major constraints for plant growth in saline soils. In addition, many nutrient interactions in salt–stressed plants can occur that may have important consequences for growth. The relationship between micro-nutrient concentrations and soil salinity is rather complex and remain poorly understood (Tozlu *et al.* 2000). An understanding of growth and survival of plants under saline conditions is needed for (i) screening the plant species for the afforestation of saline deserts and (ii) understanding the mechanism that plants use in the avoidance or tolerance of salt stress.

The influence of salinity on germination response was studied in halophytes & non-halophytes (glycophytes) by Rozema (1975). However inhibition of germination by salt could play a decisive role in limiting geographical distribution of a species & determining their position in the vegetation (Waisel 1972).

Toxic effects of certain ions on seed germination and seedling development had been studied by a number of investigators at the beginning of the century. Stewart (1898) and Harris and Pittman (1918) found that chloride salts were most toxic for germination, sulphate less so, and carbonate the least. Harris (1915) found the relative toxicity of soluble salts to be in the following descending order: NaCl, $CaCl_2$, KCl, $MgCl_2$, KNO_3, Mg $(NO_3)_2$, $(Na)SO_4$. He also concluded that salt mixtures were not as toxic in soil as in solution culture.

A similar concentration between the ability to germinate under saline conditions and zonation of plants in a salt marsh was also reported by Unger (1965, 1967b). Seeds of *Limonium vulgare* Milll. and *Limonium humile* Mill. slowly germinated in seawater. However, most of the seeds, which did not germinate in such a medium, rapidly germinated after being transferred to fresh water (Boorman 1968). The same was true for *Puccinellia nuttalliana* (Mack and Ungar 1971).

For optimal growth, *Atriplex halimus* and other halophilic species of *Atriplex* require relatively high concentrations of sodium chloride in the soil or culture medium (Black 1956, 1958; Greenway 1968; Brownell 1965). Brownell and Jackman (1966) and Gale and Poljakoff- Mayber (1970) showed that small quantities of sodium are essential for the growth of some *Atriplex* species.

They showed that the optimal concentration of sodium chloride in the culture solution for growth of *Atriplex halimus* was a function of environmental conditions. The present investigation was an attempt to study the germination and seedling growth of two cultivars of wheat in relation to salinity and is given in **Chapter 2.**

Soil moisture directly influences soil- water relationships, aeration and permeability through its relationship with inter-particle pore space, and the physical conditions have a major influence on the growth of plants. Soil moisture appears to be an important factor in determining time of germination (Ratcliffe 1961 ; Pemadasa and Lovell 1975); survival of seedlings and their dry-matter production (Jones and Etherington 1971); relative growth rate (RGR) and root-shoot ratios (Ashenden *et al.* 1975) and reproductive performance, including number of seeds and seed weight (Newman 1965).

The effect of drying and rewetting the soils plays a major role on the growth, nutrient uptake and distribution of plants (Bannister 1966; Nazrul-Islam 1977). *Erica cinerea* (a dry land species) is restricted to dry mineral soil, whereas *Erica tetralix* (a wetland species) occurs in damp, often waterlogged situation (Bannister 1965, 1966) .The work of Bannister also indicated that there is a fundamental difference in the response of the species of *Erica cinerea* and *Erica tetralix* to soil moisture conditions. When plants grow in waterlogged soil, their roots are in more or less anaerobic condition. Previous work suggests that plant species have very different physiological response to such condition depending on whether they are by nature intolerant or tolerant of flooding.

Several authors have suggested that low water availability promotes earlier flowering. However, Koller (1969) points out that there are no critical observations which support this suggestion. Indeed experiments with annual crop plants (Nicholls and May 1963 ; Salter and Goode 1967; Gates 1968; Husain and Aspinall 1970) showed that the reverse may well apply and moisture stress may, if anything, slightly delay the time of initiation, though a small decrease in time to anthesis has been reported in some cases (Salter and Goode 1967; Slatyer 1973).

In the environment, differences of growth are often related to the differences in water availability. Etherington and Rutter (1964) in an experiment with *Agrostis tenuis* and *Alopecurus pratensis* have shown that a small decrease of soil water around the rooting zone cause a significant reduction of dry matter production during the early part of the growing season. Stanhill (1957) analysed data describing studies of soil water and plant growth; in sixty- six cases growth appeared to be decreased before soil moisture appeared to be reduced to the permanent wilting percentage.

The moisture regimes in different soil types have long been considered as one of the environmental factors limiting plant growth under natural environment. Stocker (1960), Taylor (1960), Etherington (1962) and Slatyer (1967) have shown that plant growth decreased; but corn, pear and lemon plants have shown to respond to differences in moisture well above the so called wilting points. (Aldrich *et al.,* 1935; Davis, 1942; Furr andTaylor, 1959*).*There is evidence that dry matter production increased due to waterlogging in Soyabean plants (Nazrul-Islam *et al.* 1980). In contrast, low moisture was favourable for the growth of tomato plants. (Nazrul –Islam and Roy, 1978).

The distribution of dry matter between root and shoot systems is a process which is strongly influenced by external environmental conditions such as nutritional regime , water regime, light intensity, and temperature (Brouwer 1966), day length (Cris and

Stout 1929; Troughton 1961), root temperature (Davidson 1969) and nature of rooting medium (Hunt and Burnett 1973). More complex conditions such as density of population and volume and nature of rooting medium have strong influences on root/ shoot ratio (Troughton 1956), it was also suggested that a constant functional balance might exist between root and shoot systems despite varying external conditions (Davidson 1969).

Relative growth rate influenced virtually due to the environmental variables (Grime and Hunt 1975; Poorter *et al.* 1990; Poorter and Remkes 1990). In general any departure from an adequate supply of light, mineral nutrients or water or from a suitable temperature regime, or from external toxins, produces a clearly adverse effect on RGR. It might be added that these factors also interact strongly. The fullest examination yet made of the effect of the environment on the RGR of a single species under comparable conditions and has been summarized by Hughes (1965). It appears that information regarding growth response in soils with different moisture regimes is not enough to explain plant growth and distribution. Hence, there is a need to measure the responses of certain plant species over a range of moisture conditions.

The present work was designed to include the growth analysis in two cultivars of wheat subjected to soil moisture regimes (wet and dry conditions) in the field conditions to explain the growth behavior and nature of adaptation. Growth analysis and yield of the two wheat cultivars in relation to soil moisture is given in **Chapter 3** and **Chapter 4** respectively.

The water relation study of a plant explains the understanding of adaptability and survival strategies of any species. It is now realized that the water stress causes physiological and morphological changes in plants. Stocker (1960) mentioned that there should be two main objectives of the water relation study. These are

i) An ecological inquiry into the living conditions in the natural habitats.

ii) A purely eco-physiological inquiry into the changes which cause water deficiency in the structure and function of plants.

These two facts can bring about changes in the protoplasm that may lead into drought resistance capacity.

Tissue takes up water when their water potential is less than that of the environment. Soil moisture stress usually affects plant growth by influencing the water deficits produced in plant tissues. Water deficits in plant tissue influence the growth and hence the ecological response of the plant. In many instances the water relations of the plants are analyzed by measuring relative water content (RWC). Relative water contents of leaves indicate water regime of plants which in turn regulates to a greater extent the eco-physiological activities, transpiration, stomatal aperture and reflect the ability of the plant to take up water under prevailing atmospheric and soil moisture conditions.

There is evidence (Nazrul-Islam 1983) on the importance of water factor in respect of plant distribution of wetland and dry land habitat species and also in crop plants grown under waterlogged and non- waterlogged conditions (Nazrul-Islam and Yasmin 1982; Nazrul-Islam and Alam 1986; Nazrul-Islam 1987).

Tissue –water relations of *Cassia tora* from sun & shade habitat was also reported by Nazrul –Islam. (1987). Bannister (1964) has explained that there is a good correlation between the distribution of species with regard to soil moisture and water relations of the species concerned. Data of Lawson and Jenik (1967) suggested that the transpiration rates measured were influenced more by factors related to water supply.

A consideration of the water loss from cut shoot (Bannister 1964d; Nazrul -Islam 1983) showed that the relative water content at the point of stomatal closure varies both between and within species (Nazrul- Islam and Yasmin 1982). Hygen (1951) had attempted an ecological characterization of plants in terms of their rates of stomatal and cuticular transpiration. From a mathematical analysis of his transpiration curves, Hygen was able to differentiate successfully between the plants, which were considered to be representative of Xeromorphic, Mesomorphic and Hygromorphic types respectively.

Plants react to the inevitable loss of water in a variety of ways and their tolerance and avoidance of water stress is the consequence for both physiological and ecological response. The loss of water from a plant will affect both the uptake of water and the water relations of cells and tissues. Water deficits in plant tissues furthermore affect upon cell expansion (Ordin 1958, Gardner and Nieman 1964), growth (Eaton and Eargle 1948), nitrogen metabolism (Shah and Loomis 1965), production of growth substances (Larson 1964), translocation of materials (Robberts 1964). Such effects influence the growth and hence the ecological response of the plant.

It was shown that plants of open or sun habitat are comparatively xeromorphic (Daubenmire 1959). Okali (1971) also has shown the water relations of some woody species in relation to their distribution in the natural environment. Okali (1971) in his work has paid particular attention to the internal water relations of leaf tissue and to the behavior of stomata under moisture stress. By use of leaves alone, the necessity for assuming differential rates of water supply to plant under comparison can be avoided. The measurements examined were the relation between leaf water content and stomatal closure. The relationship between leaf water content and stomatal aperture was studied. These relationships were also used by Wealtherley and Slatyer (1957); Jarvis and Jarvis (1963a); Bannister (1964 a); Okali (1971) and Nazrul-Islam (1983) to explain the adaptation of plants to drought. Total, stomatal and cuticular rates of transpiration were also calculated to bring the results to a sharper focus.

Transpiration alone gives little indication of the water balance of the plant. To obtain a complete picture, it was therefore, decided to study the two wheat cultivars in relation to the following measurements:

i) The relation between leaf water content and stomatal closure and

ii) The rates of transpiration.

It was expected that an investigation of tissue water relations of two cultivars wheat might show some differences in their physiological behavior which might provide a useful comparison with previous work and ecological information for a comparative study and is included in **Chapter 5.**

CHAPTER -2

SEEDLING GROWTH OF TWO WHEAT CULTIVARS IN RELATION TO SALINITY

2.1 INTRODUCTION

Salinisation of soil is common in arid and semiarid regions where the amount of rainfall is insufficient for substantial leaching. High concentrations of salts have detrimental effect on plant growth (Bernstein 1962, Taiz & Zeiger 2006, Ramoliya *et al*. 2004). Plant species differ in their sensitivity or tolerance to salts (Marschner 1995). There is evidence that organs, tissues and cells at different developmental stages of plants exhibit varying degrees of tolerance to environmental conditions (Munns 1993). It is reported that soil salinity suppresses shoot growth more than the root growth (Maas & Hoffman 1977, Munns 2002, Ramoliya *et al.* 2004). Few studies on the effect of soil salinity on root growth have been conducted (Munns 2002).

The high salt content lowers osmotic potential of soil water and consequently the availability of soil water to plants is decreased. The salt induced water deficit is one of the major constraints for plant growth in saline soils. In addition, many nutrients interactions in salt stressed plants can occur that may have important consequences for growth. An understanding of growth and survival of plants, under saline conditions is needed for (i) Screening the plant species to know the adaptive features and (ii) Understanding the mechanism that plants use in the avoidance and /or tolerance of salt stress.

Growth and development of seedlings of *Abies* and *Tsuga* were studied by Zobel and Antos (1991). Plant growth and survival are related to characteristics of resource allocation, which determines the relative size of shoot vs root and within these structures, the size and three dimensional distribution (i.e. plant architecture) of the resource absorbing surface (Givnish 1987); Hunt & Lloyd 1987; Tilman 1988;

Kuppers 1989). Measurements of whole plant growth rates and allocation can help to resolve such uncertainty, but these require root data, which are difficult to obtain from natural vegetation and are usually available only for plants grown in culture (Hunt & Lloyd 1987).

For optimal growth, *Atriplex halimus* and other halophilic species of *Atriplex* require relatively high concentrations of sodium chloride in soil or culture medium (Black 1956, 1958; Greenway 1968; Brownell 1965). Brownell and Jackman (1966) and Gale and Poljakoff Mayber (1970) showed that small quantities of sodium are essential for the growth of some *Atriplex* species. Agarwal (1957), Ram Deo (1968) studied the salt tolerance of field crops under Indian conditions. Mehrotra and Gangwar (1964) revealed that the crops vary significantly in their salt tolerance.

In Bangladesh, although wheat is cultivated in the coastal regions, the extent of their resistance as well as their ecology and physiology to solutes (especially sodium and chloride) need to be established, Moreover, there is a need to determine the effect of salts on the growth and yield which has received relatively little attention.

The present investigation was an attempt to study the seedling growth of the wheat cultivars (cv. Bari 24 and cv. Bari 26) in relation to salinity to explain the yield and nature of adaptation.

2.2. MATERIALS AND METHODS

Seeds of two cultivars of wheat (cv. Bari 24 and cv Bari 26) were obtained from BARI (Bangladesh Agricultural Research Institute), Gazipur.

Seeds of wheat (cv. Bari-24 and cv. Bari-26) were germinated with different concentrations of Nacl solution (0.05M, 0.1M, 0.2M, 0.4M) to see the effect on seedling growth. Healthy seeds (25 in number) of each species were placed on the moistened filter papers in Petridishes for each NaCl treatment. There were 4 replicates and the petridishes were moistened daily (approximately 2 ml) with the specific NaCl solutions. Seedlings were allowed to grow in the Petridishes for 7 days. A control with 25 healthy seeds was also done simultaneously.

After 7 days of growth 4 seedlings of each species were harvested from each Petri dish. Length of root, shoot and fresh weight of each seedling were taken; then dried in the oven at 80^0C for 24 hours and dry weight was then recorded.

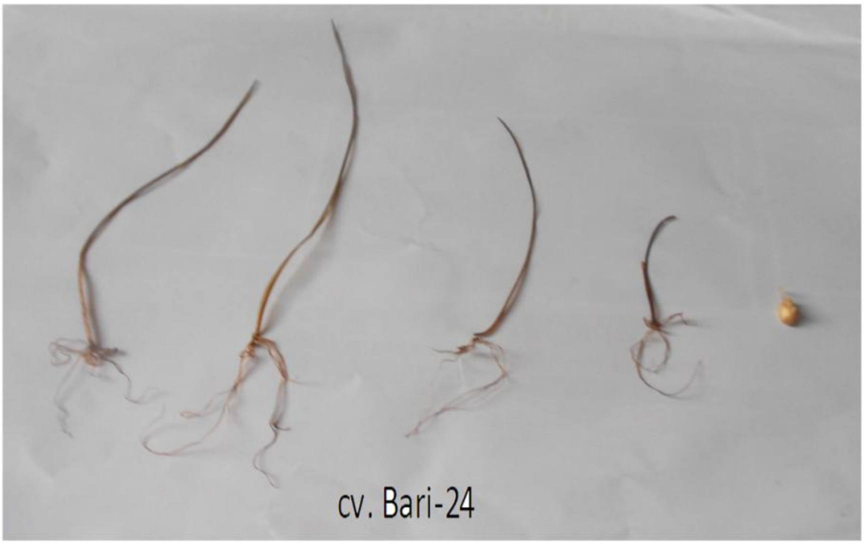


Plate 1: Seedling growth at different concentrations of salinity. Extreme left control then 0.05 M, 0.1 M, 0.2 M and 0.4 M NaCl treatment.

