EFFECT OF GENOTYPES ON THE YIELD PERFORMANCE OF WHEAT (*Triticum aestivum* L.)

BY

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of Genotypes on the yield performance of Wheat (*Triticum aestivum* L.)"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science in Agricultural Botany**, embodies the results of a piece of bonafide research work carried out by **Farzana Afroz Linu**, Registration number: **04-01291** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
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ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2008 to March 2009. Seeds of 19 genotypes of wheat were sown on November 30 to determine their relative performance on the yield and yield components. The experiment was laid out in randomized complete block design (RCBD) with three replications. The highest yield (3.32 t ha^{-1}) was obtained in the variety Gourab and the lowest in Pavan-76(2.64 t ha^{-1}). In respect of yield the sequence of genotypes in Gourab≥ BL-1022>Sufi> kolyan Sona > BAW-1104> BL-1883≥BAW-1051>BAW-917> BAW-1064> Prodip> Bijoy> IVT-9> Sonora> Sourab> Shatabdhi≥IVT-10> Flag-66> Kanchan> Pavan-76. Gourab produced the higest yield. It also produced the highest weight of 1000 seeds (49.10g) which was statistically similar (48.62g) to Kolyan Sona and the lowest weight (36.98g) was found in Pavan-76. The maximum number of spike lets per spike (19.73) was found in Prodip, while the minimum number (15.30) was recorded in IVT-10. Results revealed that the genotype which produced the highest yield that also produced best yields components characters. Low yielding genotype produced decreased leaf area, TDM, Fewer fertile spike let. Genotypes Gourab and BL-1022 showed better performance over the others in respect of growth, reproductive, yield and yield contributes characters among the genotypes under study.

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CHAPTER 1

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world grown in diversed environmental conditions. It is a staple food for about one billion people in as many as 43 countries and provides about 20% of the total food calories. About two third of the total world's population consume wheat as staple food (Majumder, 1991). It contains carbohydrate (78.1%), protein (14.7%), minerals (2.1%), fat (2.1%) and considerable proportion of vitamins.

In Bangladesh, it is the second most important staple food crop and at present about 707.56 thousand hectares of land in Bangladesh is covered by wheat with the annual production of 1,578 thousand tons (BBS, 2008). Though wheat is an important cereal crop in Bangladesh but the average yield is very low compared to that of the advanced countries. In order to meet the on going food deficit and to cope with the food demand for the increasing population, wheat production needs to be increased in Bangladesh. Though this yield of wheat is low and even lower than its genetically yield potential the popularity of this crop is increasing in our country day by day. The scope of increasing the cultivated land is limited in Bangladesh due to occupation of land for accommodating the ever growing population. So, the only way to meet the food demand is to increase the total production as yield per unit area.

Generally wheat is sown in mid-November to ensure optimal crop growth. Late planting of wheat is one of the major reasons of yield reduction because about 60% of the wheat crop is cultivated at late sowing condition after harvesting the transplanted aman rice (Badaruddin *et al.*, 1994). In Bangladesh, late planting wheat exposed to high temperature at reproductive stage causing reduced kernel number per spike (Al-Khatib and Paulsen, 1990 and Bhatta *et al.*, 1994) and reduced kernel size (Acevedo *et al.*, 1991 and Asana and Saini, 1962). The net effect of those is the reduced grain yield. However, this problem will be further increased due to global warming because in Bangladesh also the annual mean temperature of 25.75^{0}C will rise by about 0.21^{0}C by 2050 and 2100, respectively (Karmakar and Srestha, 2000).

In Bangladesh, wheat is grown during Rabi (winter) season and it is dry and as such, the inadequate soil moisture in this season limits the use of fertilizers, and consequently results in decreased grain yield. About 42.78% of the total wheat area in the country is irrigated and the rest of the area is cultivated under rainfed condition (BBS, 1998). Irrigation plays a vital role in terms of bringing good growth and development of wheat. Insufficient soil moisture affects both the germination of seed and uptake of nutrients from the soil. Irrigation frequency also has a significant influence on growth and yield of wheat (Khajanij and Swivedi, 1988). These suggest that irrigation water should be supplied precisely at the peak period of crop growth, which may provide good yield of wheat. Shoot dry weight, number of grains, grain yield, biological yield and harvest index decreased to a greater extent when water stress was imposed at the anthesis stage while imposition of water stress at booting stage caused a greater reduction in plant height and number of tillers (Gupta *et al.*, 2001). The lowest value corresponded to the treatment with irrigation during grain filling and that under rainfed conditions (Bazza *et al.*, 1999).

Variety plays an important role in producing high yield and good quality wheat. Different varieties respond differently to input supply, cultivation practices and the prevailing environment during the growing season. Recently, efforts were taken to increase the yield of wheat in Bangladesh by releasing a number of high yielding varieties. In Bangladesh, although some varieties have been identified for late sowing condition (Islam *et al.*, 1993 and Ahmed *et al.*, 1989) but determining characters of water deficit tolerant varieties have not yet been well studied. Identification of wheat genotypes or crop characters of wheat suitable for water deficit condition would be an important step for achieving high yield potential of wheat in Bangladesh, although some varieties were identified for late sowing condition (Islam *et al.*, 1993).

In the selection of superior variety with proper water application facilities, its productivity needs to be tested. Lack of irrigation facilities was found to be a major constraint for 38% wheat growers, and 25% of the farmers of Bangladesh could not grow wheat due to this problem (Ahmed and Elias, 1986). Considering the above mentioned facts 19 genotypes of wheat were selected to examine their yield performance where only one irrigation was provided. In present situation, this research work was carried out with the following objectives-

1. To determine the effect of different genotypes on various morphological attributes of wheat.
2. To determine the influence of genotypes on the yield and yield components of wheat.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Suitable variety and sowing time are important determinates of growth, yield contributing characters and yield of wheat, wheat being a important cereal, some works have been done in our country to develop a sustainable improved management practices required to achieve higher yield of this crop. Very few research works related to growth, yield and development of wheat variety due to sowing time, water deficit and morpho-physiological attributes have been carried out. The research work also so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works and research findings related to the sowing time, water deficit and varieties of wheat done at home and abroad on this crop have been reviewed under the following heading in this chapter.

2.1 Effect of sowing date

The major non-monitory inputs for enhancing wheat production is optimum time of sowing which is the most important agronomic factor affecting the growth and development of plants. Research works done at home and abroad showed that delay in sowing after the optimum time which coincides with the onset of seasonal rains, consistently reduced yields. However, the important works regarding the sowing dates are presented below-

Plant height is the total length of plant from the soil to the top of the leaf. In the early stage of development, it is a good indicator for overall development. It is considered as an important plant character related to grain yield in barley. Plant height has been found to vary from variety to variety in barley and is dependent on genotype and cultural environment. In a trial with cultivar Balaka in Joydepur and Jessore, BARI (1984) reported that the tallest plant (76.83 cm) was obtained at Jessore when sowing was done on 20 November and shortest with 30 December sowing.

In an experiment Moula (1999) study the effect of sowing time on growth and development of barley varieties and reported that the tallest plant was recorded by Novenber 25 sowing (111.8 cm) and the shortest plant was recorded by December 25 sowing (73.8 cm). Similar results have also been observed by Farid *et al.* (1993).

Chowdhury (2002) conducted an experiment with four sowing dates and reported that delay in sowing decreased plant height. At the final harvest highest plant height was observed in November 1 sown plant. But at 60 DAS highest plant height was recorded in December in 15 sown plants.

Haider (2002) reported that November 15 sown plants of all cultivars of wheat under each irrigation regimes were found to be taller than December 5 sown wheat plants. In a trial with wheat in Joydebpur and Jessore, BARI (19984) reported that the highest number of effective tillers plant-1 was obtained by 20 November sowing similar finding were reported by sarker *et al.* (1999).

The associations of yield and effective tiller were also reported by many scientists. Shrivastava *et al.* (1998) studied relationship between various traits in wheat. They reported that yield had significant positive correlation with effective tillers per plant. Chowdhury (2002) conducted an experiment with four sowing dates and reported that the highest number of average tillers plant^{-1} were produced by November 15 sown wheat plants and the second highest number were produced by November 30 sown plants which was at par with November 1 sown plants. The lowest number of tillers plant-1 were produced by December 15 sown plants.

Zhao *et al.* (1985) conducted experiments on barley in China under two different sowing dates, viz., October 28 and November 17 in 1982-83 and November 7 and November 27 in 1983-84. They found that with delay in sowing tiller and ear number/10 plants decreased from 64 to 41 in 1982-83 and from 49 to 18 in 1983-84. The full growth period was shortened with delay in sowing.

Sekhon *et al.* (1991) reported that early sowing decreased the number of spikelets $spike^{-1}$, grains $spike^{-1}$ but increased 1000-grain weight and yield of wheat. They also reported that late sowing decreased 1000 grain weight and yield.

Ryu *et al.* (1992) concluded that the highest grain weight of barley was reached at 40 days after heading in early and intermediated sowing and 35 days in late sowing.

Eissa *et al.* (1994) observed that spikes m^{-2} and grains $spike^{-1}$ were significantly increased while grain weight non-significantly decreased as sowing date was delayed from November to December.

Chowdhury (2002) conducted an experiment with four sowing dates and reported that spike length, grains $spike^{-1}$ and 1000-grain weight decreased with delay in sowing date from November 15 and the lowest spike length, grains $spike^{-1}$ and 1000-grain weight were recorded in December 15 sown plants. Haider (2002) reported that early sown plants (November 15) had the highest spike length, grains $spike^{-1}$ and 100-grain weight and late sown plants (December 5) resulted the lowest values of these parameters of wheat.

Zende *et al.* (2005) An experiment was conducted during the 2002/03 rabi season in Akola, Maharashtra, India, to evaluate the effects of sowing time (15 November, 1 December and 15 December) on the growth and yield of durum wheat (*Triticum durum)* and concluded that the growth, yield and yield attributes, except for the spike length, showed significant increases when durum wheat crops were sown on 15 November compared with those sown on 1 December and 15 December.

Hossain *et al.* (1990) observed that maximum grain yield was obtained when the wheat was sown November 20 due to higher number of grains $spike^{-1}$ and the highest 1000-grain weight.

Farid *et al.* (1993) conducted an experiment on_sowing dates in 1987-88 having five_sowing times started from November with 15 day intervals with three cultivars of barley viz. Centinella, AP-1-19 and AP-1-20. They observed that November 5 was found to be the optimum time for AP-1-20 and November 5 to December 5 for Centinella and AP-1-20, respectively. In general, all the cultivars of barley performed better when sown on November 5. In all cases yield was reduced significantly with delayed sowing beyond December 20.

Comy (1995) concluded from two years study in Ireland on malting barley cv. Blenhiem sown on March, early April and late April that the earliest sown spring barley generally gave the highest yield and the best quality grain. BARI (1997) reported from the study in Jamalpur during the rabi season of 1997-98 on barley cv. Conquest that among the five sowing dates viz. November 5, November 20, December5, December 20 and January 5, the grain yield was statistically different among those sowings. The crop sown on December 20 produced the lowest grain yield which was closely followed by that of January 5 sowing. Adrastic reduction in grain yield was observed when the crop was sown on December 5 or later.

A field experiment was conducted by Chowdhury (2002) at four sowing dates viz. sown at November 1, November 15, November 30 and December 15 and reported that the highest grain yield was recorded in November 15 sown plants and the next highest value was recorded in November 30 sown plants and the lowest yield was recorded in December 15 sown plants.

Haider (2002) conducted experiment in 1998-1999 and 1999-2000 with two sowing dates and reported that December 5 sown plants produced significantly higher grain yield in both the years for all the irrigation regimes and varieties of wheat and the lowest yield was recorded in December 5 sown plants.

A field experiment was conducted by Ahmed *et al.* (2006) at Farming System Research and Development (FSRD) site, Chabbishnagar, Godari, Rajshahi under rainfed condition during rabi seasons of 2001-2002 and 2002-2003 to find out the suitable variety (BARI Barley-1, BARI Barley-2 and local) and sowing time of barley (30 November, 15 December and 30 December). They concluded that grain and straw yields increased significantly with early sowing (30 November) in all varieties in both the years. The results show that early sowing (30 November) combined with BARI Barley-1 gave the highest grain (2.55 t/ha) and straw yield (4.28 t/ha), whereas the lowest grain yield (1.23 t/ha) and straw yield (3.21 t/ha) was obtained from local variety with delay sowing.

Harvest index (HI) is the ratio of economic yield to biological yield and is a useful index of assessing the extent of phytomass converted into useful economic yield. The economic yield of barley is its grain and biological yield of a crop is the TDM at final harvest (Donald and Hamblim, 1976).

Sharma (1993) conducted an experiment with eight spring wheat (*Triticum aestivum)* cultivars and 2 advanced breeding lines in Nepal and showed that due to delayed sowing harvest index was reduced and maximum harvest index of 41.1% occurred with the November 25 sowing.

Samuel *et al.* (2000) reported that late sowing condition (6 January 1997) reduce the harvest index (36.1%) from (41.5%) of normal sowing condition (29 November 1996) in wheat. Ehdaie *et al.* (2001) reported that early sowing decreased harvest index. Ram *et al.* (2004) found that the highest harvest index was obtained in November 20 sown wheat.

From the above review of literature it is evident that sowing time has a significant influence on yield and yield components of barley. The literature suggests that early or delay sowing other than optimum time reduces the grain yield of barley which is directly related with the temperature of the growing period of the crop. Reduction in grain yield is mainly attributed by the reduced number of spike plant^{-1}, grains spike^{-1} and thousand grain weight due to curtailment of period for development of these parameters.

2.2 Effect of water shortage

Supply of irrigation water or moistures has dramatic effects on growth, development and yield of any crop. Water deficit at various phases of crop growth has direct effect on crop yield. Reduction in growth as result of water deficit crop yields under dry land condition are related to seasonal rainfall, water use efficiency can be substantially can be substantially improved by crop management practices (Harris *et al.*, 1991). The introduction of supplemental irrigation to winter grown cereals can potentially stabilize and increase yields, as well as increasing water use efficiency received both from rainfall and from irrigation (Oweis *et al.*, 1992). In Bangladesh, very little works have been done regarding agronomic practices of barley especially on the response of irrigation frequency. However, some available findings on the performance of barley and related crops like wheat and millet under irrigation are reviewed and presented below.

Growth and yield of barley under water stress was studied by Gales and Wilson (1979). They observed that water stressed plants mature earlier than the well watered plants. Singh and Bhalla (1994) reported that both bread wheat and duram wheat are susceptible to water stress during germination, total germination percentage, germination rate, coleoptile and root length decreased with increasing water stress.

Won Yul *et al.* (1997) conducted a pot experiment to know the effects of water stress at heading, or 20 or 10 days before heading in barley cv. Milyang 12, Durubori, Olbori, Baegdong and Hyangmaeg and reveled that resistance to water stress was in the order Olbori > Milyang 12 = Durubori > Hyangmaeg > Baegdong.

It was observed that irrigation frequency had significant effect on days required to maturity of barley. Three irrigations (irrigations at 25 DA + 50 DAS + 75 DAS) took the longest days to maturity that of two irrigations i.e., 25 DAS and 50 DAS (Moula, 1999).

Crop growth and yield are largely limited by soil water availability. Water stress is a serious problem in many parts of the world where cereals are a part of the staple diets. Although crop growth is controlled by numerous factors, water stress is by far the most important impediment. According to the available literature increase water stress reduces germination and plant growth activities (Quarrie *et al.*, 1999).

Islam (1992) reported that dry matter accumulation in bread wheat cultivars decreased with increasing degree of water stress. Intermittent water stress is more harmful than continuous water stress and stressed at heading affected dry matter production more than stress at earlier.

Torofder *et al.* (1993) observed that increase in total dry matter (TDM) production in barley was noticed clearly up to three irrigations as compare to one or two irrigation. They also found that increased in TDM due to irrigation compared to control (no irrigation). Gaffer (1995) reported that increased in TDM due to increased number of irrigation in millet.

Rahman (1997) reported that irrigated plants had always greater TDM plant^{-1} than the rainfed plants. Hossain (2006) conducted an experiment with barley and reported that TDM production plant^{-1} increased with increased the number of irrigation upto 90 DAS and the highest TDM production plant^{-1} was observed in three irrigation and the lowest was in control. Similar result was also reported by Kumar and Agarwal (1991) in barley.

Rahman (1997) reported that irrigated plants had always greater LAI at all the growth stages than rainfed plants and in both treatments starting from a lower value, LAI reached a certain peak at the booting stage of growth and declined thereafter gradually and the similar result was also reported by Haider (2002) in wheat.

Moula (1999) conducted a field experiment during 1998-99 season on barley with levels of irrigation viz. one at crown root initiation (CRI) and two both at CRI +

booting stage and reported that leaf area index (LAI) increased over control (no irrigation) and the highest was recorded at two irrigation schedule.

Singh and Anureet (2001) carried out experiment on malt barley cv. Alfa-93 was treated with 4 levels of irrigations, viz. I0 (no irrigation), I1 (one irrigation at tillering stage), I2 (one irrigation at flag leaf stage) and I3 (two irrigations, first at tillering and second at flag leaf stage), in Hisar, Haryana, India and reported that treatment I3 significantly increased plant height, number of tillers, dry matter accumulation, leaf area index, yield (grain + straw) and yield attributes.

Rahman (1997) reported that plant height was higher in irrigated condition than rainfed condition. Singh and Anureet (2001) reported that plant height of barley increased with increased number of irrigation. Similar result in barley was also reported by many researchers such as Wahab and Singh (1983), Singh *et al.* (1989), Kumar and Agarwal (1991) and Torofder *et al.* (1993).

Hossain (2006) conducted an experiment to observe the growth and development of barley as affected by irrigation frequency and reported that plant height of barley increased with increased the number of irrigation. He further reported that plant height of barley was greater in irrigated plot than in the control plot.

Torofder *et al.* (1993) observed that application of one irrigation at crown root initiation (CR) stage and two irrigations both at CRI and heading stage showed statistically similar number of effective tillers plant $^{-1}$ but significantly increased over control (no irrigation). Similar result was reported by Singh *et al.* (1989), Grant *et al.* (1991) and Kumar and Agarwal (1991) in barley.

Rahman (1997) reported that number of tillers plant^{-1} significantly higher in irrigated plants in comparison to rainfed plants. Similar result was also reported by Haider (2002) in wheat.

Hossain (2006) reported that number of tiller plant $^{-1}$ increased with increased number of irrigation. The highest effective tiller plant^{-1} was observed under three irrigations (irrigation at 25 DAS + 50 DAS + 75 DAS) which was statistically similar to that of two irrigations (irrigation at 25 DAS + 50 DAS). In contrast, the lowest number of effective tiller plant -1 was recorded in rained plants.

The most of the researchers reported that spike length increased with increase number of irrigation (Grant *et al.*, 1991, Torofed *et al.*, 1993, Rahman, 1997 and Uppal *et al.,* 1998). In contrast, Anonymous (1998) reported that irrigation had no significant effect on panicle length in barley.

Both significant and insignificant effect due to irrigation on spike length was observed in barley. Moula (1999) reported that length of spike was significantly influenced by irrigation and the longest spike length was obtained at two irrigation compared to one no irrigation.

Irrigation regimes had significant effect on panicle length and the rainfed treatment resulted in the lowest panicle length in all cultivars in both growing season in wheat (Haider, 2002).

Torofder *et al.* (1993) opinioned that supplemental irrigation had beneficial effect on barley when they concluded that application of one irrigation at CRI and two irrigations both at CRI and heading stage produced greater spikelets spike^{-1} than in control but within the irrigation treatments, there was no significant difference in spikelet number spike^{-1} .

Haider (2002) conducted an experiment to find out the effect of water stress on the physiology and grain yield of four bread wheat cultivars and reported that irrigation treatments increased the number of spikelets per spike in both growing dates and the I_2 plants were found to have the highest number of spikelest per spike and the I_0 plants had the lowest number of spikelets per spike in both growing season.

Rahman (1997) reported that soil moisture regimes had significant effect on 1000-grain weight of wheat. On the other had, Rahman (1997) reported that irrigation regimes had no significant effect on 1000-grain weight of foxtail millet. Haider (2002) reported that irrigation had significant influenced on 1000-garin weight in wheat. Similar result was also reported by Shaheb (2004) in wheat.

In a field trial on barley in India, Uppal *et al.* (1998) observed that two irrigations both at active tillering and heading stage produced higher yield than that of one irrigation at active tillering stage. Similar result was also reported by Kumar and Agarwal (1991), Torofder *et al.* (1993) and Moula (1999) in barley.