2.3 RESULTS

2.3.1 Seedling growth in relation to salinity

The growth of seedlings of two cultivars of wheat was best in 0.05M, followed by 0.1M, 0.2M and 0.4M NaCl salinity. This result suggested that the growth of seedling was prevented at high levels of NaCl salinity.

The seedling length of cv. Bari 24 was highest (20.48±4.62cm) at salinity 0.05M, which was slightly higher than control (i.e. 18.33±3.37cm). Further increase of salinity to 0.1M, the length of seedling decreased (16.32±1.98 cm). At 0.2M, the length was lowest (9.65±2.47cm) and at 0.4M seeds were germinated only but no growth was observed. (Table 2.1)

In contrast, cultivars Bari-26 showed highest seedling length in control (i.e. 23.07 ±4.13cm) followed by 0.05M NaCl treatment (i.e. 19.70±2.52 cm). With the further increase of salinity to 0.1M, it was decreased to 17.90±0.91 cm, and at 0.2M, it was only 8.47±2.81cm, but no seedling growth was observed at 0.4M. (Table 2.1)

2.3.2 Shoot height and root length

Both cultivars Bari-24 and Bari-26 showed that salinity suppresses shoot growth more than root growth. Cultivar Bari-26 had the highest height of shoot and root in control i.e. 13.65 cm and 9.42 cm respectively. With the increase of salinity, the length of shoot and root was decreased up to 4.32 cm and 4.15 cm at 0.2M. (Fig. 2.1 and 2.2 and 2.3 and Table 2.1)

Cultivars Bari-24 showed the highest length of shoot and root at 0.05M NaCl treatment i.e 13.55 cm and 6.93 cm, respectively. Then with the increase of salinity the shoot and root length gradually decreased.

A tentative order of tolerance of seedling length (shoot and root) in term of salinity in these two cultivars may be arranged as follows:

cv. Bari 26 > cv. Bari 24

The seedling length of cv. Bari-26 in different NaCl concentrations is higher than cv. Bari 24. In spite of these small differences, the results show that both cv. Bari 24 and cv. Bari 26 are sensitive to salinity. The results suggest the limitation of cultivation of these two cultivars in the coastal areas.

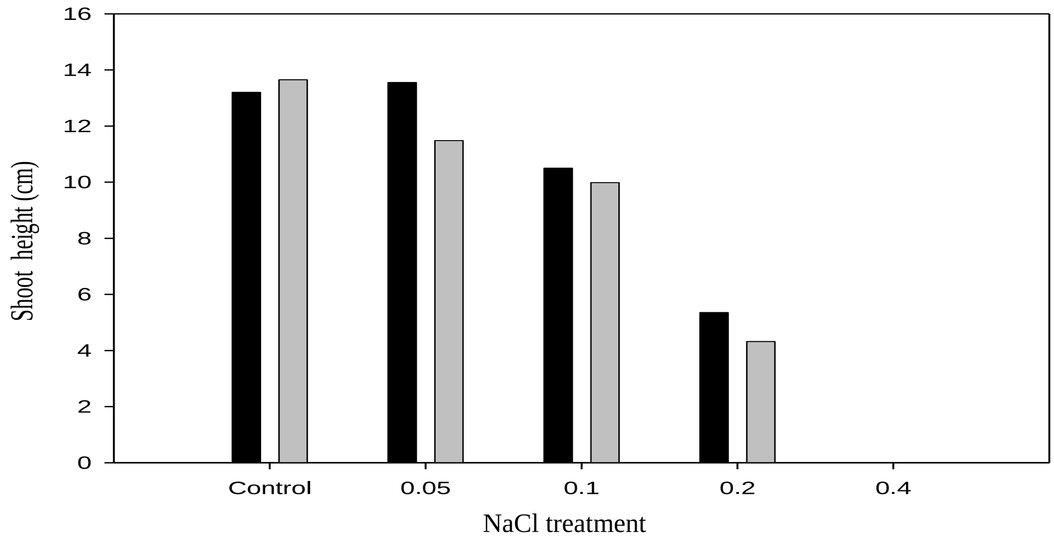


Figure 2.1: Mean value of shoot height of cv. Bari- 24 Black Color ( ) cv. Bari-26 light color ( )

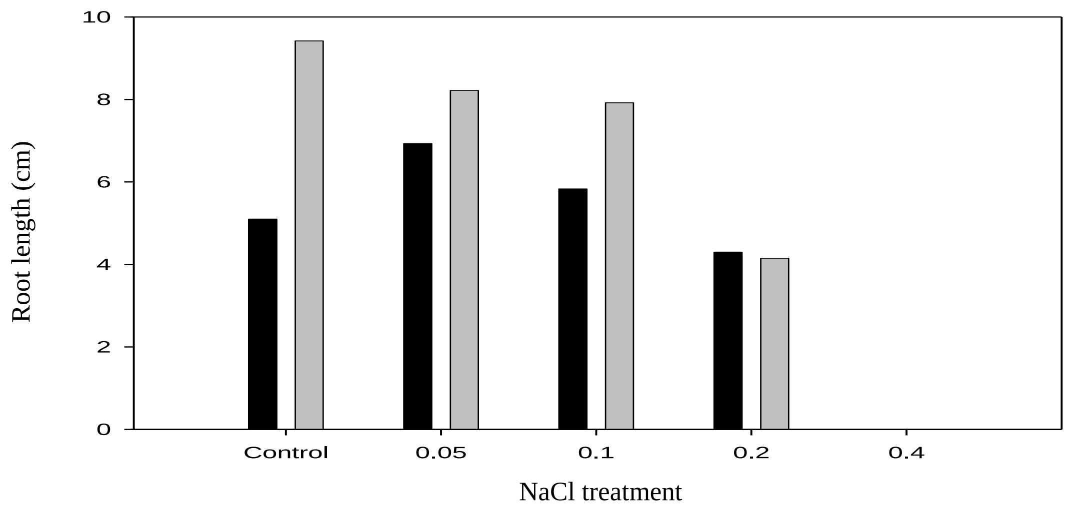


Figure 2.2: Mean value of root length cv. Bari- 24 Black color ( ) & cv. Bari- 26 light color ( )

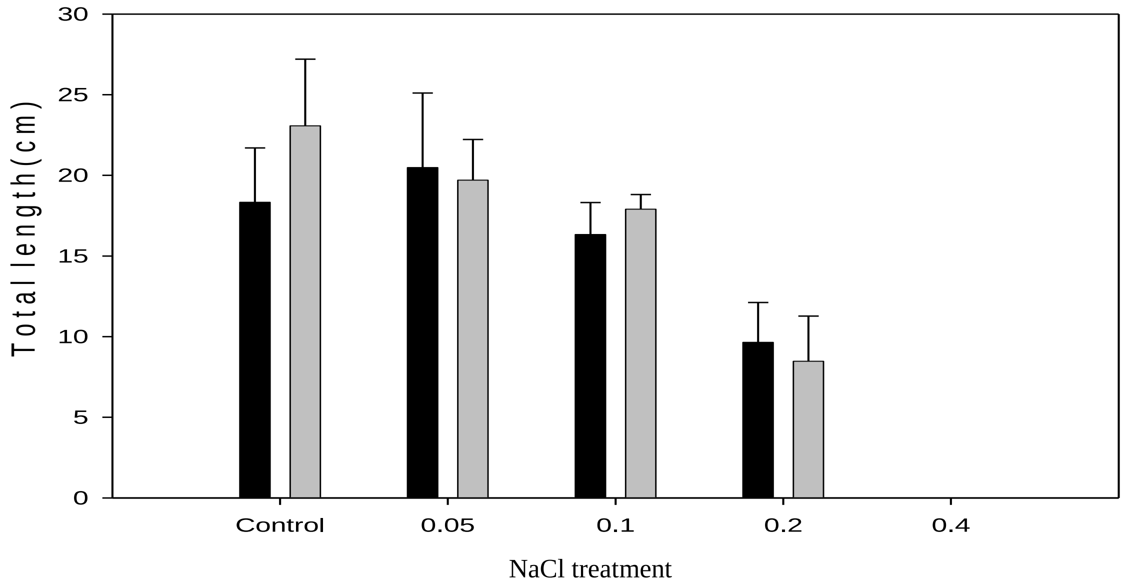


Figure 2.3: Mean value of total seedling length cv. Bari-24 Black color ( ) & cv. Bari- 26 light color ( )

Table-2.1 Mean values for length of seedling, shoot and root length of cv. Bari-24 and cv. Bari-26 at different salinity treatments. 95% confidence limits are also given.

Cultivar	Nacl treatment (Molar)	Shoot height (cm)	Root length (cm)	Total length with 95% confidence limit
Bari-24	Control	13.20	5.10	18.33 ± 3.37
	0.05	13.55	6.93	20.48 ± 4.62
	0.1	10.50	5.83	16.32 ± 1.98
	0.2	5.35	4.30	9.65 ± 2.47
	0.4	-	-	-
Bari-26	Control	13.65	9.42	23.07 ± 4.13
	0.05	11.48	8.22	19.70 ± 2.52
	0.1	9.98	7.92	17.90 ± 0.91
	0.2	4.32	4.15	8.47 ± 2.81
	0.4	-	-	-

2.3.2 Fresh and dry weights of the seedlings in relation to salinity

Fresh and dry weights due to salt treatment although initially showed an increase but with the increase of salinity levels from 0.1M onwards, both cultivars of wheat decreased growth. (Fig. 2.4, 2.5 and 2.6).

These two cultivars of wheat were sensitive to salinity treatment and showed decrease of fresh and dry weights as the salinity levels were increased. There was a significant decrease (P=0.05) of all the measurements (Table-2.2) when concentration of NaCl was increased from 0.1M to 0.2M solution onward.

Cultivar Bari-24 exhibited highest fresh and dry weight at salinity 0.05M, i.e. 143±0.00 mg (F.wt) and 26.75±0.01 mg (D.wt) respectively. Further increase of salinity, these values were gradually decreased to 107.25±0.02mg (F.wt) and 19.75±0.00 mg (D.wt) at 0.1M and showed drastic reduction of fresh and dry weights at 0.2M salinity i.e. 78.70±0.01 mg (F.wt) and 15.00±00.00mg (D.wt) respectively.

Cultivar Bari-26 also showed the highest fresh weight and dry weight at salinity 0.05M i.e. 134.75±0.02 mg (F.wt) and 22.00±0.00 mg (D.wt) respectively. With the increase of salinity to 0.1M these values were decreased i.e. 109.50±0.02mg (F.wt) and 18.75±0.01 mg (D.wt) At 0.2M, the values were lowest and it was 69.70±0.02mg (F.wt) and 12.70±0.00 mg (D.wt).

In case of root dry weight the results were very different with the increase of salinity. There was a significant (P=0.05) reduction of root dry weight in cultivars Bari-26 at 0.2M NaCl than cv. Bari-24.

Both cultivars of wheat (cv. Bari 24 and cv. Bari 26), the maximum value for root/shoot ratio was found in control. But with the increase of NaCl levels, R/S ratio showed a tendency to decrease gradually.

The total dry weight was highest in both cv. Bari-24 and cv. Bari - 26 at 0.05M NaCl treatment and was more than that of control. The increase of total dry weight at 0.05M NaCl was higher in cv. Bari-24 (26.75±0.01 mg) than cv. Bari-26 (22.00±0.00 mg).

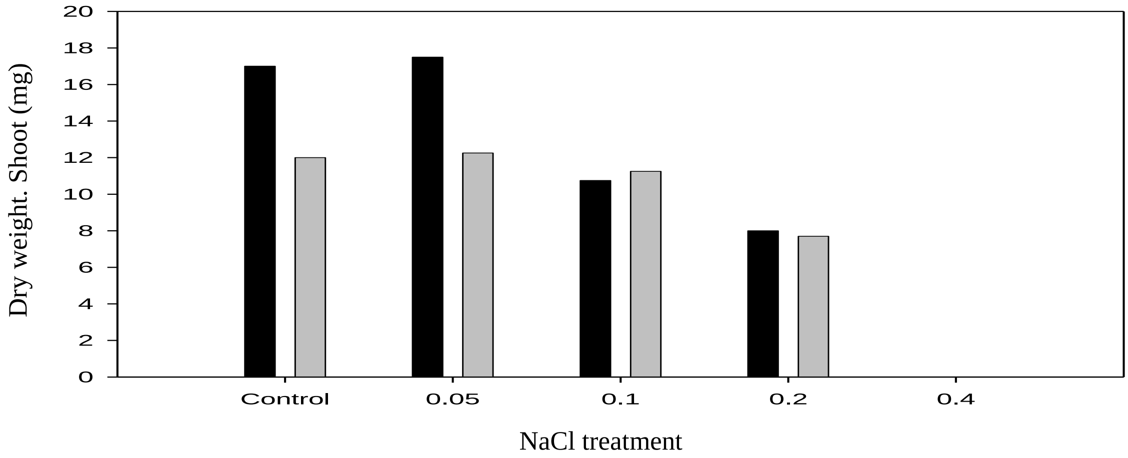


Figure 2.4: Mean value of dry weight of shoot cv. Bari- 24 Black color (▬) cv, Bari- 26 light color (▭)

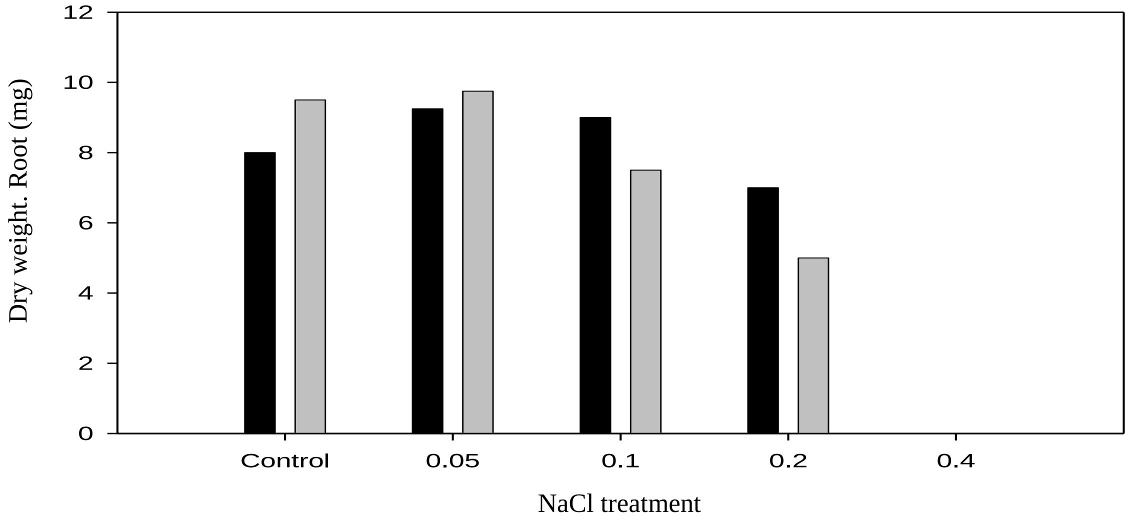


Figure 2.5: Mean value of dry weight of root cv. Bari- 24 Black color (▬) & cv. Bari -26 light color (▭).