Haider (2002) conducted an experiment to find out the effect of water stress on the physiology and grain yield of four bread wheat cultivars and reported that the rainfed condition resulted the in the lowest grain yield per plant in all cultivars in both years as well and drastic reduction in grain yield per plant due to rainfed condition was found in Opata and Protiva variety of wheat in both growing season. Similar result was also reported by Rahman (1997) in wheat.

Wojtasik (2004) conducted field and laboratory experiments during 1996-98 in Poland to evaluate the effect of sprinkling irrigation and fertilizer application on malt and fodder barley. Sprinkling irrigation and high rates of NPK fertilizers significantly increased photosynthesis, carbon dioxide assimilation (by 50%) and transpiration (by 30%). Similarly, both treatments increased nitrate reductase activity, stalk length and width, and leaf and ear size. Fodder barley gave the best results.

Nowak *et al.* (2005) a field experiment conducted in the years 2002-2004 in Samotwor near Wrocaw (Poland) assessed the usefulness in the cultivation of spring brewing barley cv. Scarlett on a light soil under sprinkler irrigation. Under natural precipitation the yield of barlet grain tanged from 34.06 dt ha^{-1} (2992) to 54.16 dt ha^{-1} (2003) They also reported that sprinkler irrigation caused a 7.5% increase in the grain yield.

Hossain (2006) reported that frequency of irrigation had significant effect on grain yield of barley. Result revealed that grain yield increased with increasing number of irrigation. The grain yield (3.43 t ha^{-1}) was observed in three irrigations in growing period which was statistically similar with two irrigation and the lowest yield was recorded in rainfed plant (1.72 t ha^{-1}).

Two use terms used to describe partitioning of dry matter by the plant are biological yield and economic yield the term biological yield. Harvest index reflects the proportion of assimilate distribution between economic and total biomass (Donald and Hamblin, 1976). Crop yield can be increased either by increasing the total dry matter produced in the field or by increasing the proportion of economic yield (the harvest index) or both.

Moula (1999) carried out an experiment on barley with two irrigation viz. no irrigation, one irrigation at CRI and two irrigations both at CRI and booting stage and reported that two irrigations had the highest harvest index (HI) followed by one irrigation and control (no irrigation) had the lowest HI. Similar result was also reported by Kumar and Agrwal (1991) and Torofder *et al.* (1993) in barley.

2.3 Effect of variety on growth and yield of wheat

Maikstenicne *et al.* (2006) carried out a field experiment at the Lithuanian Institute of Agriculture's Joniskelis Experimental Station during 2004-2005 to estimate the changes in productivity and quality indicators of winter wheat varieties. The tests involved: Ada and Bussard (with very good food qualities), Lars and Tauras (with satisfactory food qualities) varieties. The higher grain yield was produced in varieties with satisfactory food qualities compared with those with very good food qualities. The highest contents of protein for grain quality improvement at ripening stage without urea solution application were accumulated by the varieties.

Sulewska (2004) carried out an experiment with 22 wheat genotypes for comparing vegetation period, plant height, number of stems and spikes, yield per spike. He noticed a greater variability of plant and spike productivity and of other morphological characters due to variety. He also reported that the variety

Waggershauser Hohenh Weisser Kolben gave the highest economic value among the tested genotypes.

Jalleta (2004) conducted an experiment in farmer's level with a number of improved bread wheat varieties for production in the different climatic zones. Farmers identified earliness, yield and quality as the main criteria for adaptation of wheat varieties and they found that the variety HAR-710 gave 2.56 t ha^{-1} and PAVON-76 gave 2.49 t ha^{-1} grain yield.

Wheat Research Center (2003) of Bangladesh conducted an experiment in the Wheat Research Centre Nashipur, Dinajpur to examine the performance of genotypes among various tillage operations and to understand the effects of interaction between genotypes and tillage operations. Two cultivation methods were applied in the main plot and 10 wheat genotypes (Kanchan, Gourav, Shatabdi, Sourav, BAW 1008, BAW 1006, BAW 1004, BAW 969, BAW 968 and BAW 966) were tested in the sub plots. The genotypes showed a wide range of variation for yield and related characters. Under bed condition, all the genotypes significantly produced higher grain yield except Gourav and Sourav. Variety Shatabdi produced maximum grain $spike^{-1}$ and 1000 grain weight.

BARI (2003) tested performance of different varieties of wheat and found Shatabdi produced the highest yield (2.72 t ha^{-1}) followed by Gourav (2.66 t ha^{-1}). The lowest yield was produced by Kanchan (2.52 t ha^{-1}).

Litvinrnko *et al.* (1997) produced winter wheat with high grain quality for bread making in Southern Ukraine. Wheat breeding was started more than 80 years ago. Over this time, seven wheat varieties were selected where yield potential increased from 2.73 to 6.74 t ha^{-1}.

Samson *et al.* (1995) reported that among the different varieties the significant highest grain yield (3.5 t ha^{-1}) was produced by the variety Sowghat which was closely followed by the variety BAW-748. Other four varieties namely Sonalika, CB-84, Kanchan and Seri-82 yielded 2.70, 2.83, 3.08 and 3.15 t ha^{-1}, respectively.

Arbinda *et al.* (1994) observed that the grain yield was significantly affected by different varieties in Bangladesh. The genotypes CB-15 produced higher grain yield (3.7 t ha^{-1}) that was attributed to more number of spikes m^{-2} and grains $spike^{-1}$.

In varietal demonstration at different districts of Bangladesh BARI (1993) reported that mean yield of Kanchan, Akbar, Agrani and Sonalika were 3.59, 3.29, 3.12 and 2.81 t ha^{-1}, respectively. Variety Kanchan, Akbar, Aghrani showed 28, 17 and 12% higher grain yield over check variety Sonalika.

MATERIALS AND METHODS

MATERIALS AND METHODS

In this chapter the details of different materials used and methodologies followed during the experimental period have been described under the following heads:

3.1 Description of the experimental site

3.1.1 Location

The present piece of research work was conducted in the experimental field of Agricultural Botany, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site was $23^0 74'$N latitude and $90^0 35'$E longitude with an elevation of 8.2 meter from sea level (FAO 1988).

3.1.2 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al.*, 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e Bangla Nagar, presented in Appendix II.

3.1.3 Soil

The soil belonged to "The Modhupur Tract", AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details have been presented in Appendix I.

3.2 Treatments of the experiment:

The experiment comprised of 19 wheat varieties. Name and source of these varieties were:

Variety/Line	Source	Variety/Line	Source
BL-1883	BARI	Sufi	BARI
BAW-1104	BARI	Shatabdi	BARI
BAW-1064	BARI	Kanchan	BARI
Sonora	BARI	Pavan-76	BARI
Sourab	BARI	IVT-10	WRC
Prodip	BARI	Bijoy	BARI
Fang-66	WRC	BL-1022	BARI
Gourab	BARI	Kalyan Sona	BARI
BAW-917	BARI	BAW-1051	BARI
IVT-9	WRC		

3.2.2 Experimental design and layout

The experiment was laid out in randomized complete block design (RCBD) with three replications. There were 57 plots having the size of 2 m(10 row) × 1.5 m.long. 19 varieties of wheat were randomly distributed in the plots.

3.3 Growing of crops

3.3.1 Seed collection

The seeds of different wheat varieties and genotypes for this experiment were collected from Wheat Research Centre (WRC) and Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur.

3.3.2 Preparation of the main field

The plot selected for the experiment was opened in the third week of November 2008 with a power tiller, and was exposed to the sun for a week after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally a desirable tilth of soil was obtained for sowing of seeds.

3.3.3 Application of fertilizers and manure

The fertilizers N, P, K and S in the form of Urea, TSP, MP and Gypsum, respectively were applied. The entire amount of TSP, MP and Gypsum, 2/3rd of urea were applied during the final preparation of land. Rest of urea was top dressed after first irrigation (BARI, 2006). The doses and method of application of fertilizers are shown in Table 1.

Table 3.1 Doses and method of application of fertilizers in wheat field

Fertilizers	Dose (ha)	Application (%)	
		Basal	1st installment
Urea	220 kg	66.66	33.33
TSP	180 kg	100	--
MP	50 kg	100	--
Gypsum	120 kg	100	--
Cowdung	10 ton	100	--

Source: Krishi Projukti Hatboi, BARI, Joydebpur, Gazipur, 2006

Sowing of seeds: The seeds of wheat were hand sown in November 30, 2008. Seeds were placed at about 4-5 cm depth from the soil surface and the seed rate was 36 gm per plot which was equivalent to 120 kg/ ha.

3.3.4 After care

After the germination of seedlings, various intercultural operations such as irrigation and drainage, weeding, top dressing of fertilizer and plant protection measures were accomplished for better growth and development of the wheat seedlings as per the recommendation of BARI (2006).

3.3.4.1 Irrigation and drainage

One flood irrigation at early stage of crop growth was provided for the Experiment (sown on December 30, 2008). Proper drainage system was also developed for draining out excess water.

3.3.4.2 Weeding

Weedings were done to keep the plots free from weeds which ultimately ensured better growth and development of wheat seedlings. The newly emerged weeds were uprooted carefully at tillering (30 DAS) and panicle initiation stage (55 DAS) manually.

3.3.4.3 Plant protection

The crop was attacked by different kinds of insects during the growing period. Triel-20 ml was applied on 5 January and sumithion-40 ml/20 litre of water were applied on 25 January as plant protection measure.

3.4 Harvesting, threshing and cleaning

The crop was harvested manually depending upon the maturity of plant from each plot from the third week of March, 2009. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of wheat grain. Fresh weight of wheat grain and straw were recorded in m^{-2} from each plot. The grains were cleaned and weighed. The weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of wheat grain and straw m^{-2} were recorded and converted to t ha^{-1}.

3.5 Data collection

3.5.1 Emergence of seedlings

The emergence of wheat seedlings in the experimental plots was recorded on the basis of visibility of emergence of seedlings and expressed days to starting of seedling emergence. Days to 50% and 100% seedling emergence was estimated by observing absolute visibility of seedlings of the experimental plots and expressed in days.

3.5.2 Plant height

The height of plant was recorded in centimeter (cm) at 30, 40, 50, 60 DAS (Days after sowing) and at harvest. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.5.3 Number of tillers plant^{-1}

The number of tillers plant^{-1}was recorded at the time of 30, 40, 50, 60 and 70 DAS (Days after sowing). Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.5.4 Number of fertile tillers plant^{-1}

The total number of effective tiller plant^{-1}was counted as the number of panicle bearing tiller plant^{-1}. Data on effective tillers plant^{-1} were counted from 10 selected plants at harvest and average value was recorded.