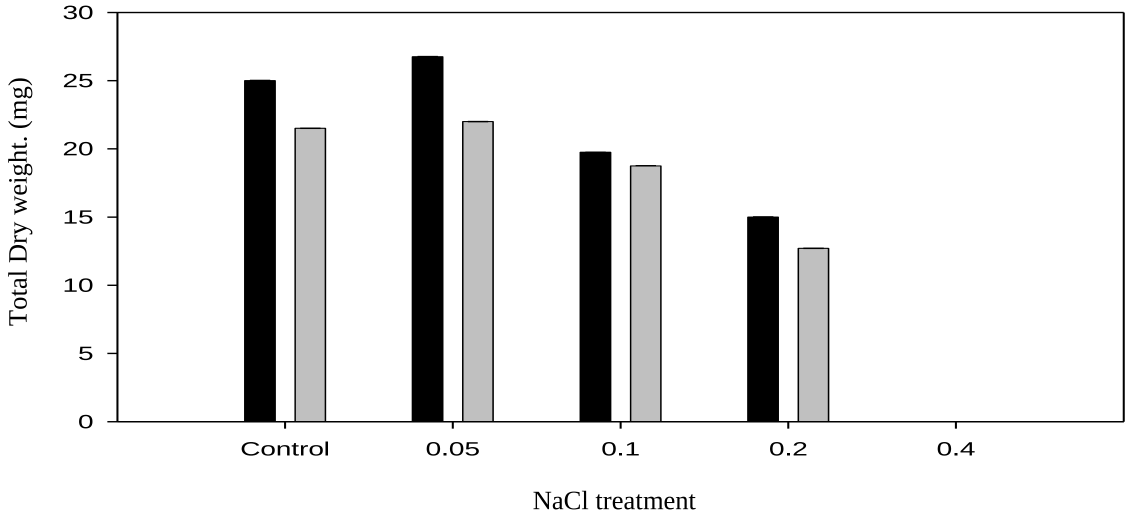


Figure 2.6: Mean value of total dry weight of cv. Bari- 24 Black color ( ) & cv. Bari- 26 light color ( ).

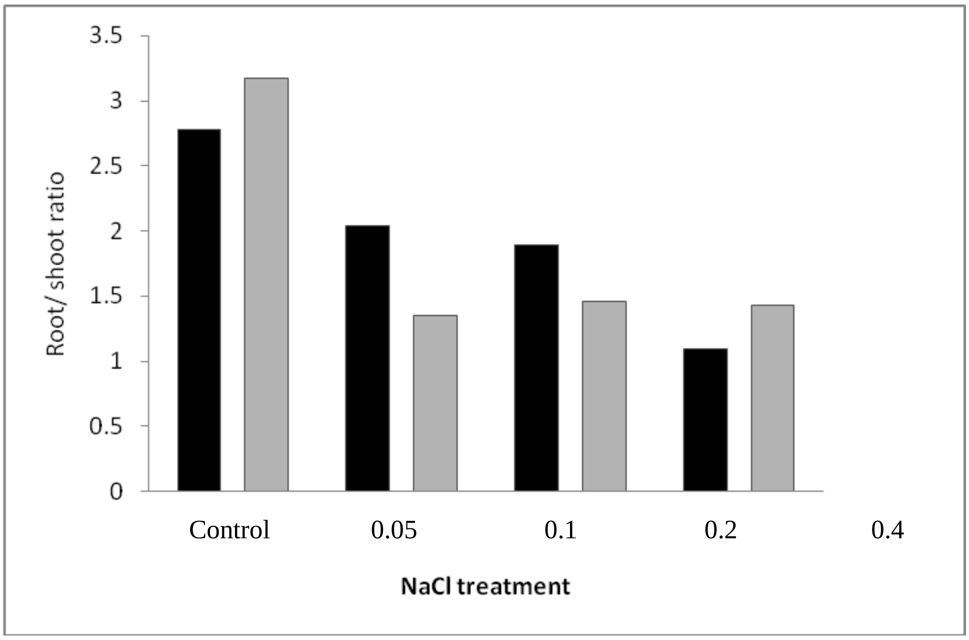


Figure: 2.7 Root shoot ratio of cv. Bari- 24 Black Color ( ) & cv. Bari -26 Light color ( ).

Table 2.2
Fresh and dry weights (mg) of cv. Bari-24 and cv. Bari-26 at different salinity treatments, 95% confidence limits are also given.

Cultivar	NaCl treatment	Fresh weight of Seedlings (mg)		Total fresh weight (mg)	FW/DW	Dry weight of seedling (mg)		Total dry weight (mg)	Root/ Shoot ratio
		Shoot	Root			Shoot	Root		
Bari-24	Control	77.20	27.70	105.00 ± 0.03	4.20	17.00	8.00	25.00 ± 0.01	2.78
	0.05M	96.00	47.00	143.00 ± 0.04	5.35	17.50	9.25	26.75 ± 0.01	2.04
	0.1M	70.00	37.00	107.25 ± 0.02	5.43	10.75	9.00	19.75 ± 0.00	1.89
	0.2M	42.00	36.70	78.70 ± 0.01	5.38	8.00	7.00	15.00 ± 0.00	1.09
	0.4M	-	-	-	-	-	-	-	-
Bari-26	Control	91.00	28.75	119.75 ± 0.03	5.57	12.00	9.50	21.00 ± 0.00	3.17
	0.05M	77.50	57.25	134.75± 0.02	6.125	12.25	9.75	22.00 ± 0.00	1.35
	0.1M	64.50	44.00	109.50 ± 0.02	5.00	11.25	7.50	18.75 ± 0.01	1.46
	0.2M	41.00	28.70	69.70 ± 0.02	5.60	7.70	5.00	12.70 ± 0.00	1.43
	0.4M	-	-	-	-	-	-	-	-

2.4 DISCUSSION

Salinity is a major form of land degradation worldwide (Dudal and Purnell 1986). Growth of plants on salt affected soils may be restricted by salinity (High concentrations of soluble salts). Greenway (1968) with his experiments with *Hordium Vulgaris* to salinity treatments showed the results of growth of leaf, shoot and root separately. In general, NaCl treatment decreased the development of leaves. He has also shown that the uptake of sodium by the leaves was the main factor for the decrease of growth. It was found that cultivars Bari-24 is more sensitive to NaCl treatment than cv. Bari-26.

Throughout the experiment growth of the seedlings of two cultivars of wheat as a whole decreased by sodium chloride treatment.

Optimal shoot growth of *Aster tripholium* occurred when plants were grown in a salt solution. Whereas roots grew best in fresh water (Montfort and Brandrup 1928). An increase in root growth and decrease in shoot growth was obtained under high water stress induced by NaCl, whereas total growth of the plants was reduced (Stocker 1960; and Troughton 1960). Shoot growth of *Aster tripholium* was best in 2% NaCl but roots grew best at only 1% (Bickenbach 1932). In *Atiplex polycarpa*, salinity inhibited shoot growth more than the root growth (Chatterton and Mckell 1969).

In the present experiment with two cultivars of wheal shoot and root length of the seedlings showed a significant (P=0.05) reduction at the highest salinity treatment but at the lowest salinity treatment i.e. at 0.05 M NaCl both shoot and root length increased.

It can be said from the data presented in this investigation that growth of both cultivars of wheat seedling is favoured by low NaCl salinity.

Adverse effect on the growth and development was reported in wheat (Nazrul Islam 1987). However the ability to grow well at low salinity level could be of special ecological advantage.

C H A P T E R- 3

GROWTH ANALYSIS OF TWO WHEAT CULTIVARS IN RELATION TO SOIL MOISTURE

3.1 INTRODUCTION

Soil moisture directly influences soil water relationships, aeration and permeability through its relationship with interparticle pore space, and the physical conditions have a major influence on the nutrition of plants. The effect of drying and rewetting the soils plays a major role on the growth, nutrient uptake and distribution of plants. (Bannister 1966: Nazrul-Islam1977). The work of Bannister (1966) also indicated that there is a fundamental difference in the response of the spceies of *Erica cinerea* and *Erica tetralix* to soil moisture conditions.

In the environment, differences of growth are often related to the differences in water availability, Etherington and Rutter (1964) in an experiment with *Agrostis temuis* and *Alopecurus pratensis* have shown that a small decrease of soil water around the rooting zone caused a significant reduction of dry matter production during the early part of the growing season. Stanhill (1957) analysed data describing studies of soil, water and plant growth; in sixty six cases growth appeared to be decreased before soil moisture appeared to be reduced to the permanent wilting percentage.

The wheat plant is cultivated in the winter season when there is a shortage of moisture in soil and is of great importance to Bangladesh, particularly in high land areas, where the flood water does not reach. Since shortage of moisture in soil affects the growth of plants, it was therefore thought that, extra supply of water may influence the growth and yield of wheat. More over there are also considerable low lying areas in some districts which are inundated by flood and rain water during the monsoon. In these areas wheat is also cultivated where the soil moisture is high.

Selection of some cultivars of wheat, that can tolerate such environmental stress and also give good harvest, is a problem that has to be paid careful attention for ensuring successful cultivation of wheat in these tracts. An optimum amount of water is needed for the better growth and yield of wheat plants. With this view in mind, the study on the effect of moist and dry conditions was undertaken to investigate the growth and yield of wheat plants.

When plants grow in wet soil, their roots are in more or less anaerobic condition. Previous work suggests that plant species have very different physiological response to such condition depending on whether they are by nature intolerant or tolerant of flooding or wet conditions (Crawford and Taylor 1969).

Nazrul – Islam *et al.* (1980) reported that dry matter production increased due to waterlogging in Soyabean plants. In contrast, low moistune was favouravble for the growth of tomato plants (Nazrul-Islam and Roy 1978).

The distribution of dry matter between root and shoot system is a process which is influenced strongly by external environmental conditions such as nutritional regrime, water regrime , light intensity and temperature (Brownell and Jackman 1966), day length (Cris and Stout 1929), Troughton (1961), root temperature (Davidson 1969) and nature of rooting medium (Hunt and Burnett 1973). More complex conditions such as density or population and volume and nature of rooting medium have strong influences on root / shoot ratio (Troughton 1956); it was also suggested that a constant functional balance might exist between root and shoot systems despite varying external conditions (Davidson 1969).

The present work was designed to investigate the vegetative growth of two cultivars of wheat (cv. Bari 24 and cv. Bari-26) subjected to moist and dry conditions in soil.

3.2 MATERIALS AND METHODS

Seeds of two cultivars of wheat *Triticum aestivum* cv. Bari 24 and cv. Bari 26 were obtained from BARI. Gazipur. Viability and germination of seeds were conducted in the laboratory.

The experimental plot was selected in the Botanical Garden of Dhaka University. The experimental plot was divided into sixteen sub plots Fig 3.1. The size of each plot was 70×60 cm. There are three rows in each plot. Soils were broken down by hands to make it free from large particles and made to homogenous. Then the sub plots were marked.

After one week seeds of two cultivars were sown on the plot into three rows. In each row 20 to 25 seeds were sown 1.0 cm below the soil surface and the distance from one seed to another was 1.5 cm and the distance between the rows was 6.0 cm. The experimental design was 2 species × 2 treatments ×4 replicates =16 plots.

Among the sixteen plots, eight (8) plots were selected for cv. Bari 24 and remaining eight (8) plots were for cv. Bari 26. The experiment was set on 05.12.2012. At first plants were allowed to grow for one week with watering everyday. Then among the

16 plots, 8 were treated wet (W) which were watered everyday. The other set was dry (D) and watered once in a week.

Seedlings were allowed to grow for two weeks; and an initial harvest was made at this stage. After the initial harvest the plants were subjected to dry (D) and wet (W) treatments. The plants were harvested after 21, 28, 35, 42, 49 and 56 days. In each harvest 3 to 4 plants were removed from each plot.

After the harvest, the plants were washed free of soil, rinsed with distilled water. Then the height, length and weight of the whole plants were measured. The plants were then dried in an oven at 80^{0}C for 48 hours. Dry weights of the plants were then determined with an electrical balance. Roots were then cut with the scissor and dry weight of the roots and shoots were determined individually. The mean length of the root, shoot height, number of primary and secondary lateral roots of both treatments were measured in every harvest. Root: shoot ratio was also calculated. Plants of the various moisture regime treatments showed variation in dry weight and height.
Relative Growth Rate (RGR) was calculated from the following formula:

$$RGR = \frac{LogeW_2 - LogeW_1}{T_2 - T_1}$$

(Fisher 1921)

Where W_1 and W_2 are the dry weights of the plants of initial (T_1) and next (T_2) harvest.

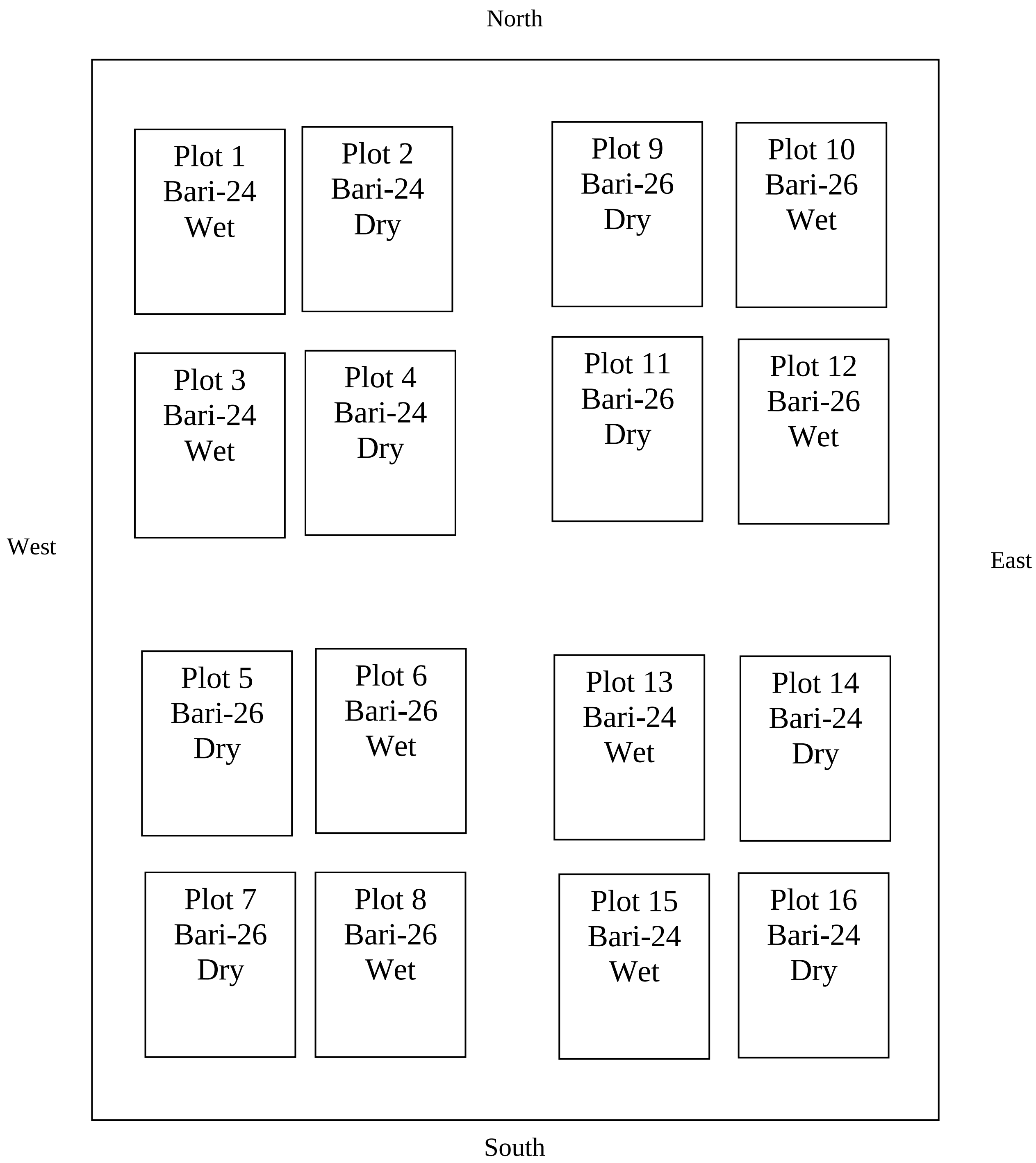


Fig 3.1: Experimental design of the plots in the field. Size of each plot is 70 × 60 cm.

3.3 ENVIRONMENTAL CONDITIONS

The mean temperature and relative humidity (data of meteorological station, Dhaka) were recorded during the experimental period and the mean of every 10 days is given in Table 3.1

There was a tendency to decrease of temperature from December to January and again from the last week of January showed an increasing tendency and maximum temperature was 30.62 ºC in February. The temperature varied from 26 ºC to 30.62 ºC and that of the minimum was in the range of 13 ºC to 16.62 ºC in February. Relative humidity was highest in January 91.33 % in the morning and in December 76.60% in the evening.

Table 3.1: Environmental conditions during the experimental period

Year	Month	Date	Temperature ºC		Relative Humidity (%)	
			Maximum	Minimum	Morning	Evening
2012	December	01-10	26.90	14.10	72.00	66.40
		11-20	26.00	13.00	82.40	76.60
		21-31	26.00	13.00	60.44	52.89
2013	January	01-10	28.00	13.00	85.50	71.90
		11-20	26.90	13.00	91.33	75.78
		21-31	27.90	13.20	68.82	47.27
	February	01-10	28.00	14.00	49.60	35.50
		11-20	28.80	14.90	55.40	41.60
		21-28	30.62	16.62	60.00	49.29

Temperatures and Relative humidity (Dec 2012 – March 2013)

Table- 3.2: Shoot height, root length and total seedling length of two cultivars of wheat at different harvests in relation to water treatments.

Cultivar	Harvest No	Total seedling length (cm)		Shoot height (cm)		Length of Root (cm)	
		Treatments					
		Wet	Dry	Wet	Dry	Wet	Dry
Bari 24	Initial	35.50	35.50	29.87	29.87	5.53	5.53
	1st	39.12	41.05	32.60	34.17	6.52	6.88
	2nd	43.30	42.28	35.90	35.27	7.40	7.01
	3rd	56.38	54.03	46.90	44.90	9.48	9.13
	4th	64.20	60.18	54.12	50.38	10.08	9.80
	5th	89.08	83.40	77.23	72.10	11.85	11.30
	6th	104.55	91.00	88.45	78.65	16.10	12.35
Bari 26	Initial	33.60	33.60	28.20	28.20	5.40	5.40
	1st	39.40	38.20	32.38	31.20	7.02	7.00
	2nd	50.02	48.33	41.37	40.21	8.65	8.12
	3rd	57.38	53.08	45.40	44.28	11.98	8.80
	4th	67.25	66.88	55.03	57.60	12.22	9.28
	5th	87.38	81.03	73.10	71.33	14.28	9.70
	6th	96.75	88.63	81.13	77.93	15.63	10.70

Table- 3.3: Growth characteristics of two cultivars of wheat at different harvests in relation to wet and dry treatments.

Cultivars	Harvest No	Mean dry wt/plant (mg)		Mean dry wt of Shoot/plant (mg)		Mean dry wt of root/plant(mg)		Root/Shoot		RGR Successive mg/g/week	
		Treatments		Treatments		Treatments		Treatments		Treatments	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Bari 24	Initial	87.0	87.0	77.0	77.0	10.0	10.0	0.1298	0.1298		
	1st	195.0	142.5	177.5	132.5	17.5	10.0	0.0985	0.0754	0.115298	0.070490
	2nd	505.0	325.0	470.0	302.5	35.0	22.5	0.0744	0.0743	0.135936	0.117783
	3rd	1062.5	855.0	972.5	792.5	90.0	62.5	0.0925	0.0788	0.106260	0.138182
	4th	1755.0	1130.0	1602.5	1020.0	152.5	110.0	0.0952	0.1078	0.071692	0.039837
	5th	5632.0	5030.0	5010.0	4477.5	597.5	550.0	0.11926	0.1228	0.166489	0.211331
	6th	7930.0	6407.5	6945.0	5492.5	990.0	91.5	0.1425	0.1665	0.048884	0.034578
Bari 26	Initial	90.0	90.0	75.0	75.0	7.5	7.5	0.10	0.10		
	1st	187.5	170.0	177.5	160.0	10.0	10.0	0.0563	0.0625	0.117282	0.103285
	2nd	572.5	392.5	540.0	365.0	32.5	27.5	0.0601	0.0753	0.159461	0.119534
	3rd	1305.0	1072.5	1197.5	970.0	107.5	102.5	0.0897	0.1056	0.117706	0.143601
	4th	2762.5	1920.0	2502.5	1610.0	260.0	185.0	0.1038	0.1149	0.107133	0.083190
	5th	5305.0	4872.0	4495.0	4090.0	560.0	537.5	0.1245	0.1314	0.093216	0.133302
	6th	6887.5	6090.0	5942.5	5002.5	945.0	837.5	0.1590	0.1674	0.037294	0.031731

3. 4 RESULTS AND DISCUSSION

3.4.1 The effect of soil moisture on the morphology and growth

The morphology of the plants was recorded at various harvests. The vegetative growth was vigorous in both water regime treatments in the early stages in both cultivars of wheat, but the time required to reach each particular phase of development was longest at wet treatment and shortest at dry condition.

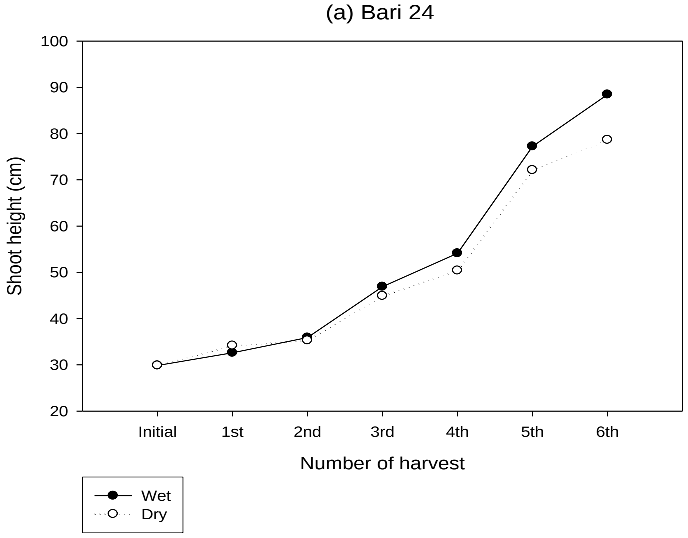
It was found that the plants of wet condition were taller than the plants of dry treatment at different harvests (both in cv. Bari 24 and cv. Bari 26). (Fig 3.4.) Roots were well developed in wet treatment (Fig. 3.3). Apices soon become buried in the soil where their growth continued with repeated branching.

3.4.2 Shoot height and root length

Increase of shoot height with time is shown in Fig: 3.2. The shoot height in dry condition was lower than wet treatment and is more marked in cv. Bari 24.

At wet treatment the length of the root of both cultivars showed significantly ($p=0.05$) higher than dry treatment. In wet treatment at final harvest the root length of cv. Bari 24 was 16.10 cm, it was 12.35 cm in dry treatment (Fig. 3.3). In contrast in cv. Bari 26 the root length in dry treatment (10.70 cm) significantly ($p= 0.05$) decreased from that of wet treatment (15.63 cm) Fig. 3.3.

The component part the root, (primary and secondary), lateral roots of cv. Bari 24 showed luxurious growth in wet treatment. It suggests that this cultivar can well spread their root system under wet than dry condition, which supports the data of the experiment on two cultivars of jute reported by Nazrul-Islam and Noor Newaz (1991).



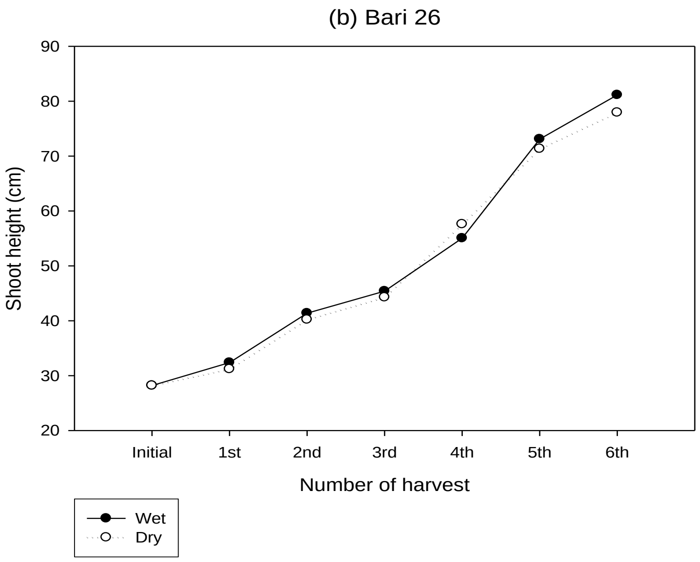
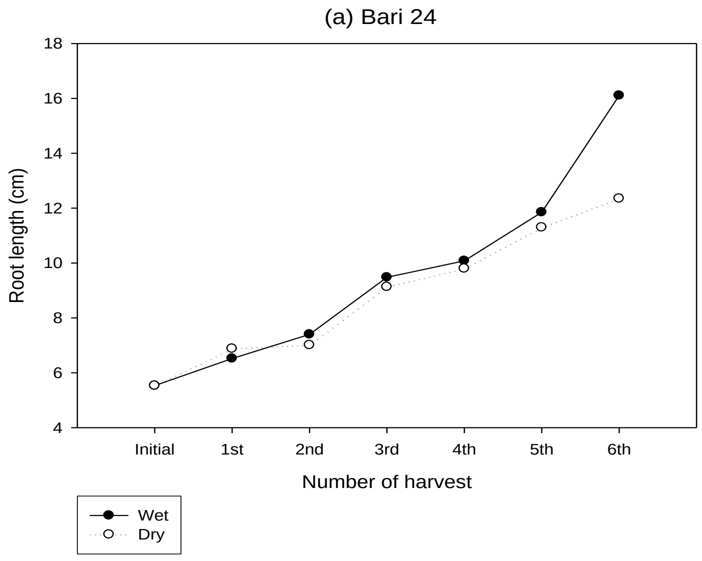


Fig 3.2: The effect of different of water treatments on the increase in Shoot height with time (a) Bari 24 (b) Bari 26



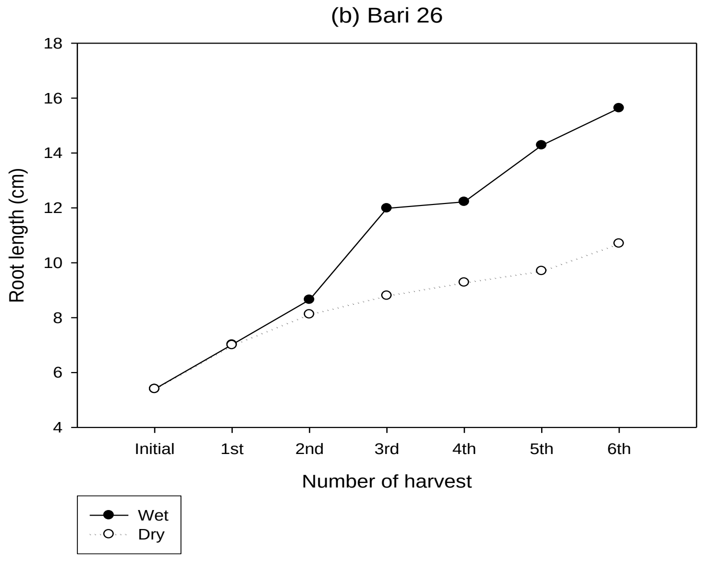
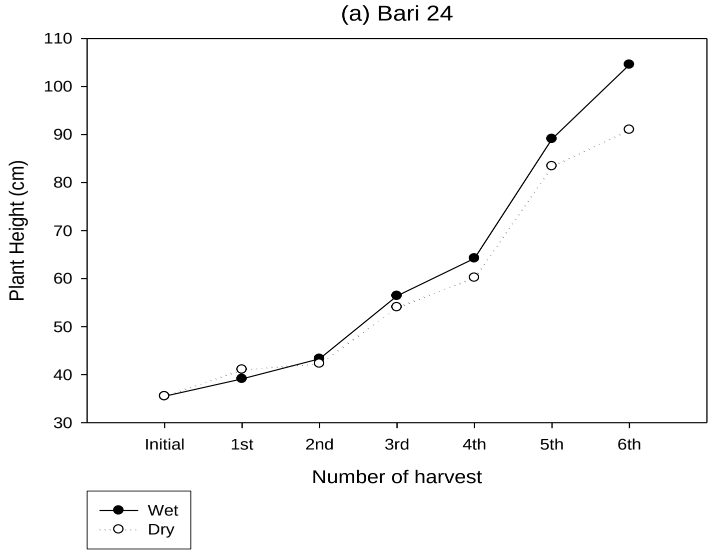


Fig 3.3: The effect of different of water treatments on the increase in root length with time (a) Bari 24 (b) Bari 26



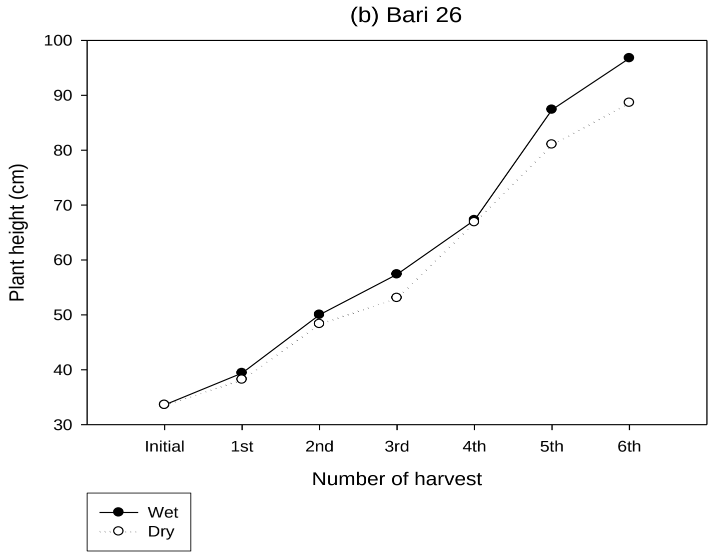


Fig 3.4: The effect of different of water treatments on the increase in Plant height with time (a) Bari 24 (b) Bari 26

3.4.3 Increase in Dry Weight with time

There was a significant difference in total dry weight, root and shoot dry weights in both the cultivars (cv. Bari 24 and cv. Bari 26) with the difference of water in soil (wet and dry) in almost all the harvests fig. 3.5, 3.6 and 3.7.