3.5.5 Number of sterile tillers plant^{-1}

The total number of non-effective tiller plant^{-1} was counted as the number of tillers plant^{-1} without panicle. Data on sterile tillers plant^{-1} were counted from 10 selected plants at harvest and average value was recorded.

3.5.6 Number of total tillers plant^{-1}

The total number tillers plant^{-1} was recorded by adding effective and sterile tillers plant-1. Data on total tillers plant^{-1} were counted from 10 selected plants at harvest and average value was recorded.

3.5.7 Number of leaves per plant

The total number of leaves per plant was counted as the number of leaves from 10 randomly selected plants from each plot and average value was recorded.

3.5.8 Length of flag leaf

The length of flag leaf was measured as the average of 10 plants selected at random from the inner rows of each plot. The length was measured from the base to tip of the flag leaf.

3.5.9 Breadth of flag leaf

The breadth of flag leaf was measured as the average of 10 plants selected at random from the inner rows of each plot. The breadth was measured from the base to tip of the flag leaf and the average of 3 measurements was calculated for getting the mean value.

3.5.10 Leaf area of flag leaf

The area per flag leaf was determined by multiplying the maximum flag leaf length with maximum breadth and with a correction factor 0.75.

3.5.11 Ear length

The length of ear was measured with a meter scale from 10 selected panicles and the average value was recorded.

3.5.12 Days to booting

Days to starting of booting, 50% and 100% booting was recorded by observing and calculating the number of days from sowing to starting of booting, 50% and 100% plant attained their booting condition.

3.5.13 Days to ear emergence

Days to starting of ear emergence, 50% and 100% emergence of ear was recorded by counting the number of days from sowing to starting of ear emergence, 50% and 100% plant completed spike emergence.

3.5.14 Days to anthesis

Days to starting of anthesis, 50% and 100% anthesis was recorded by counting the number of days from sowing to starting of anthesis, 50% and 100% spikes completed their anthesis.

3.5.15 Days to maturity

Days to starting of maturity, 50% and 100% maturity was recorded by calculating the number of days from sowing to starting of maturity, 50% and 100% spikes become brown color.

3.5.16 Number of spikelets spike^{-1}

The total number of spikelets spike-1 was counted as the number of spikelets from 10 randomly selected spikes from each plot and average value was recorded.

3.5.17 Number of fertile florets spike^{-1}

The number of fertile florets spike^{-1} was counted as the number of fertile floret from 10 randomly selected spikes in each plot and average value was recorded.

3.5.18 Number of filled grains spike^{-1}

The total number of filled grains spike^{-1} was counted as the number of filled grains from 10 randomly selected spikes from each plot and average value was recorded.

3.5.19 Number of unfilled grains spike^{-1}

The total number of unfilled grains spike^{-1} was counted as the number of unfilled grains from 10 randomly selected spikes from each plot and average value was recorded.

3.5.20 Number of total grains spike^{-1}

The total number of grains spike^{-1} was counted by adding the number of filled and unfilled grains from 10 randomly selected spike from each plot and average value was recorded.

3.5.21 Grain yield m^{-2}

Grains obtained from per m^2 area of each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area was used to record grain yield m^{-2} and converted this into t ha^{-1}.

3.5.22 Grain yield hectare^{-1}

Grains obtained from m^2 were converted into t ha^{-1} grain.

3.5.23 Straw yield m-^{2}

Straw obtained from m-^{2} area of each unit plot was sun-dried and weighed carefully. The dry weight of straws of central 1 m^2 area was used to record straw yield m^{-2} and converted this into t ha^{-1}.

3.5.24 Straw weight hectare^{-1}

Straw obtained from m^{-2} was converted into t ha^{-1} straw weight.

3.5.25 Weight of 1000 seeds

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

3.5.26 Biological yield

Grain yield and straw yield together were regarded as biological yield of wheat. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield.

3.5.27 Harvest index

Harvest index was calculated from per hectare grain and straw yield that were obtained from each unit plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.5.28 Dry matter content

Stem from ten sample plants of each plot were collected and gently washed with tap water, thereafter soaked with paper towel. Then fresh weight was taken immediately after soaking by paper towel. After taking fresh weight, the sample was oven dried at 70^0C for 72 hours. Then oven-dried samples were transferred into a desiccator and allowed to cool down to room temperature, thereafter dry weight of stem was taken. Dry matter content of stem was calculated using the following formula:

$$\text{Dry matter content of stem} = \frac{\text{Dry weight of stem (g)}}{\text{Fresh weight of stem (g)}} \times 100$$

As per the above procedure dry matter content of lamina, leaf sheath, ear, seeds and husk per plant were recorded.

3.6 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the variety in response to one irrigation. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatment means were estimated by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

Data on different growth characters and yield were recorded to find out the suitable variety which responded better in response to the effect of one irrigation. The results have been presented and discussed, and possible interpretations have been given under the following headings:

The results of this experiment have been presented in the tables 4.1.1-4.1.12, figures 4.1.1-4.1.4 and the ANOVA III-XIV for different characters in the Appendices

4.1.1 Emergence of seedlings

4.1.1.1 Days to emergence

Days to starting of emergence of seedlings varied significantly for different wheat varieties at early sowing with water deficit condition (Table 4.1.1). The maximum days to starting of emergence of seedlings (6.00 days) was recorded from wheat genotypes IVT-10 which was followed by other genotypes except BAW-917 which started emergence of seedlings within minimum days (4.33 days).

4.1.1.2 Days to 50% emergence of seedlings

Different wheat varieties at early sowing with minimum irrigation condition showed significant variation for days to 50% emergence of seedlings (Table 4.1.1). The maximum days to 50% emergence of seedlings (10.67 days) was found from wheat genotypes IVT-9 which was statistically similar with other genotypes except Sonora, BAW-917 and Kalyan Sona, again the minimum days to 50% emergence of seedlings (8.67 days) was recorded from wheat genotypes BAW-917 and Kalyan Sona.

Table 4.1.1. Seedling emergence percentage of different wheat varieties

Genotypes	Days to seedling emergence		
	Starting of emergence	50% emergence	100% emergence
BL-1883	4.67 bc	10.00 abc	13.67 c
BAW-1104	5.00 bc	10.33 ab	14.67 bc
BAW-1064	5.00 bc	9.67 abc	15.33 abc
Sonora	4.67 bc	9.00 bc	14.67 bc
Sourab	5.00 bc	10.67 a	15.67 abc
Prodip	5.00 bc	10.33 ab	15.33 abc
Fang-66	5.00 bc	9.33 abc	15.67 abc
Gourab	5.00 bc	9.67 abc	15.33 abc
BAW-917	4.33 c	8.67 c	13.67 c
IVT-9	6.00 a	10.67 a	17.33 a
Sufi	5.33 b	10.33 ab	16.33 ab
Shatabdi	5.00 bc	9.33 abc	15.00 bc
Kanchan	4.67 bc	9.67 abc	14.33 bc
Pavan-76	5.00 bc	9.33 abc	14.00 c
IVT-10	5.00 bc	10.33 ab	14.33 bc
Bijoy	5.00 bc	10.33 ab	14.00 c
BL-1022	5.00 bc	10.33 ab	14.67 bc
Kalyan Sona	4.67 bc	8.67 c	15.00 bc
BAW-1051	4.67 bc	10.00 abc	14.00 c
$LSD_{(0.05)}$	0.590	1.164	1.933
Level of Significance	**	**	*
CV(%)	7.19	7.16	7.83

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

4.1.1.3 Days to 100% emergence of seedlings

At early sowing with water deficit condition, different wheat varieties showed statistically significant differences in terms of days to 100% seedling emergence (Table 4.1.1). The maximum days to 100% seedling emergence (17.33 days) was observed from wheat genotypes BAW-917, whereas the minimum days (13.67 days) were found from wheat genotypes BL-1883 and BAW-917.

4.1.2 Plant height

Significant differences were observed for plant height at 30, 40, 50, 60 DAS and at harvest for different wheat genotypes at early sowing with one irrigation condition (Figure 4.1.2). At 30, 40, 50, 60 DAS and harvest the tallest plant (22.65 cm, 47.06 cm, 68.64 cm, 85.41 cm and 90.46 cm) was obtained from wheat variety Gourab and the shortest plant (17.99 cm, 37.32 cm, 56.07 cm, 68.31 cm and 70.70 cm) was recorded from wheat variety Pavan-76.

4.1.3 Number of tillers plant^{-1}

Different wheat genotypes showed statistically significant differences for number of tillers per plant at 30, 40, 50, 60 and 70 DAS for at early sowing with less irrigation condition (Table 4.1.2). At 30, 40, 50, 60 and 70 DAS the maximum number of tillers per plant (2.45, 3.27, 3.83, 5.27 and 5.46) was attained from wheat variety Gourab and the minimum number of tillers per plant (1.40, 2.60, 2.83, 3.87 and 4.07) was found from wheat variety Pavan-76.

4.1.4 Number of fertile tillers plant^{-1}

Number of fertile tillers plant-1 showed statistically significant difference for different wheat genotypes at early sowing with less irrigation condition (Table 4.1.3). The maximum number of fertile tillers per plant (5.67) was observed from wheat variety Gourab which was statistically similar (5.40) to Sufi and the minimum number (1.77) was recorded from wheat variety Pavan-76.