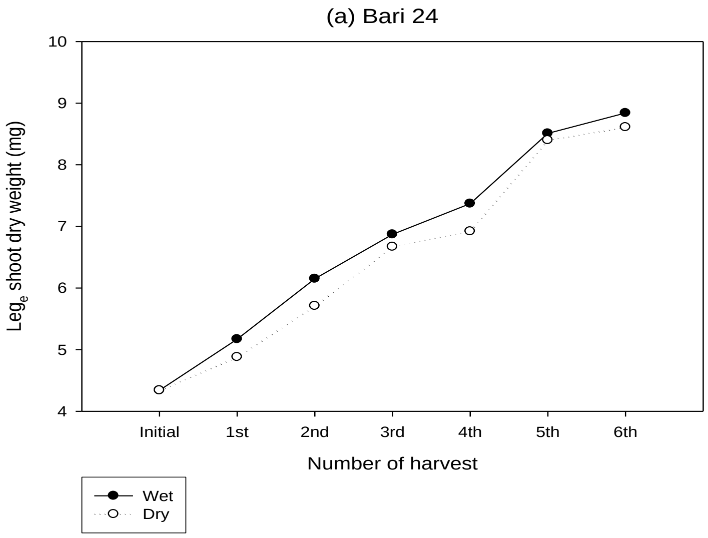
Plants grown in wet treatment had a dry weight significantly higher ($p= 0.05$) than those grown in dry treatment at every harvest. This phenomenon was occurred in both the cultivars (*Triticum aestivum* cv. Bari 24 and Bari 26).

The result showed that, apart from total dry weight, the root and shoot dry weights were also significantly ($p= 0.05$) higher in wet treatment than that dry treatment (Fig 3.5 and 3.6). This suggests that in wet treatment the plants are spreading roots and occupying more areas and possibly absorbing more nutrient than dry treatment, hence showing good growth.

It can be seen from fig 3.7 that the wet treatment had a significant effect on the increase in dry weight. There was also a striking difference in response between two cultivars to the dry treatment. Cultivars Bari 24 always showed higher dry matter production than cv. Bari 26.

Dry matter production decreased in both cultivars grown in dry treatment and this is related to the reduction of dry matter due to less water in soil environment which has been reported for other species (Mott and McComb 1975)

Mott and McComb (1975) worked with three annual species from arid zone of Western Australia and found that all the species decreased dry weight production as the water level in the root environment decreased.



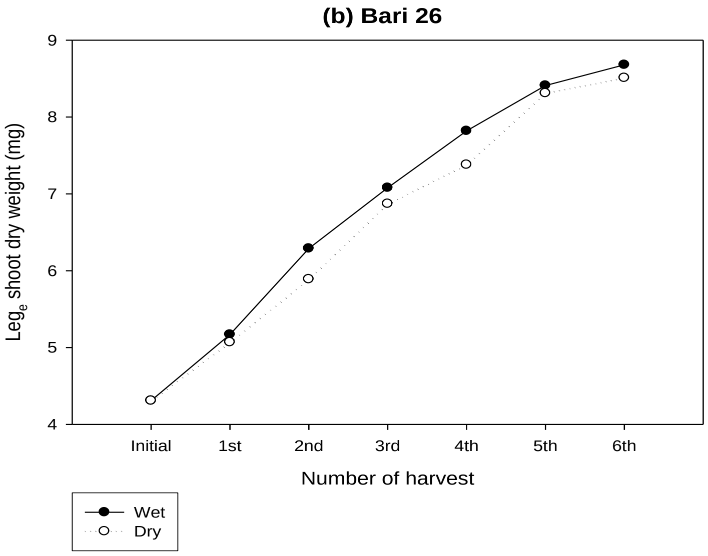
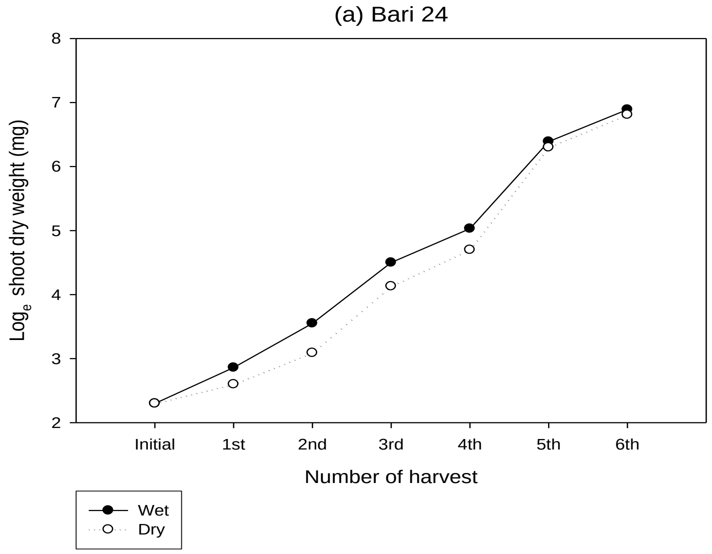


Fig 3.5: The effect of different of water treatments on the increase in Shoot dry weight with time (a) Bari 24 (b) Bari 26



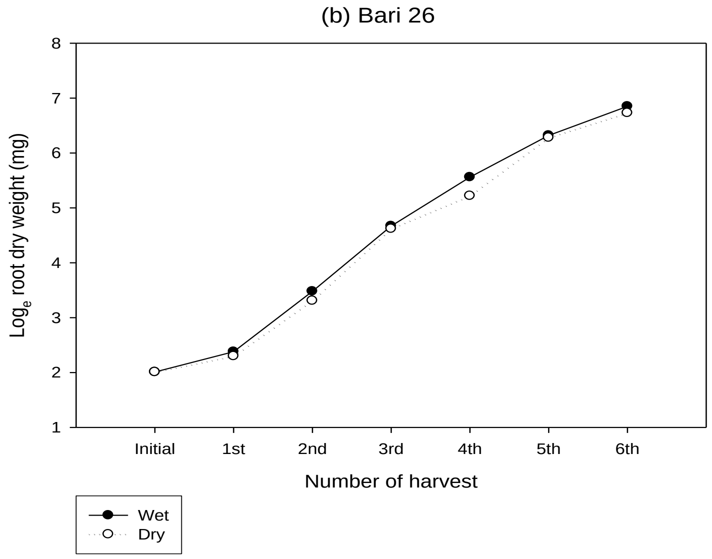
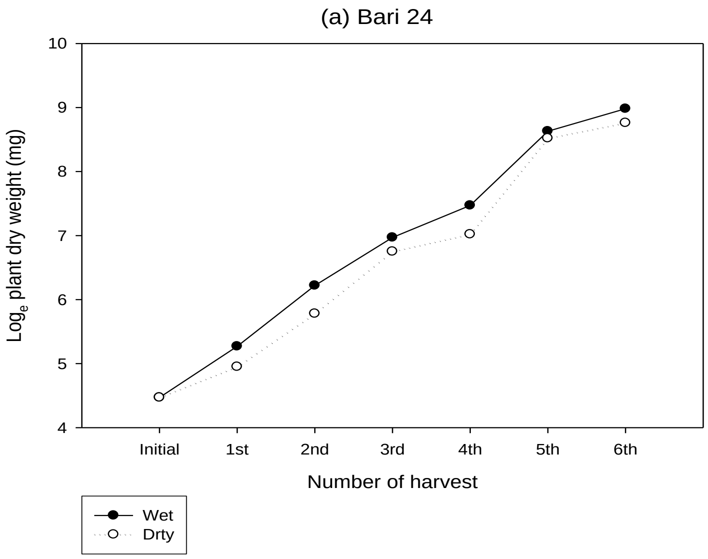


Fig 3.6. The effect of different of water treatments on the increase in root dry weight with time (a) Bari 24 (b) Bari 26



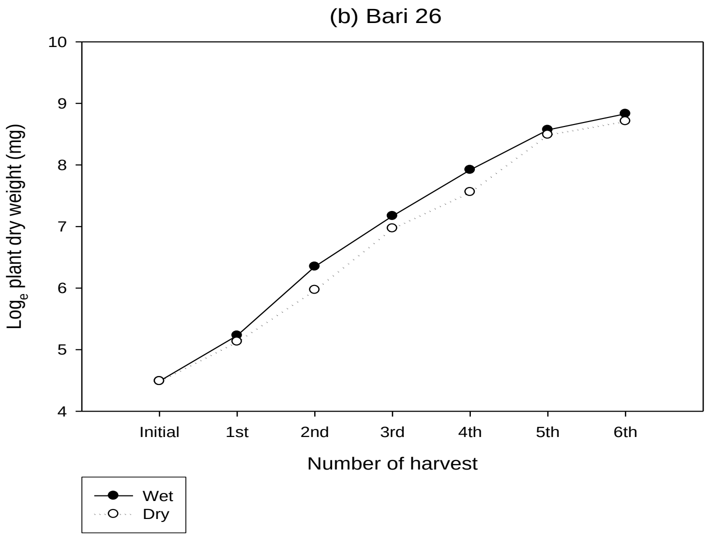
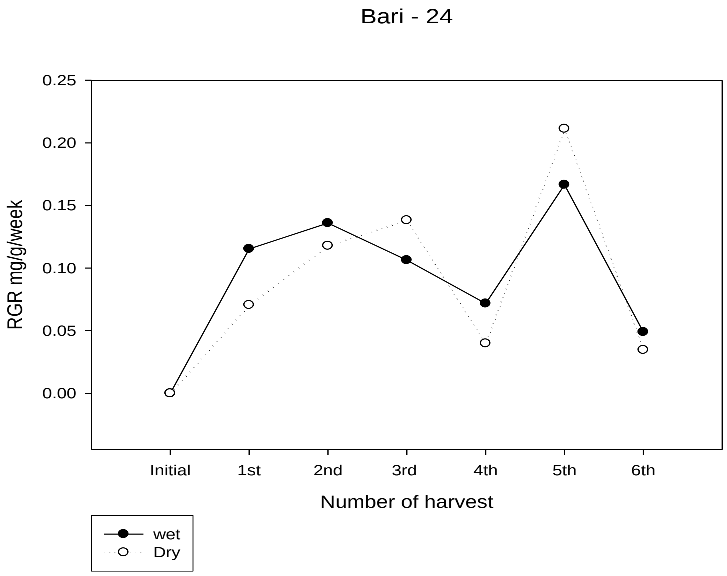


Fig 3.7: The effect of different of water treatments on the increase in total plant dry weight with time (a) Bari 24 (b) Bari 26.

3.4. 4 Relative Growth Rate (RGR)

In case of relative growth rate (RGR) no significant difference was observed between the wet and dry treatments Fig 3.8. However both cultivars showed high RGR at 2nd harvest; there was a tendency to decrease RGR with time. This phenomenon is more prominent in cv. Bari 26 than cv. Bari 24. Such a phenomenon was also observed by Hunt and Burnett (1973). The contribution of plants interest (RGR) was slightly variable in cv. Bari 26.

In cv. Bari 24 the variation of RGR was more irregular than cv. Bari 26. The highest RGR (0.213 mg/g/week) was noted in Bari 24 in the 5th harvest under dry treatment. In contrast, highest RGR in cv. Bari 26 was obtained under wet condition in the 2nd harvest (0.159 mg/g/week. Both cultivars showed increase in RGR upto 2nd and 3rd harvest in wet and dry treatments respectively and then showed a declining tendency and again increased. Such a phenomenon was also noted by Hunt and Burnett (1973) on the growth and uptake of potassium in *Lolium perenne* L in relation to light intensity.



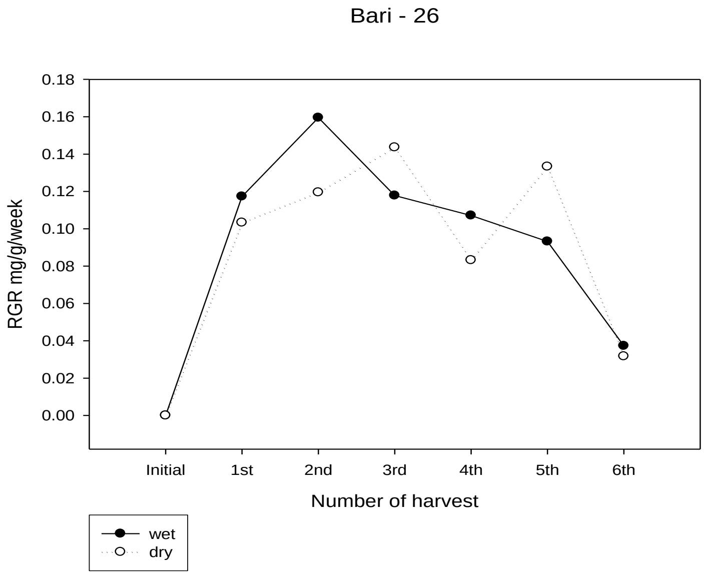
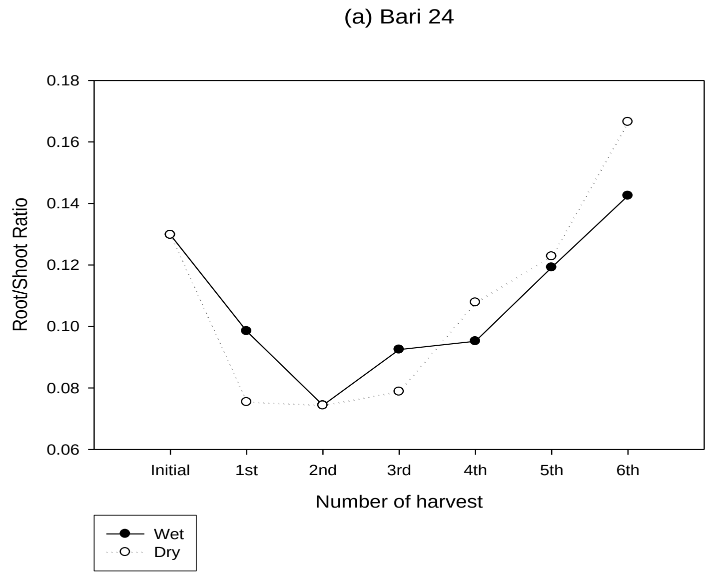


Fig 3.8: The effect of water treatments in Relative Growth Rate (RGR) in successive harvests (a) Bari 24 (b) Bari 26

3.4.5. Root: shoot

Progress curves of root: shoot dry weight ratios (R/S) of successive harvests are given in Fig 3.9. This value is decreased and fell sharply and significantly (P= 0.05) in both cultivars from an initial value of 0.1298 (cv. Bari 24) and 0.10 (cv. Bari 26) onwards. This fall of R: S with time was less steep in CV Bari 26. Hunt and Burnett (1973) in an experiment with *Lolium perenne* L. with three levels of light Flux and two potassium levels found that R/S decreased significantly; fewer signs of plateau were observed. In wet treatment the root: shoot in cv. Bari 24 in 1st harvest was 0.0985 whereas in cv. Bari -26 it was 0.0563. It is of interest to note that root: shoot ratio of cv. Bari 24 was higher in dry condition than wet treatment. It has been shown that a mathematically definable pattern of R/S is maintained (Young 1964). Species of dry sites tend to have less root/ shoot than those of mesic and hydric areas. While interspecific differences exist from site to site. Penka (1965) has demonstrated that such ratios remain more constant than some more morphological characteristics in irrigated and non irrigated plants. Increase of root: shoot ratio in the later harvest is definitely due to its tiller production. The final root: shoot ratio in both cultivars in all the treatments from 3rd harvest onward showed an increasing tendency.



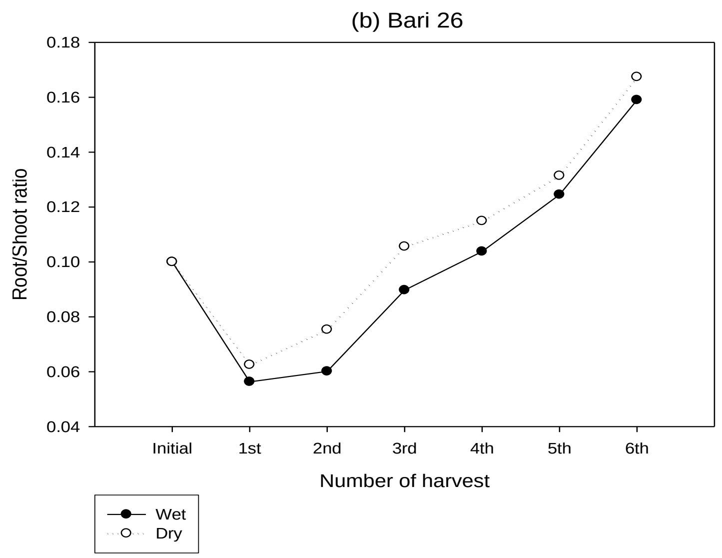


Fig 3.9: The effect of different of water treatments on the increase in Root shoot ratio with time (a) Bari 24 (b) Bari 26

CHAPTER- 4

GROWTH AND YIELD MEASUREMENT OF TWO WHEAT CULTIVARS IN RELATION TO SOIL MOISTURE

4. l INTRODUCTION

Soil moisture appears to be an important factor in determining time of germination (Ratcliffe 1961; Pemadasa and Lovell 1975; Baskin and Baskin 1979); survival of seedlings and their dry-matter production (Jones and Etherington 1971; Pemadasa and Lovell 1974a), relative growth rate (RGR) and root-shoot ratios (Ashenden *et al* 1975; Akber *et al* 2012) and reproductive performance, including number of seeds and seed weight (Newman 1965, 1967; Ernst 1981; Watkinson 1982).

The effect of drying and rewetting soils plays a strong role on growth and dry matter production in plants. *Erica cinerea* (a dry land species) is restricted to dry mineral soil whereas *Erica tetralix* (a wetland species) occurs in damp, often waterlogged situation (Bannister 1965, 1966).

When plants grow in wet soil, their roots are in more or less anaerobic condition. The work of Crawford and Taylor (1969) suggested that plant species have very different physiological response to moisture condition depending on whether they are by nature intolerant or tolerant of flooding.

The pattern of growth with variation in the magnitude of the dry weight values, in the symmetry of the curve and in the time scale which it occupies, in general among annual plants grown in a productive environment. Hunt (1978a) listed, as an example of the comparative utility of one of the chief concepts of plant growth analysis, the rates of dry weight increase for a variety of organisms grown under favourable conditions.

The classical and the functional approaches to plant growth analysis have two important concepts:

i) The classical approach, in which the course of events is followed through a series of relatively infrequent, large harvest (with much replication of measurement).

ii) The functional approach, in which supplying data for curve fitting are smaller (less replication of measurement), but more frequent and the publication in this field are less than the first one (Hunt 1978).

In the present investigation an attempt has been made to study the effect of moisture regimes at different stages of life cycle on the growth, reproductive stages, plant height, length and weight of spike, weight of grains and flag leaf area of two cultivars of wheat, *Triticum aestivum* cv. Bari 24 and cv. Bari 26

4.2 MATERIALS AND METHODS

Seeds of two cultivars of wheat, *Triticum aestivum* cv Bari 24. and cv bari 26 were obtained from BARI, Gazipur and were sown in the plots of the Botanical Garden of Dhaka University (Field description, plot arrangements and different harvests are given in **Chapter 3.**

Final harvest was done on 2nd January, 2013. Height of plants (with and without spike), length and weight of spike, weight of 100 grains were measured after the final harvest. Area of the flag leaf (length and breadth, mm^2) was also measured before the final harvest.

4.3 RESULTS AND DISCUSSION

The moisture conditions in this experiment were chosen to stimulate stress conditions likely to be experienced by the plants growing in the field. The results are valuable since the measured effects of soil moisture made it possible to draw some conclusions about the differences in response of the two cultivars of wheat (*Triticum aestivum* cv. Bari 24 and cv. Bari 26).

4.3.1 Area of the flag leaf

Both cultivars had larger flag leaf area grown in wet condition than in dry condition. In general, flag leaf area was higher in the cultivar Bari 26 than cv Bari 24 (Table 4.1). The highest value of flag leaf area was found in Bari 26, wet treatment (74.60±4.53 mm^2) and lowest one was found in Bari 24, dry treatment (61.32± 11.40 mm^2). Although, the area of flag leaf did not show any significant difference ($P = 0.05$) between the treatments but an increasing tendency of flag leaf area was noted under wet condition. The large flag leaf area usually helps to increase the size of the spike and hence fruit yield (Nazrul- Islam and Fouzia 1980).

Table 4.1: Effects of Wet and Dry treatments on the flag leaf area (mm^2), height (cm) of the plant, length (cm) and dry weight (g) of spike and weight of 100 grains (g) of two cultivars of wheat (with 95% confidence limit)

Cultivars	Treatments	Flag Leaf Area (mm^2)	Height of the plants (cm)		Length of the Spike (cm)	Weight of the spike (g)	Weight of 100 grains (g)
			With Spike	Without Spike			
Bari 24	Wet	71.97±11.24	94.08±7.76	78.83±1.2	17.75±0.95	3.05±0.51	5.53± 0.35
	Dry	61.32±11.40	88.18±1.78	72.20±1.80	16.93± 1.82	3.04± 0.31	5.48± 0.30
Bari 26	Wet	74.60±4.53	98.18±6.63	81.90±2.90	16.78± 0.53	2.67± 0.35	4.56± 0.32
	Dry	66.53±3.43	91.28±6.06	75.08±5.70	16.20± 0.45	2.69± 0.09	4.54± 0.29

4.3.2 Height of the plants

In case of plant height, the highest value was found in Bari 26, in wet treatment (with spike 98.18± 6.63 cm and without spike 81.90±2.90 cm) and lowest value was noted in Bari 24, dry (with spike 88.18±1.78 cm and without spike 72.20±1.80 cm). So, it is observed that plant height was more in wet treatment than those of the dry treatment.

4.3.3. Length and weight of spike

There are very little difference, in case of spike length and weight in relation to water treatments (Table 4.1). However, spike length in Bari 26 was low. Largest value for spike length was found in Bari 24, wet treatment (17.75±0.95 cm) and lowest one is in Bari 26, dry treatment (16.20 ±0.45cm). Hence it can be said that water treatment has little influence over the spike length.

Similarly, the spike weights did not show any significant difference (P= 0.05) of water treatment (Table 4.1). Under wet condition the highest and lowest values were in cv. Bari 24 and cv. Bari 26 (3.05± 0.51g) and (2.67±0.35g) respectively. Weight of the spike was usually higher in Bari 24 than Bari 26.

4.3.4 Weight of 100 grains

Weight of 100 grains was slightly higher in wet treatment than those of dry treatment plants (Table 4.1). The maximum weight was in Bari 24, wet treatment (5.53±0.35g) and minimum in Bari 26, dry treatment (4.54±0.29g). The results show that wet treatment the grain size to some extent was increased.

From the above analysis, it is found that, water treatment had significant role on the growth of wheat plants. It can be said that, wet condition is more favorable for the growth and yield of wheat cultivars than the dry condition. Nazrul Islam *et al.* (1980) worked with soyabean and noted that dry weight of plants was higher under wet condition than dry treatment. Newman (1967) studied the seed production in relation to drought and found that the number of inflorescences in *Aira praecox* increased during a period which lasted two weeks in the field and which was followed by a period in which they remained constant. The decrease in leaf area in *Aira species* resulted from fewer tillers and shorter leaves (Pemadasa and Lovell 1974a). Newman (1965) also concluded that desiccation of the top layer of soil is likely to occur regularly flowering and seed- sitting of winter annuals.

Seedling establishment of *Aira praecox* is also slightly higher under drought condition than that of *Aira caryophyllea* (Pemadasa and Lovell 1974a) although the germination requirements of both species are very similar (Pemadasa and Lovell 1975).

C H A P T E R-5

TISSUE WATER RELATIONS OF TWO WHEAT CULTIVARS IN DRY AND WET TREATMENTS

5.1 INTRODUCTION:

In recent years experimental ecology has developed rapidly and its main aim is to explain the occurrence of particular species or population in a particular environment. Transpiration, stomatal aperture and amount of water in leaves are indices which reflect the ability of the plant to take up water under the prevailing atmospheric and soil water conditions.

The water relation study of plants explains the understanding of adaptability and survival strategies of any species. It is now realized that the water stress causes physiological and morphological changes in plants. Stocker (1956) mentioned that there should be two main objectives of the water relation study. These are-

(i) An ecological inquiry into the living conditions of the natural habitats.

(ii) A purely eco-physiological inquiry into the changes which cause water deficiency in the structure and function of plants.

There is evidence (Nazrul-Islam 1983) on the importance of water factor in respect of plant distribution of wet land and dry land habitat species and also in tomato plants grown under waterlogged condition (Nazrul –Islam and Yasmin 1982); with two cultivars of jute (Nazrul –Islam and Alam 1986); with two cultivars of wheat (Nazrul –Islam *et al.* 2011)

Bannister (1964) has explained that there is a good correlation between the distribution of species with regard to soil moisture and water relations of the species concerned. A consideration of the water loss from cut shoots (Bannister 1964; Hygen 1951; Nazrul-Islam 1983) showed that the relative water content at the points of stomatal closure varies both between and within species (Nazrul-Islam and Yasmi).

The growth of tomato Plants is to a great extent controlled by some aspects of moisture factor (Nazrul-Islam and Roy 1978). It has been argued that transpiration alone gives little indication of the water balance of the plants; to obtain a clear picture of this upon the ecology of the plants, internal water deficit, as well as transpiration should also be assessed (Bannister 1964, Sen *et al*. 1972). The investigation here gives a detailed account concerning the waters balance of wheat plants grown in dry and wet condition with reference to water loss, water deficits, percentage water content in leaves and their relative turgidity.

The poor growth of some crop plants in dry condition is a physiological problem of considerable ecological interest and is considered in this work with reference to growth, tissue water in two cultivars of wheat (*Triticum-aestivum*) cv. Bari-24 and cv Bari-26). The relationship between leaf water content and stomatal closure investigated in two cultivars of wheat plant with two treatments. These are – (i). Dry and (ii). Wet

To obtain a complete picture, it was therefore decided to study the two cultivars in relation to the following measurements:

i. The relationship between leaf water content and stomatal closure.
ii. The relative turgidity (RT) and
iii. The rates of transpiration.

These relationships have been used by Jarvis and Jarvis (1963 a,b) Bannister (1964) and Okali (1971) to explain the adaptation of plants to drought.

5.2 MATERIALS AND METHODS

5.2.1 MATERIALS

Seeds of two cultivars of wheat, *Triticum aestivum* cv. Bari 24 and cv. Bari-26 were obtained from BARI, Gazipur.

A land area was selected in the Botanical Garden of Dhaka University. The field was divided into sixteen plots. (Fig.3.1) The length and breadth of each plot were 70 cm and 60 cm respectively. Soils were broken down by hands to make it free from large particles and made to homogenous. Then the plots were marked and two different water treatments were imposed *i.e* wet and dry.

Seeds were sown on the 5th December 2012 and tissue water relations were done on the 10th February 2013. During this time the plants were fully matured. The healthy leaves were plucked from the top of the plant for this experiment.

5.2.2 METHODS

5.2.2.1 Relative Turgidity (R.T.)

The moisture content of plant material has been expressed as relative turgidity (Weatherley 1950). This is the ratio of the water content in the field to the water content after the plant material has been allowed to make up any deficit, expressed as a percentage.

Leaves of two cultivars of wheat (cv. Bari-24 and cv. Bari 26) were used as experimental material to measure the relative turgidity (RT). The leaves of the above two cultivars were taken from four different treatments i.e. Dry and Wet (cv. Bari 24, and cv. Bari 26).

The techniques of using leaf water deficit as a measure of water stress has been employed by Weatherley (1950) and Bannister (1964) which is similar in principle to that of Yemm and Willis (1954). Weatherley (1950) used leaf dises, which were floated on water to achieve saturation. Bannister (1964) used shoots of different plant species sampled throughout the year. The method of Bannister (1964) was adopted in this study to measure deficits of leaves.

The leaves of more or less uniform size were cut from the plants at 10:00 A.M and were collected in saturated polythene bags and carried to the laboratory. The leaves were then rapidly surface dried with absorbent paper and then weighed (within 10 minutes of collection). These weights were taken as the fresh weight (FW).

The leaves were then kept to a saturated environment and allowed to stand in water with their cut petioles immersed under water in specimen bottles (capacity 30 ml) for 24 hours to attain turgidity.

At the end of this period the leaves were taken from the saturated environment to determine the saturated weight (SW). The leaves were then oven dried at 80^0 C and finally the dry weight (DW) of the leaves was determined. The relative turgidity (RT) was then calculated from the following formula of Bannister (1964)

$$RT= \frac{FW-DW}{SW-DW} \times 100$$

5.2.2.2 The relationship between leaf water content and stomatal closure

Hygen's (1951) quick weighing method for analysis of transpiration of detached leaves was used for the comparison of the relation between leaf water content status and stomatal closure. Transpiration rates were estimated from weight loss of detached leaf from the weighing at frequent intervals. In this way transpiration decline curves were obtained. The method adopted in this investigation was to cut leaves of convenient size and shape from the plants growing under moist and dry treatments.

The leaves used in transpiration were collected from the field at 10:00 A.M. and immediately kept in a sealed saturated polythene bag. The leaves were then transported to the laboratory, rapidly surface dried with sheets of absorbent paper and weighed (within 10 minutes of collection) on an electric balance. The water loss was followed for about three hours by recording fresh weight (FW) at an interval of 10 minutes (for the first 70 minutes) and then intervals of 20 minutes over a period of up to approximately 2 hours. Between weighing, the leaves were returned to the natural environment and placed vertically in small specimen bottles (capacity 30 ml). The leaves were then oven dried at 80^0 C and their dry weights (DW) were determined at the end of the experiment, so that the change of relative turgidity with time could be plotted. The initial weight was taken as the saturated weight (SW). There were six replicates for each treatment.

Leaf water status at any point during a drying cycle was calculated as relative water content (RWC) from the following formula:

Relative Water Content = $\frac{FW-DW}{SW-DW} \times 100$

(The relative turgidity of Weatherley, 1950)

The curve is divisible into three phases. The first, final and linear phases, when the stomata are opened and closed (cuticular loss) respectively, and a curvilinear phase during the time of stomatal closure. The point of intersection of the two linear portions of the curve has been taken as indicating the relative water content (RWC) at stomatal closure (Jarvis and Jarvis 1963)

5.2.2.3 Rates of transpiration

Transpiration rates are usually expressed on a weight basis. In the present investigation the most convenient basis of expression in view of the methods used is mg transpiration/g dry weight/minute, the initial fresh weight at the time of excision was recorded.

The basic data for the determination of points of stomatal closure were used to calculate rate of transpiration. Total transpiration rates (calculated from transpiration decline curves) in terms of rate of loss of water, were first calculated in mg/ g / min. from the weight loss during the first 10 minutes after recording the saturated weight. Maximum cuticular rate of transpiration was similarly determined from weight loss during the last half an hour of transpiration and stomatal rate of transpiration was then obtained by difference. This method of calculation permits the partitioning of total transpiration rate into stomatal and cuticular rate.