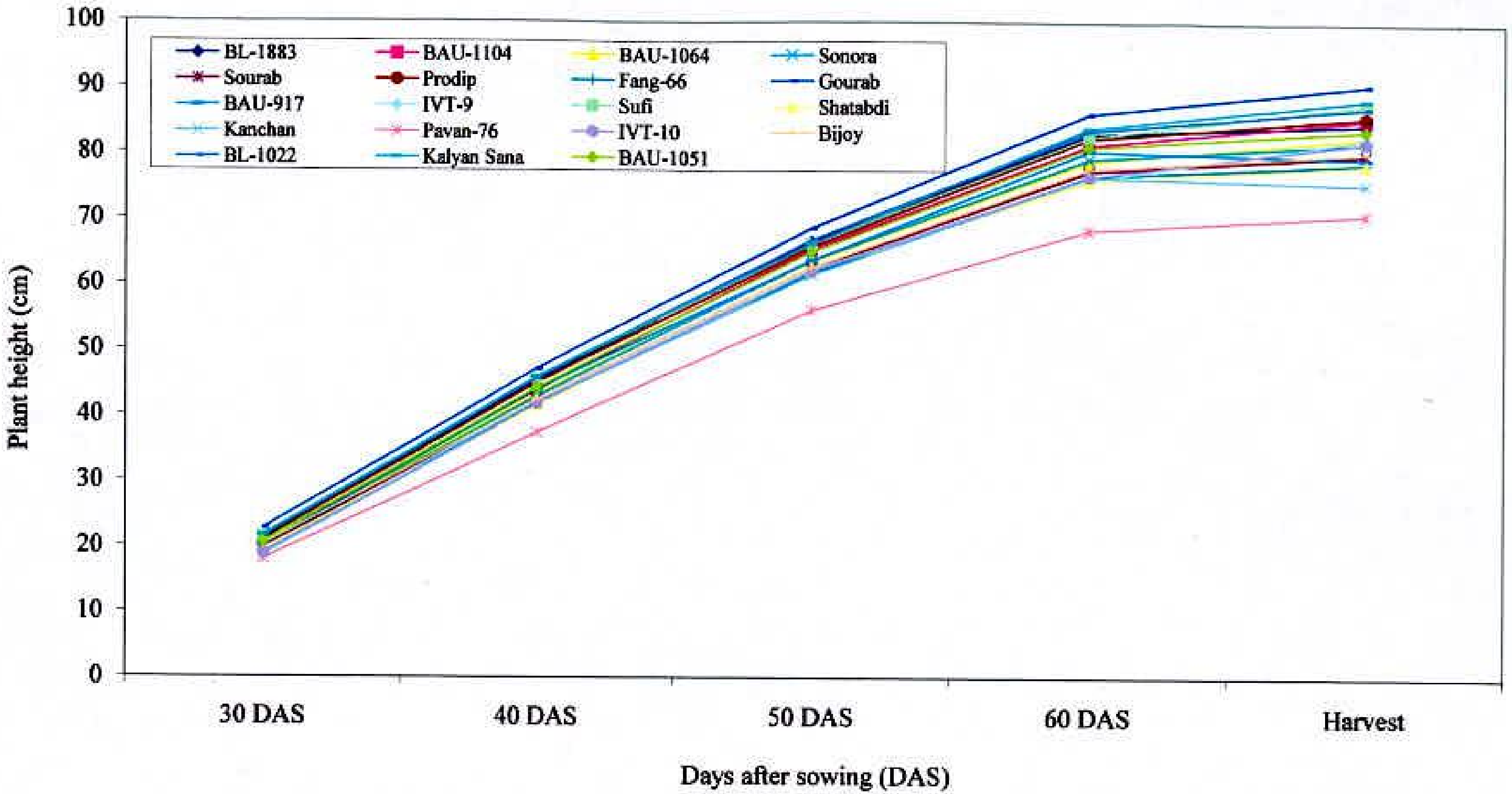

Figure 4.1.1. Trend of increase of plant height of different wheat varieties in response to normal sowing (normal) with one irrigation condition.

Table 4.1.2. Number of total tillers per plant of different wheat genotypes at different days after sowing (DAS)

Genotypes	Number of tillers per plant at				
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS
BL-1883	2.17 ab	3.17 abc	3.74 ab	4.70 abc	5.22 abcde
BAW-1104	2.12 ab	3.17 abc	3.63 ab	4.83 abc	5.16 abcde
BAW-1064	2.04 ab	3.05 abc	3.52 ab	4.52 abcd	4.91 abcde
Sonora	1.95 ab	3.08 abc	3.60 ab	4.47 bcd	4.99 abcde
Sourab	1.92 b	2.97 abc	3.41 ab	4.36 bcd	4.76 bcde
Prodip	2.23 ab	3.14 abc	3.74 ab	4.77 abc	5.18 abcde
Fang-66	1.96 ab	2.93 bc	3.38 b	4.32 bcd	4.63 def
Gourab	2.45 a	3.27 a	3.83 a	5.27 a	5.46 a
BAW-917	1.87 bc	3.04 abc	3.60 ab	4.37 bcd	5.02 abcde
IVT-9	1.82 bc	3.03 abc	3.46 ab	4.47 bcd	4.79 bcde
Sufi	2.25 ab	3.19 abc	3.68 ab	4.97 ab	5.24 abcd
Shatabdi	1.97 ab	3.02 abc	3.52 ab	4.27 bcd	4.68 cde
Kanchan	1.87 bc	2.90 c	3.30 b	4.10 cd	4.60 ef
Pavan-76	1.40 c	2.60 d	2.83 c	3.87 d	4.07 f
IVT-10	2.00 ab	2.97 abc	3.43 ab	4.37 bcd	4.63 def
Bijoy	1.89 b	2.98 abc	3.42 ab	4.38 bcd	4.81 bcde
BL-1022	2.34 ab	3.22 ab	3.72 ab	5.04 ab	5.27 abc
Kalyan Sona	2.25 ab	3.21 ab	3.73 ab	4.77 abc	5.35 ab
BAW-1051	2.08 ab	3.12 abc	3.63 ab	4.70 abc	5.09 abcde
$LSD_{(0.05)}$	0.441	0.257	0.367	0.648	0.529
Level of Significance	*	**	**	*	**
CV(%)	13.16	5.02	6.23	8.58	6.47

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

Table 4.1.3. Number of fertile, sterile and total tillers plant-1 of different wheat varieties

Genotypes	Number of fertile tillers plant-1	Number of sterile tiller plant-1	Number of total tillers plant-1
BL-1883	5.39 abcde	0.99 bcde	6.38 abcd
BAW-1104	5.73 abcd	0.89 ef	6.63 abc
BAW-1064	4.85 cde	0.99 bcde	5.84 cd
Sonora	4.99 bcde	0.97 cde	5.96 bcd
Sourab	4.18 ef	1.03 bcd	5.21 de
Prodip	5.53 abcde	1.04 bcd	6.58 abc
Fang-66	3.08 fg	1.09 abc	4.16 e
Gourab	6.67 a	0.83 f	7.50 a
BAW-917	4.79 cde	0.98 cde	5.77 cd
IVT-9	5.77 abcd	0.96 de	6.73 abc
Sufi	6.40 ab	0.88 ef	7.28 ab
Shatabdi	3.39 fg	1.07 abcd	4.46 e
Kanchan	3.15 fg	1.11 ab	4.26 e
Pavan-76	2.77 g	1.17 a	3.93 e
IVT-10	3.17 fg	1.03 bcd	4.20 e
Bijoy	4.70 de	1.06 abcd	5.76 cd
BL-1022	6.18 abc	0.89 ef	7.06 abc
Kalyan Sona	5.66 abcd	0.98 cde	6.63 abc
BAW-1051	5.34 abcde	0.97 cde	6.31 abcd
$LSD_{(0.05)}$	1.225	0.105	1.164
Level of Significance	**	**	**
CV(%)	12.70	6.23	10.30

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

4.1.5 Number of sterile tillers plant^{-1}

At early sowing with one irrigation condition, number of sterile tillers per plant for different wheat genotypes showed significant difference (Table 4.1.3). The minimum number of sterile tillers per plant (0.83) was recorded from wheat variety Gourab which was statistically similar (0.88) to Sufi and the maximum number (1.17) was observed from wheat variety Pavan-76.

4.1.6 Number of total tillers plant^{-1}

Statistically significant difference was recorded for number of total tillers per plant for different wheat varieties at early sowing with one irrigation condition (Table 4.1.3). The maximum number of total tillers per plant (6.50) was obtained from wheat variety Gourab which was statistically similar (6.28) to Sufi and the minimum number (2.93) was recorded from wheat variety Pavan-76.

4.1.7 Number of leaves per plant

Number of leaves per plant for different wheat varieties, at early sowing with one irrigation condition showed statistically significant differences under the present trail (Figure 4.1.2). The maximum number of leaves per plant (5.87) was found from wheat variety Gourab which was statistically similar (5.63, 5.60 and 5.53) with Sufi, BL-1022 and Kalyan Sona, respectively, whereas the minimum number (4.43) was recorded from wheat variety Pavan-76.

4.1.8 Length of flag leaf

A statistically significant difference was observed for length of flag leaf for different wheat genotypes at early sowing with water deficit condition (Table 4.1.4). The longest flag leaf (19.20 cm) was observed from wheat variety Gourab which was statistically similar (18.70 cm, 18.44 cm and 18.14 cm) with Sufi, BL-1022 and Kalyan Sona wheat varieties, while the shortest (14.98 cm) was found from wheat variety Pavan-76.