5.3 RESULTS AND DISCUSSION

5.3.1. Relative turgidity

The percentage of water content in the leaves of different treatments of two cultivars is given in Table 5.1. It appears that the percentage of water content was higher (P= 0.05) in the leaves of both cultivars of dry treatments cv. Bari- 24 in (87.81 ± 4.13) and cv. Bari- 26 in (92.00 ± 1.20) than the leaves of wet treatment cv. Bari- 26 in (91.07± 1.54) and cv. Bari 24 in (85.29 ± 3.70) respectively.

Water content at stomatal closure was higher in dry treatment in both cultivars than wet treatment (not significant p= 0.05); cv. Bari 26 closed stomata at water content between 91 to 92% whereas this value for cv. Bari 24 was 85 to 87% in wet and dry treatments respectively. This suggests that cv. Bari 26 is more sensitive than cv. Bari 24. The results of the present investigation also suggest that in general the relative water content values at stomatal closure were high in dry treatment. Okali (1971) worked with a number of woody species of the Accra plains, Ghana and noted that *Securinega virosa* had low stomatal response (67.2%) to water loss and *Dichapetalum guineense* had (91.8%), the later species is more sensitive than the former one.

Leaf water content and stomatal closure were also studied by Nazrul- Islam (1983) in a range of wet land and dry land species. *Rumex acetosa* (dry land sp.) was found to be more sensitive than *Filipendula ulmaria* (wetland sp.). Bannister (1964) has shown that *Calluna vulgaris* from dry sites had a lower relative turgidity at stomatal closure than those of wet sites. In the present experiment both cultivars of wet treatment had lower relative water content than dry treatment.

Table- 5.1: The relative water content of leaves at points of stomatal closure (with 95% confidence limit). Time taken to stomatal closure is also given.

Cultivars and Treatments	Relative water content (RWC)%	Time taken to stomatal closure (in minutes)
cv. Bari- 24, Wet	85.29 ± 3.70	58.25
cv. Bari- 24, Dry	87.81 ± 4.13	42.00
cv. Bari- 26, Wet	91.07 ±1.54	52.00
cv. Bari- 26, Dry	92.00 ± 1.20	44.00

5.3.2. The relationship between leaf water content and stomatal aperture

Leaves of dry treatment plants of cv. Bari 24 and cv. Bari 26 appeared to show more rapid stomatal closure (42: 00 minutes and 44: 00 minutes respectively) than the leaves of the other treatment investigated which possibly respond better to wet conditions. The wet treatment in cv. Bari-24 took the longest time (58.25 minutes) for stomatal closure. The time taken for stomatal closure at dry treatment in cv. Bari 24 (42:00 minutes) and cv. Bari 26 (44:00 minutes) were very nearer Table 5.1.

Initially the relative turgidity dropped quickly at a steady rate while the stomata were still widely open. After about half an hour or more (depending on the treatment) the rate of water loss lessened and eventually settled to a steady low rate which continued for several hours. However, the curves from which relative water content (RWC) and time taken to stomatal closure were calculated by extrapolation are shown in Fig. 5.1.

The results of this investigation indicate some of the basic differences in the water relations of the wheat plants between wet and dry conditions. Under the different conditions of water availability, the plant showed contrasting behavior with respect to transpiration rates and stomatal change.

Ecological differences of the plants of various moisture regimes may well in part have a physiological basis in terms of water relations, characteristically plants of the wet habitat have an efficient means of regulation of transpiration, whereas this is not essential and may be lacking in plants growing under the dry condition.

The sensitivity of these two cultivars in relation to adaptation to drought in terms of relative water content at stomatal closure may therefore be arranged as follows:

Wet treatment: cv. Bari 26 > cv. Bari 24

Dry treatment: cv. Bari 24 > cv. Bari 26

The growth of tomato plants was found to be the best in the wet treatment and was worse in waterlogged condition (Nazrul-Islam and Roy 1978). Bannister (1964) has shown that *Calluna vulgaris* from dry sites had a lower closure of R.T. than those of wet sites. In the present experiment the wet treatment was done by supplying water everyday. It is possible that this may have caused the variation of result. Hence, some precise measurements of soil moisture and also plant moisture (ratio of the water content in the field to the water content after the plant material has been allowed to make up deficit) from wet and dry treatments may show some significant result.

Bannister (1964) found that *Erica tetralix* in the dry soils with a reduction in transpiration rate which was coupled with a drastic reduction in relative turgidity. It was also shown that *Calluna vulgaris* from dry sites had a lower relative turgidity at stomatal closure than those from wet sites and that those from intermediate wet site lay somewhere between the two extremes (Bannister 1964).

5.3.3 Rates of transpiration

Total transpiration rate (calculated from transpiration decline curves) in terms of rate of loss of water was calculated from the weight loss during the first ten minutes after recording the saturated weight; cuticular rates of transpiration was determined from weight loss during the last hour of transpiration and stomatal loss of transpiration was then obtained by difference. Wet treatment plants showed the maximum rate of loss of water, while dry treatment plants showed the lowest Table 5.2.

If the total transpiration rate is partitioned into stomatal and cuticular losses (Table 5.2), it is clear that the differences between the treatments result mainly due to difference in rate of stomatal transpiration. Okali (1971) found that cuticular transpiration represents a high proportion of the total water loss from the leaves of the cultivars with a low transpiration rate. In both cv. Bari 24 and cv. Bari 26 of wet treatment exhibited highest total (8.75 ± 1.42 and 8.07 ± 0.09 respectively) and also stomatal (7.09 ± 1.35 and 6.43 ± 0.88 respectively) loss of water, while dry condition cv. Bari 24 and cv. Bari 26 have the lowest total (4.83 ± 0.51 and 5.90 ± 0.76 respectively) loss of water. High rate of total and stomatal transpiration in cv. Bari- 24 of wet treatment is an indication of high uptake of water and ions. The results also showed that the species with high transpiration rate also showed high cuticular transpiration. It is of interest that the species with high rate of total transpiration (wet treatment plants cv. Bari 24 and cv. Bari 26) have the highest stomatal sensitivity to water loss (Table 5.2). This result agrees with the work done in jute by Nazrul-Islam and Alam (1986); and Nazrul- Islam (1983).

After partitioning the total transpiration rate into stomatal and cuticular (Table 5.2), it is clear that differences between the treatments result mainly due to difference in rate of stomatal transpiration. The cuticular rate does not differ significantly except from the dry treatment. The results also indicated that with high cuticular transpiration, (1.66 ± 0.23) plants of wet treatment also showed high total transpiration rate (8.75 ± 1.42)

Table 5.2: Rates of transpiration calculated as rates of loss of water content (stomatal values calculated by difference). 95% confidence limits are also given.

Cultivars and treatments	Loss of water in mg/g /min			Cuticular/Total %
	Total	Stomatal	Cuticular	
cv. Bari- 24, wet	8.75±1.42	7.09±1.35	1.66±0.23	18.97
cv. Bari- 24, dry	4.83±0.51	3.32±0.61	1.52±0.32	31.47
cv. Bari- 26, wet	8.07±0.09	6.43±0.88	1.64±0.16	20.32
cv. Bari-26, dry	5.90±0.76	4.37±0.62	1.53±0.40	26.02

Fig 5.1: Examples of curves of the relation between leaf water content and stomatal closure, showing extrapolation of the straight line parts intersecting at closure.

(a) Bari- 24, wet

(b) Bari- 24, dry

(c) Bari- 26, wet

(d) Bari- 26, dry

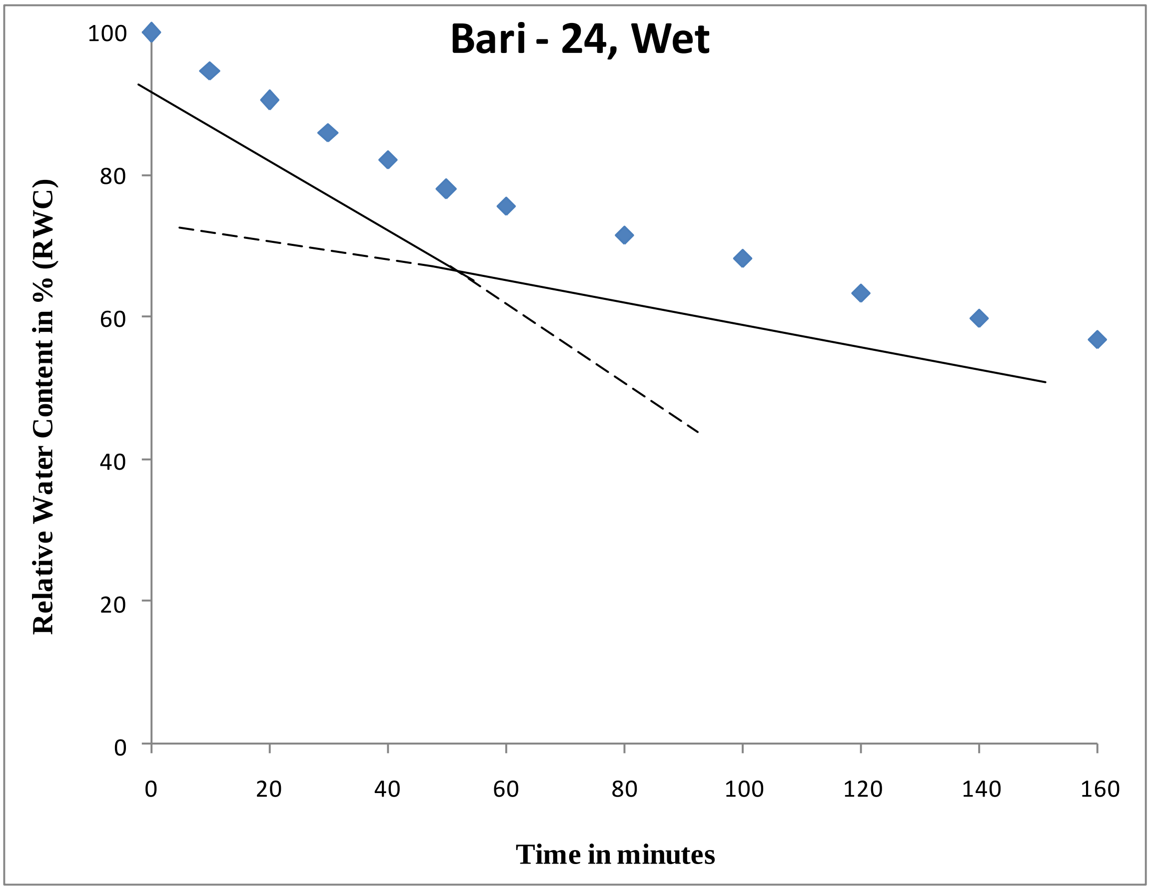

Bari - 24, Wet
Relative Water Content in % (RWC)
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
Time in minutes

Fig. 5.1 (a)

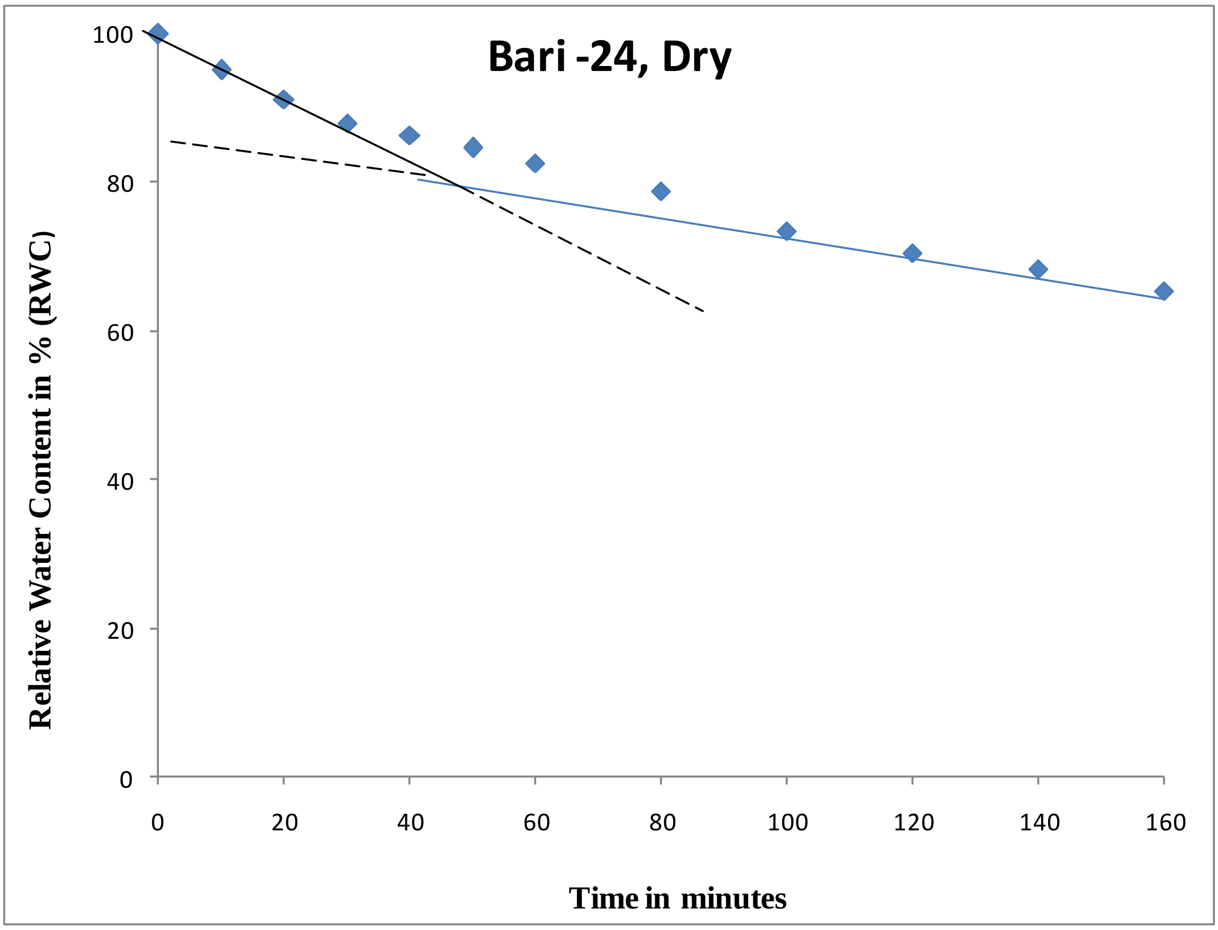

Bari -24, Dry
Relative Water Content in % (RWC)
Time in minutes
0
20
40
60
80
100
120
140
160

Fig. 5.1 (b)