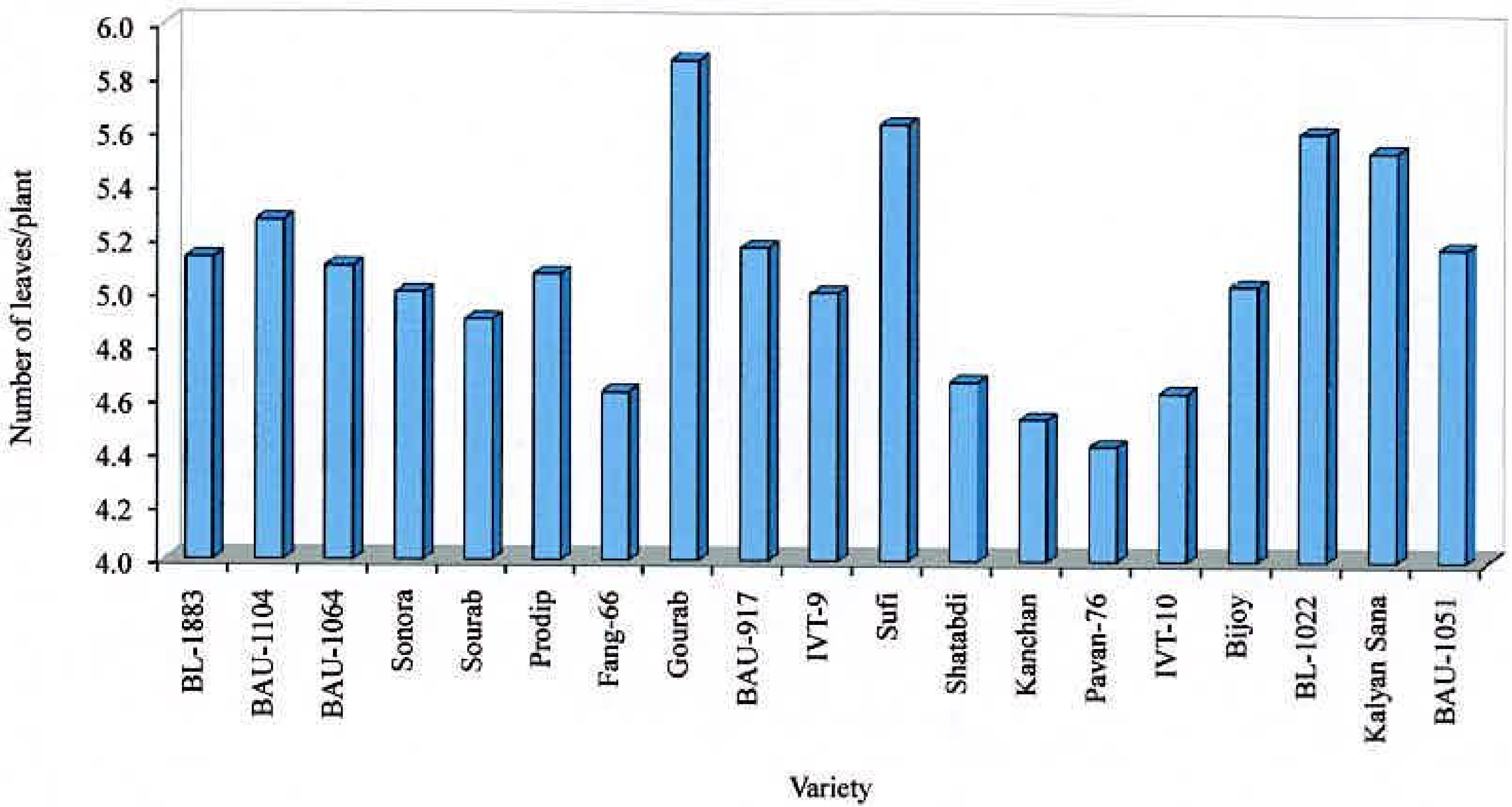

Figure 4.1.2. Number of leaves/plant of different wheat varieties in response to Normal sowing with one irrigation condition

Table 4.1.4. Length, breadth and area of flag leaf and ear length of different wheat genotypes

Genotypes	Length of flag leaf (cm)	Breadth of flag leaf (cm)	Area of flag leaf (cm^2)	Ear length (cm)
BL-1883	17.60 bcde	1.45 ab	25.52 abc	13.92 bcde
BAW-1104	17.85 bcde	1.44 ab	25.78 abc	14.17 bcde
BAW-1064	17.49 bcde	1.28 cd	22.39 bcde	13.75 bcde
Sonora	17.30 cde	1.42 abc	24.56 abc	13.61 cde
Sourab	17.02 de	1.21 de	20.60 defg	13.29 de
Prodip	17.62 bcde	1.47 a	25.95 abc	13.88 bcde
Fang-66	16.65 e	1.10 e	18.34 fgh	12.99 e
Gourab	19.20 a	1.40 abc	26.95 a	15.51 a
BAW-917	17.25 cde	1.41 abc	24.27 abcd	13.56 cde
IVT-9	17.85 bcde	1.44 ab	25.78 abc	14.16 bcde
Sufi	18.70 ab	1.41 abc	26.37 ab	15.01 ab
Shatabdi	16.74 e	1.11 e	18.63 efgh	13.05 e
Kanchan	16.90 de	1.09 e	18.48 fgh	13.20 de
Pavan-76	14.98 f	1.07 e	16.04 h	11.29 f
IVT-10	16.95 de	1.06 e	18.02 gh	13.28 de
Bijoy	16.78 e	1.30 bcd	22.12 cdef	13.06 e
BL-1022	18.44 abc	1.40 abc	25.93 abc	14.70 abc
Kalyan Sona	18.14 abcd	1.37 abc	24.86 abc	14.47 abcd
BAW-1051	17.71 bcde	1.39 abc	24.61 abc	13.99 bcde
$LSD_{(0.05)}$	1.141	0.139	3.508	1.144
Level of Significance	**	**	**	**
CV(%)	10.95	6.44	9.25	5.03

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

4.1.9 Breadth of flag leaf

Significant variation was observed for breadth of flag leaf for different wheat genotypes at early sowing with one irrigation condition (Table 4.1.4). The highest breadth (1.47 cm) was recorded from wheat variety Prodip and the lowest breadth (1.06 cm) was attained from wheat genotypes IVT-10.

4.1.10 Area of flag leaf

Leaf area of flag leaf for different wheat genotypes at early sowing with one irrigation condition varied significantly (Table 4.1.4). The highest leaf area of flag leaf (26.95 cm^2) was obtained from wheat variety Gourab which was statistically similar (26.37 cm^2) to Sufi and the lowest (16.04 cm^2) from variety Pavan-76.

4.1.11 Ear length

In case of early sowing with one irrigation condition significant difference was observed in terms of ear length for different wheat genotypes (Table 4.1.4). The longest ear (15.51 cm) was found from the wheat variety Gourab which was statistically similar (15.01 cm) to Sufi and the shortest length (11.29 cm) was observed from the wheat variety Pavan-76.

4.1.12 Days to booting

4.1.12.1 Days to starting of booting

Days to booting for different wheat genotypes varied significantly in case of early sowing with one irrigation condition (Table 4.1.5). The maximum days to starting of booting (48.33 days) was recorded from wheat genotypes IVT-9 which was statistically similar (47.33 days) to Sufi and the minimum (42.33 days) was recorded from wheat genotypes BL-1883 and BAW-917.

4.1.12.2 Days to 50% booting

Different wheat genotypes at early sowing with one irrigation condition showed significant difference for days to 50% booting (Table 4.1.5). The maximum days to 50% booting (63.00 days) was found in case of wheat variety Gourab which was statistically similar (59.67 days) to Kalyan Sona and the minimum (47.67 days) was recorded from wheat variety Pavan-76.

Table 4.1.5. Days required for booting of different wheat genotypes

Genotypes	Days to booting		
	Starting of booting	50% booting	100% booting
BL-1883	42.33 e	57.67 abcd	62.00 ab
BAW-1104	43.00 cde	56.33 abcd	60.33 ab
BAW-1064	46.67 abcd	55.33 bcd	59.67 ab
Sonora	43.00 cde	54.33 bcde	59.33 ab
Sourab	46.33 abcde	53.33 bcde	59.00 b
Prodip	46.33 abcde	57.67 abcd	61.33 ab
Fang-66	47.00 abc	51.33 cde	58.33 b
Gourab	44.00 bcde	63.00 a	63.67 a
BAW-917	42.33 e	54.67 bcde	60.33 ab
IVT-9	48.33 a	52.33 bcde	58.67 b
Sufi	47.33 ab	58.67 abc	62.00 ab
Shatabdi	45.67 abcde	52.67 bcde	58.00 b
Kanchan	45.33 abcde	50.33 de	58.33 b
Pavan-76	44.00 bcde	47.67 e	54.00 c
IVT-10	42.67 de	51.00 de	58.33 b
Bijoy	43.33 bcde	55.00 bcd	59.00 b
BL-1022	45.00 abcde	58.67 abc	62.00 ab
Kalyan Sona	43.33 bcde	59.67 ab	62.33 ab
BAW-1051	43.67 bcde	56.00 abcd	60.67 ab
$LSD_{(0.05)}$	3.433	6.185	3.764
Level of Significance	**	**	**
CV(%)	5.64	6.79	7.80

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

4.1.12.3 Days to 100% booting

Significant difference was found for days to 100% booting for different wheat genotypes at early sowing with one irrigation condition (Table 4.1.5). The maximum days to 100% booting (63.67 days) was obtained from wheat variety Gourab, whereas the minimum (54.00 days) was observed in case of wheat variety Pavan-76.

4.1.13 Days to ear emergence

4.1.13.1 Days to starting of ear emergence

At early sowing with one irrigation condition statistically significant difference was observed for days to starting of ear emergence for different wheat genotypes under the trial (Table 4.1.6). The maximum days to starting ear emergence (61.00 days) was recorded from wheat variety Gourab, while the minimum (49.33 days) was recorded from wheat variety Pavan-76.

4.1.13.2 Days to 50% ear emergence

Significant variation was recorded for days to 50% ear emergence for different wheat genotypes at early sowing with one irrigation condition (Table 4.1.6). The maximum days to 50% ear emergence (68.00 days) was found from wheat variety Gourab, again the minimum (51.33 days) was observed from wheat variety Pavan-76.

4.1.13.3 Days to 100% ear emergence

Different wheat genotypes varied significantly in terms of days to 100% ear emergence in case of early sowing with one irrigation condition (Table 4.1.6). The maximum days to 100% ear emergence (77.00 days) was found from wheat variety Gourab which was statistically similar (74.33 days and 74.67 days) to Sufi and Kalyan Sona, respectively, whereas the minimum (55.00 day) was observed in wheat variety Pavan-76.

Table 4.1.6. Days required for ear emergence of different wheat genotypes

Genotypes	Days to ear emergence		
	Starting to ear emergence	50% ear emergence	100% ear emergence
BL-1883	59.00 ab	65.00 ab	71.00 abcd
BAW-1104	57.67 ab	63.33 ab	71.67 abcd
BAW-1064	55.67 ab	60.67 ab	69.00 abcde
Sonora	56.00 ab	61.33 ab	68.00 bcde
Sourab	54.67 abc	59.00 bc	66.33 bcde
Prodip	58.00 ab	64.33 ab	72.00 abcd
Fang-66	54.33 bc	58.67 bc	65.00 cde
Gourab	61.00 a	68.00 a	77.00 a
BAW-917	56.00 ab	62.67 ab	65.67 cde
IVT-9	54.67 abc	58.00 bc	68.67 abcde
Sufi	58.33 ab	64.33 ab	74.33 ab
Shatabdi	54.33 bc	57.67 bc	64.67 de
Kanchan	53.67 bc	58.33 bc	61.67 ef
Pavan-76	49.33 c	51.33 c	55.00 f
IVT-10	54.33 bc	58.67 bc	68.33 bcde
Bijoy	55.00 abc	59.67 abc	66.33 bcde
BL-1022	59.00 ab	65.33 ab	73.33 abc
Kalyan Sona	58.67 ab	65.67 ab	74.67 ab
BAW-1051	57.33 ab	63.00 ab	70.00 abcde
$LSD_{(0.05)}$	5.334	7.235	7.195
Level of Significance	*	**	**
CV(%)	5.74	7.13	6.34

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

4.1.14 Days to anthesis

4.1.14.1 Days to starting of anthesis

Significant difference was observed for days to starting of anthesis for different wheat genotypes in case oft early sowing with one irrigation condition (Table 4.1.7). The maximum days to starting of anthesis (81.87 days) was obtained from wheat genotypes BL-1022 which was statistically similar (79.00 days, 77.33 days and 76.33 days) with Gourab, Sufi and Prodip, while the minimum (58.33 days) was recorded from wheat variety Pavan-76.

4.1.14.2 Days to 50% anthesis

At early sowing with one irrigation condition significant difference was observed for days to 50% anthesis for different wheat genotypes (Table 4.1.7). The maximum days to 50% anthesis (80.00 days) was found from wheat variety Gourab which was statistically similar (79.67 days) to Kalyan Sona and the minimum (62.67 days) was observed in wheat variety Pavan-76.

4.1.14.3 Days to 100% anthesis

A statistically significant difference was observed for days to 100% anthesis for different wheat varieties in case of early sowing with less irrigation condition (Table 4.1.7). The maximum days to 100% anthesis (85.00 days) was recorded from wheat variety Gourab which was statistically similar (83.00 days, 82.67 days, 82.33 days and 82.00 days) to BL-1883, Prodip, Kalyan Sona and BL-1022, whereas the minimum (64.33 days) was recorded from Pavan-76 wheat variety.

4.1.15 Days to maturity

4.1.15.1 Days to starting of maturity

Days to starting of maturity for different wheat genotypes at early sowing with less irrigation condition varied significantly (Table 4.1.8). The maximum days to starting maturity (95.00 days) was observed from the wheat variety Gourab which was statistically similar (92.67 days and 91.33 days) to Kalyan Sona and Bl-1022, again the minimum (80.00 days) was recorded from the wheat variety Fang-66.

Table 4.1.7. Days required for anthesis of different wheat genotypes

Genotypes	Days to anthesis		
	Starting of anthesis	50% anthesis	100% anthesis
BL-1883	74.67 abc	78.00 abc	83.00 ab
BAW-1104	70.67 abcd	77.67 abc	79.67 abc
BAW-1064	72.67 abcd	74.33 abcd	77.33 abc
Sonora	73.00 abcd	75.33 abcd	79.00 abc
Sourab	67.33 bcde	72.00 bcd	74.33 abc
Prodip	76.33 ab	78.67 abc	82.67 ab
Fang-66	68.33 bcde	71.33 cd	73.33 bcd
Gourab	79.00 ab	80.00 a	85.00 a
BAW-917	63.67 cde	74.00 abcd	79.33 abc
IVT-9	62.00 de	74.00 abcd	75.33 abc
Sufi	77.33 ab	78.00 abc	81.33 abc
Shatabdi	67.33 bcde	73.67 abcd	77.00 abc
Kanchan	63.33 cde	69.33 d	71.00 cd
Pavan-76	58.33 e	62.67 e	64.33 d
IVT-10	69.00 bcde	72.00 bcd	75.00 abc
Bijoy	72.33 abcd	74.33 abcd	74.67 abc
BL-1022	81.67 a	79.00 ab	82.00 ab
Kalyan Sona	74.67 abc	79.67 a	82.33 ab
BAW-1051	72.67 abcd	76.00 abcd	79.67 abc
$LSD_{(0.05)}$	9.837	6.376	9.079
Level of Significance	**	**	**
CV(%)	8.40	5.15	7.06

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

Table 4.1.8. Days required for maturity of different wheat genotypes

Genotypes	Days to maturity		
	Starting of maturity	50% maturity	100% maturity
BL-1883	90.33 abcd	98.00 abcde	102.67 abcd
BAW-1104	89.67 abcd	101.00 abcd	106.00 abc
BAW-1064	85.00 abcd	94.33 bcde	99.67 abcd
Sonora	86.33 abcd	93.33 bcde	93.00 cd
Sourab	82.33 bcd	90.67 cde	109.00 ab
Prodip	89.67 abcd	99.67 abcde	106.00 abc
Fang-66	80.00 d	90.67 cde	96.67 abcd
Gourab	95.00 a	110.33 a	99.67 abcd
BAW-917	87.00 abcd	91.33 cde	90.00 d
IVT-9	83.00 bcd	93.33 bcde	109.67 a
Sufi	90.67 abc	104.00 abc	105.67 abc
Shatabdi	80.67 cd	89.33 de	96.33 bcd
Kanchan	82.67 bcd	85.67 e	99.67 abcd
Pavan-76	85.00 abcd	87.33 de	96.33 bcd
IVT-10	83.00 bcd	91.33 cde	106.00 abc
Bijoy	83.00 bcd	91.67 bcde	106.00 abc
BL-1022	91.33 ab	105.33 ab	106.00 abc
Kalyan Sona	92.67 ab	99.33 abcde	90.00 d
BAW-1051	88.00 abcd	98.33 abcde	103.00 abc
$LSD_{(0.05)}$	8.656	11.80	11.00
Level of Significance	*	**	**
CV(%)	6.04	7.46	6.57

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

4.1.15.2 Days to 50% maturity

Significant variation was recorded for days to 50% maturity for different wheat genotypes in case of early sowing condition (Table 4.1.8). The maximum days to 50% maturity (110.33 days) was found from wheat variety Gourab which was statistically similar (105.33 days) to BL-1022, while the minimum (85.67 days) was recorded from wheat variety Kanchan.

4.1.15.3 Days to 100% maturity

In case of early sowing with one irrigation condition significant difference was observed for days to 100% maturity for different wheat genotypes (Table 4.1.8). The maximum days to 100% maturity (109.67 days) was obtained from wheat variety IVT-9 which was statistically similar (109.00 days) to Sourab, while the minimum (90.00 days) was recorded from wheat genotypes BAW-917 and Kalyan Sona.

4.1.16 Number of spikelets spike^{-1}

Spikelets per spike for different wheat genotypes showed statistically significant difference in case of at early sowing condition (Figure 4.1.3). The maximum number of spikelets per spike (19.73) was found from wheat variety Prodip, while the minimum number (15.30) was recorded from wheat variety IVT-10.

4.1.17 Number of fertile florets spike^{-1}

Significant difference was observed for number of fertile florets per spike for different wheat genotypes (Table 4.1.9). The maximum number of fertile florets per spike (2.97) was recorded from wheat variety Gourab which was statistically similar (2.88) to Sufi and the minimum number (2.07) was recorded from wheat variety Pavan-76.

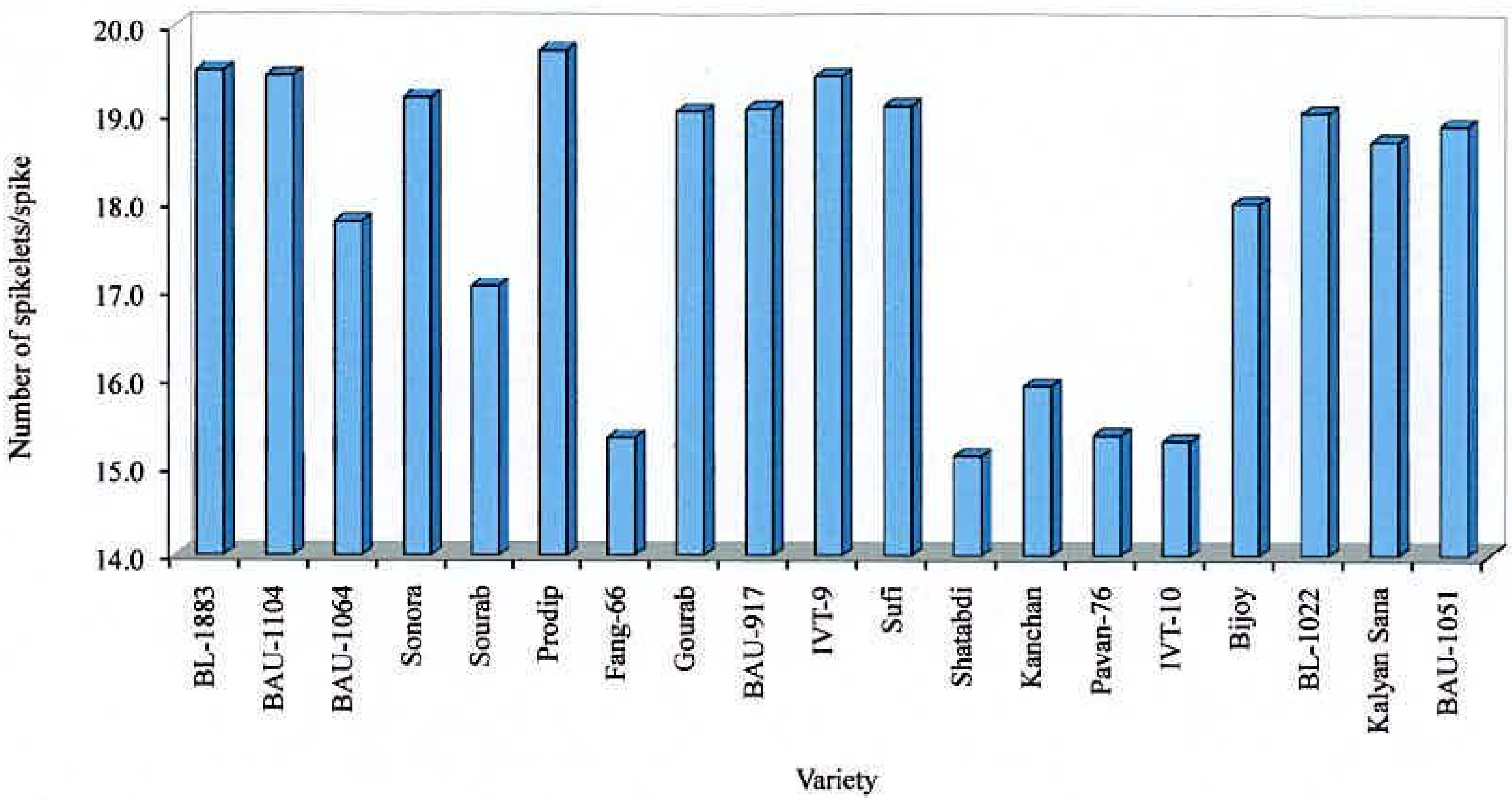

Figure 4.1.3. Number of spikelets/spike of different wheat varieties in response to normal sowign with one irrigation condition