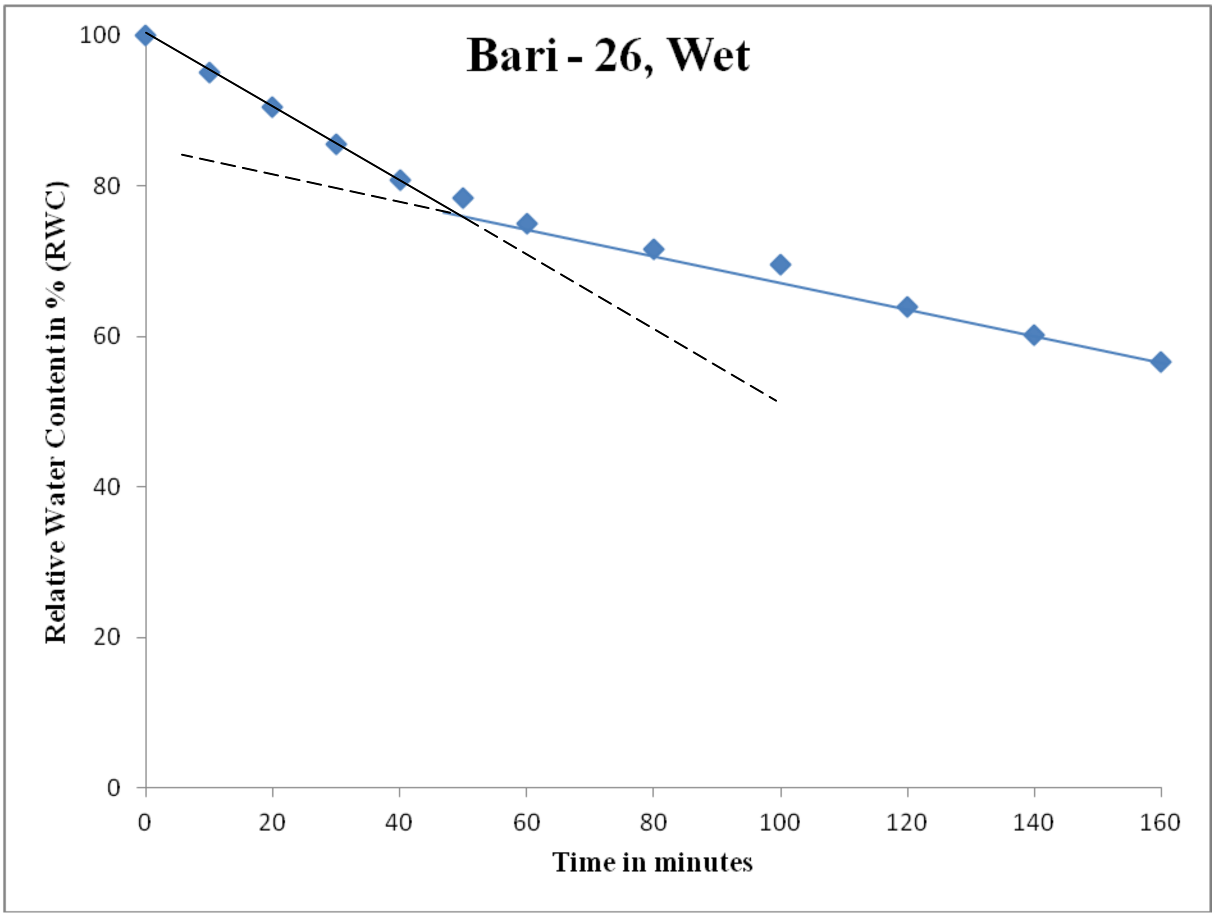

Bari - 26, Wet
Relative Water Content in % (RWC)
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
Time in minutes

Fig. 5.1 (c)

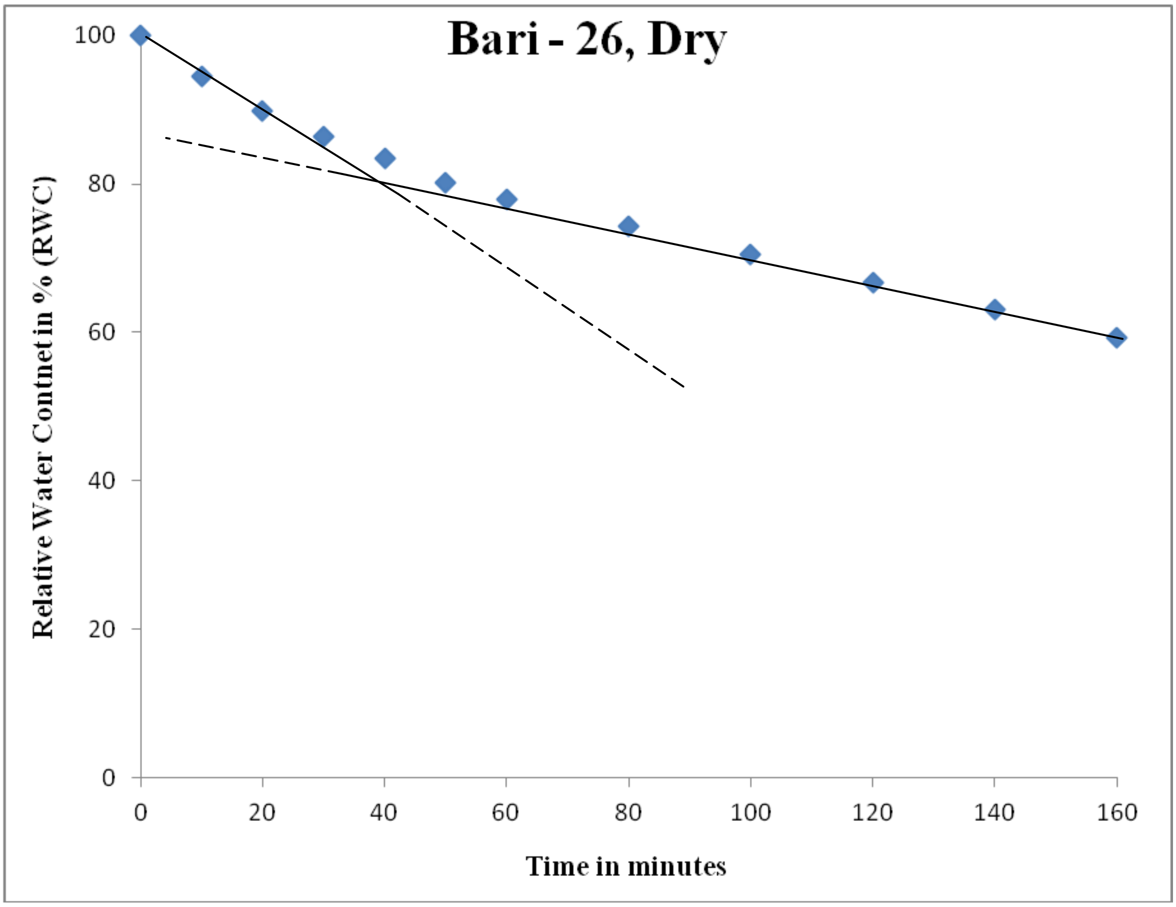

Bari - 26, Dry
Relative Water Contnet in % (RWC)
Time in minutes
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160

Fig. 5.1 (d)

C H A P T E R -6

GENERAL DISCUSSION

GENERAL DISCUSSION

Number of topics has been discussed in relation to its own implications in the previous chapters. In this section, the salient features will be brought together. The results are valuable since the measured effects of salinity and soil moisture made it possible to draw some conclusions about the differences in response of these two cultivars.

The results of the present observation were considered from different growth measurement and are discussed below.

- **I. Seedling growth of two wheat cultivars in relation to salinity.**
- **II. Growth analysis of two wheat cultivars in relation to soil moisture.**
- **III. Growth and yield measurements of two wheat cultivars in relation to soil moisture.**
- **IV. Tissue water relations of wheat cultivars in dry and wet treatments.**

I. Seedling growth of two wheat cultivars in relation to salinity

The present study shows that growth of two cultivars of wheat (cv. Bari 24 and cv. Bari 26) seedling is favoured by low NaCl salinity. Shoot and root length of both cultivars of wheat seedlings showed a significant (P=0.05) reduction in the highest salinity treatment but at the lowest salinity treatment i.e. at 0.05 M NaCl both shoot and root length increased. It is reported that soil salinity suppresses shoot growth more than the root growth (Mass and Hoffman 1977, Munns 2002, Ramoliya *et al.* 2004).

The seedling length of cv. Bari 26 in different NaCl concentrations is higher than cv. Bari 24. The results show that both cv. Bari- 24 and cv. Bari 26 are sensitive to salinity. The result suggested that different NaCl treatments had some roles in the salt tolerance at low concentration of the above cultivars of wheat.

Fresh and dry weights due to different NaCl concentration treatments although initially showed an increase but with the increase of salinity, the growth of both cultivars of wheat decreased. Cultivars Bari 24 exhibited highest fresh and dry weight at salinity 0.05M i.e. 143 ± 0.04 mg (F. wt) and 26.75 ± 0.01 mg (D. wt) respectively.

In contrast, cultivars Bari 26 also showed the highest fresh and dry weight at salinity 0.05 M NaC1, i,e, 134.75 ± 0.02 mg (F.wt) and 22.00 ± 0.00mg (D.wt) respectively but with the increase of salinity both cultivars of wheat showed the reduction of seedling weight. This indicates the susceptibility of wheat cultivars to salinity.

Optimal shoot growth of *Aster tripholium* occurred when plants were grown in a salt solution. Whereas roots grew best in fresh water (Montfort and Brandrup 1928). An increase in root growth and decrease in shoot growth was obtained under high water stress induced by NaCl, whereas total growth of the plants was reduced (Stocker 1960; and Troughton 1960). Shoot growth of *Aster tripholium* was best in 2% Nacl but roots grew best at only 1% (Bickenbach 1932). In *Atiplex polycarpa*, salinity inhibited shoot growth more than the root growth (Chatterton and Mckell 1969).

The maximum value of root /shoot ratio in control was found in both cultivars. But at highest level of salinity i,e, at 0.2 M NaC1. R/S ratio decreased in both cultivars. In the present experiment, the data showed that the ability to grow well at low salinity level could be of special ecological advantage.

II. Growth analysis of two wheat cultivars in relation to soil moisture

In the present investigation, wet treatment plants were taller than the plants of dry treatment at different harvests. (Both in cv. Bari 24 and cv. Bari 26).

At wet treatment, the length of the root and shoot of both cultivars showed higher than dry treatment. The component part the root, (primary and secondary) lateral roots of cv. Bari 24 showed luxurious growth in wet treatment than those of cv. Bari 26. It suggests that this cultivars can well spread their root system under wet from dry conditions, which supports the data of the experiment on two cultivars of jute reported by Nuzrul Islam and Noor Newaj (1991).

The result showed that wet treatment plants had a dry weight greater than the dry treatment plants at every harvest. This was occurred in both cultivars (cv. Bari 24 and cv. Bari 26). The results also showed that apart from total dry weight, the root and shoot dry weights were also higher in wet treatment than that of dry treatment. This suggests that in wet treatment, the plants are spreading roots and occupying more areas and possibly absorbing more nutrient than dry treatment.

Cultivars Bari 24 always showed higher dry matter production than cv Bari 26. Dry matter production decreased grown in dry treatment in both cultivars and this is related to the reduction of dry matter due to less water in soil environment which has been reported by Mott and McComb 1975. There is evidence that dry matter production increased due to water logging in soybean plants (Nazrul Islam *et al*. 1980); in contrast, low moisture was favourable for the growth of tomato plants (Nazrul Islam and Roy 1978).

Both cultivars (cv. Bari 24 and cv. Bari 26) showed high RGR in 2nd harvest. But there was a tendency to decrease RGR with time. This phenomenon is more marked in cv Bari 26 than cv. Bari 24. such a phenomenon was also observed by Hunt and Burnett (1973). Relative growth rate influenced virtually due to the environmental variables (Grime and Hunt 1975; Poorter *et al.* 1990; Poorter and Remakes 1990).

The root: shoot ration of cv. Bari 24 was higher in wet condition than dry treatment. The final root: shoot ratio in both cultivars in all the treatments from 3rd harvest onward showed an increasing tendency. Increasing of root: shoot ratio in the later harvest is definitely due to its tiller production.

III. Growth and yield measurement of two cultivars in relation to soil moisture

Both wheat cultivars had longer flag leaf area grown in wet condition than in dry condition. In general, flag leaf area was higher in the cv. Bari 26 than cv. Bari 24. The highest value of flag leaf area was found in Bari 26, wet treatment and lowest one was found in Bari 24, dry treatment. Although, the area of flag leaf did not show any significant difference (p= 0.05) between the treatments but an increasing tendency of flag leaf area was noted under wet condition. The large flag leaf area usually helps to increase the size of the spike and hence spike yield. (Nazrul Islam and Fouzia 1980)

Plant height was highest in cv. Bari 26 in wet treatment and lowest was noted in cv. Bari 24 in dry treatment. It is observed that plant height was more in wet treatment than those of the dry treatment plants.

Highest value for spike length was found in cv. Bari 24 in wet and lowest one is in cv. Bari 26, dry. So, it can be said that water treatment has little influence over the spike length.

In the same way, there was little difference in spike weight with the difference of water treatment. In wet treatment the highest and lowest spike weights were in cv. Bari 24 and cv. Bari 26. It is noticeable that in cv. Bari 24 highest spike weight was observed in wet condition but in case of cv. Bari 26, the maximum spike weight was found in dry condition.

Weigth of 100 grains was slightly higher in wet treatment than those of dry treatment plants. The maximum weight was in Bari 24, wet treatment (5.53 ± 0.35 g) and minimum in Bari 26 in dry treatment (4.54± 0.29g). The results show that in wet treatment, the grain size to some extent was increased.

From the above analysis, it was found that water treatment had significant role on the growth of wheat plants. It can be said that, wet conditions are more favorable for the growth and yield of wheat cultivars than the dry condition. Seedling establishment of *Aira praecox* is slightly higher under drought condition than that of *Aira caryophyllea* (Pemadasa and Lovell 1974) although the germination requirements of both species are very similar (Pemadasa and Lovell 1975).

IV) Tissue water relation of wheat cultivars in dry and wet treatments

In general, cultivars of dry treatment not only had highest relative water content but also showed quick stomatal closure. Cv- Bari 26, dry treatment plants exhibited highest (92.00 ± 1.20) relative water content at stomatal closure. The wet treatments of cv. Bari 26 and cv. Bari 24 showed a lower relative water content (91.07 ± 1.54 and 85.29 ± 3.70) respectively of leaves at stomatal closure and significantly different from the other treatments. This suggests that cv Bari 26 is more sensitive than cv Bari 24. The results of the present investigation also suggest that in general the relative water content values at stomatal closure were low in wet treatment. There is evidence (Nazrul Islam 1983) on the important of water factor in respect of plant distribution of wetland and dry land habitat species and also in crop plants grown under waterlogged and non waterlogged conditions (Nazrul Islam and Yasmin 1982); Nazrul Islam and Alam 1986; Nazrul Islam 1987).

Leaves of dry treatment plants of cv Bari 24 and cv Bari 26 appeared to show more rapid stomatal closure (42: 00 minutes and 44: 00 minutes respectively) than the leaves of the wet treatment; cv. Bari- 24 of wet treatment took the longest time (58.25 minute) for stomatal closure (Table 5.1)

Wet treatment plants showed the maximum rate of loss of water, while dry treatment plants exhibited the lowest. In both cv. Bari 24 and cv Bari 26 wet treatment exhibited highest total (8.75 ± 1.42 and 8.07 ± 0.09 respectively) and also stomatal (7.09± 1.35 and 6.43 ± 0.88 respectively) loss of water, while dry condition cv. Bari 24 and cv Bari 26 have the lowest total (4.84 ± 0.51 and 5.90 ± 0.76 respectively) loss of water (Table 5.2). This result agrees with the work reported in jute (Nazrul Islam and Alam 1986, and Nazrul Islam 1983).

High rate of total and stomatal transpiration in cv. Bari 26 of wet treatment is an indication of high uptake of water and ions. The results also showed that the species with high transpiration rate also showed high cuticular transpiration. It is of interest that the species with high rate of total transpiration (wet treatment cv Bari 24 and cv Bari 26) have the highest stomatal sensitivity to water loss (Table 5.2). Okali (1971) found that cuticular transpiration represents a high proportion of the total water loss from the leaves of the cultivars with a low transpiration rate.

CHAPTER-7

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