Table 4.1.9. Number of fertile, unfertile and total grains of different wheat genotypes

Genotypes	No. of fertile floret/ spikelet	Filled grains/ spike	Unfilled grains/ spike	Total grains/ spike
BL-1883	2.50 cdefg	43.93 abcde	4.77 bcde	48.70 abcd
BAW-1104	2.60 bcde	46.30 abcd	4.17 ef	50.47 abc
BAW-1064	2.50 cdefg	40.21 cde	4.76 bcde	44.97 cd
Sonora	2.39 defghi	41.16 bcde	4.62 cde	45.78 bcd
Sourab	2.36 defghi	35.63 ef	4.98 bcd	40.61 de
Prodip	2.53 cdef	44.90 abcde	5.07 bcd	49.97 abc
Fang-66	2.18 ghi	28.03 fg	5.32 abc	33.36 e
Gourab	2.97 a	52.73 a	3.77 f	56.50 a
BAW-917	2.33 efghi	39.80 cde	4.70 cde	44.50 cd
IVT-9	2.63 bcde	46.57 abcd	4.53 de	51.10 abc
Sufi	2.88 ab	50.87 ab	4.09 ef	54.96 ab
Shatabdi	2.33 efghi	30.20 fg	5.20 abcd	35.40 e
Kanchan	2.13 hi	28.50 fg	5.47 ab	33.97 e
Pavan-76	2.07 i	25.90 g	5.80 a	31.70 e
IVT-10	2.20 fghi	28.67 fg	4.97 bcd	33.63 e
Bijoy	2.43 defgh	39.19 de	5.13 abcd	44.32 cd
BL-1022	2.79 abc	49.33 abc	4.13 ef	53.46 abc
Kalyan Sona	2.70 abcd	45.77 abcd	4.67 cde	50.43 abc
BAW-1051	2.54 bcdef	43.56 abcde	4.62 cde	48.18 abcd
$LSD_{(0.05)}$	0.301	8.423	0.617	8.052
Level of Significance	**	**	**	**
CV(%)	7.29	12.70	7.80	10.84

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

4.1.18 Number of filled grains spike^{-1}

In case of early sowing significant difference was observed for number of filled grains per spike due to different wheat genotypes (Table 4.1.9). The maximum number of filled grains per spike (52.73) was found from wheat variety Gourab which was statistically similar (50.87) to Sufi, again the minimum number (25.90) was observed from wheat variety Pavan-76.

4.1.19 Number of unfilled grains spike^{-1}

Significant difference was recorded in terms of number of unfilled grains per spike for different wheat genotypes (Table 4.1.9). The maximum number of unfilled grains per spike (5.80) was obtained from wheat variety Pavan-76 which was statistically similar (5.47) to Kanchan, whereas the minimum number (3.77) was recorded from Gourab wheat variety.

4.1.20 Number of total grains spike^{-1}

Total grains per spike for different wheat genotypes varied significantly for number of (Table 4.1.9). The maximum number of total grains per spike (56.50) was recorded from wheat variety Gourab which was statistically similar (54.96) to Sufi, while the minimum number (31.70) was found from wheat variety Pavan-76.

4.1.21 Grain yield m^{-1}

Statistically significant difference was found for grain yield/m^2 for different wheat genotypes at early sowing with one irrigation condition (Table 4.1.10). The highest weight of grain/m^2 (331.56 g) was observed from wheat variety Gourab which was statistically similar (321.18 g) with BL-1022, whereas the lowest weight (263.59 g) was recorded from wheat variety Pavan-76.

Table 4.1.10. Grain and straw yield of different wheat genotypes

Genotypes	Grain	Straw
	Yield (t/ha)	Yield (t/ha)
BL-1883	2.99 bcde	3.99 def
BAW-1104	3.06 bcd	4.23 bcde
BAW-1064	2.96 bcde	4.02 de
Sonora	2.90 def	3.74 efgh
Sourab	2.86 defg	3.71 efgh
Prodip	2.95 cde	3.90 efg
Fang-66	2.73 efg	3.27 gh
Gourab	3.32 a	5.23 a
BAW-917	2.98 bcde	3.82 efgh
IVT-9	2.91 def	4.03 de
Sufi	3.21 ab	4.85 ab
Shatabdi	2.74 efg	3.31 fgh
Kanchan	2.67 fg	3.28 gh
Pavan-76	2.64 g	3.15 h
IVT-10	2.74 efg	3.26 gh
Bijoy	2.92 cdef	3.91 efg
BL-1022	3.21 ab	4.71 abc
Kalyan Sona	3.18 abc	4.66 abcd
BAW-1051	2.99 bcde	4.09 cde
$LSD_{(0.05)}$	0.228	0.602
Level of Significance	**	**
CV(%)	8.64	9.18

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

4.1.22 Grain yield hectare^{-1}

Grain yield per hectare for different wheat genotypes varied significantly (Table 4.1.10). The highest weight of grain per hectare (3.32 ton) was obtained from wheat variety Gourab which was statistically similar (3.21 ton) to BL-1022 and the lowest weight (2.67 ton) was recorded from wheat variety Pavan-76.

4.1.23 Straw yield m^{-1}

Statistically significant variation was recorded for straw yield/m^2 for different wheat genotypes in case of early sowing with one irrigation condition (Table 4.1.10). The highest weight of straw m-^{2} (522.64 ton) was found from wheat variety Gourab which was statistically similar (484.64 g) to Sufi. On the other hand the lowest weight (314.86 g) was obtained from wheat variety Pavan-76.

4.1.24 Straw weight hectare^{-1}

Different wheat varieties in case of early sowing with water deficit condition showed significant difference for straw yield per hectare (Table 4.1.10). The highest weight of straw per hectare (5.23 ton) was obtained from wheat variety Gourab which was statistically similar (4.85 ton) to Sufi, while the lowest weight (3.15 ton) was found from wheat variety Pavan-76.

4.1.25 Weight of 1000 seeds

Significant difference was observed for weight of 1000 seeds for different wheat genotypes in case of early sowing with one irrigation condition (Table 4.1.11). The highest weight of 1000 seeds (49.10 g) was recorded from wheat variety Gourab which was statistically similar (48.62 g) to Kalyan Sona and the lowest weight (36.98 g) was found from wheat variety Pavan-76.

Table 4.1.11. Weight of 1000 seeds, biological yield, harvest index of different wheat genotypes

Genotypes	Days to maturity		
	Weight of 1000 seeds (g)	Biological Yield (t/ha)	Harvest Index (%)
BL-1883	44.75 bcde	6.97 def	42.84 cdefg
BAW-1104	45.85 abcde	7.28 bcde	42.10 efgh
BAW-1064	44.03 cdefg	6.99 def	42.47 defg
Sonora	43.67 defgh	6.64 efgh	43.67 abcde
Sourab	42.21 efgh	6.56 efgh	43.62 abcde
Prodip	44.02 cdefg	6.84 efg	43.14 abcdef
Fang-66	40.17 fghi	5.99 gh	45.50 ab
Gourab	49.10 a	8.54 a	38.82 i
BAW-917	44.75 bcde	6.80 efg	43.79 abcde
IVT-9	44.10 cdef	6.94 def	41.93 efgh
Sufi	47.89 abc	8.06 ab	39.91 hi
Shatabdi	41.76 efgh	6.05 fgh	45.33 abc
Kanchan	39.75 hi	5.94 gh	44.87 abcd
Pavan-76	36.98 i	5.78 h	45.56 a
IVT-10	39.99 ghi	6.00 gh	45.61 a
Bijoy	43.09 efgh	6.83 efg	42.95 bcdefg
BL-1022	47.26 abcd	7.92 abc	40.69 fghi
Kalyan Sona	48.62 ab	7.83 abcd	40.54 ghi
BAW-1051	44.88 bcde	7.09 cde	42.32 defgh
$LSD_{(0.05)}$	3.529	0.804	2.217
Level of Significance	**	**	**
CV(%)	6.86	7.05	5.12

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

4.1.26 Biological yield

Biological yield per hectare varied significantly for different wheat genotypes (Table 4.1.11). The highest biological yield (8.54 ton/ha) was obtained from wheat variety Gourab which was statistically similar (8.06 ton/ha) to Sufi, while the lowest yield (5.78 ton/ha) was found from wheat variety Pavan-76.

4.1.27 Harvest index

Significant variation was observed for harvest index for different wheat genotypes (Table 4.1.11). The highest harvest index (45.61%) was calculated from wheat variety IVT-10 which was statistically similar (45.56%) to Pavan-76, whereas the lowest harvest index (38.82%) was found from wheat variety Gourab. Moula (1999) carried out an experiment on barley with two irrigation viz. no irrigation, one irrigation at CRI and two irrigations both at CRI and booting stage and reported that two irrigations had the highest harvest index (HI) followed by one irrigation and control (no irrigation) had the lowest HI. Similar result was also reported by Kumar and Agrwal (1991) and Torofder *et al.* (1993) in barley

4.1.28 Dry matter content

4.1.28.1 Dry matter content in stem

In case of early sowing with water deficit condition significant difference was observed for dry matter content in stem for different wheat genotypes (Table 4.1.12). The highest dry matter content in stem (3.01 g) was obtained from wheat variety Gourab which was statistically similar (2.82 g) to Sufi, again the lowest weight (1.97 g) was recorded from wheat variety Pavan-76.

4.1.28.2 Dry matter content in lamina

Dry matter content in lamina for different wheat genotypes showed statistically significant difference (Table 4.1.12). The highest dry matter content in lamina (0.83 g) was found from wheat variety Gourab which was statistically similar (0.82 g) to Kalyan Sona, while the lowest weight (0.59 g) was observed from wheat variety Pavan-76.

Table 4.1.12. Dry matter content of different part of different wheat genotypes

Genotypes	Dry matter content/plant (g)				
	Lamina	Leaf Sheath	Stem	Ear	Husk
BL-1883	0.74 bcde	0.90 bcde	2.39 def	6.27 def	2.07 def
BAW-1104	0.77 abcde	0.92 abcd	2.51 bcde	6.58 bcde	2.16 bcde
BAW-1064	0.73 cdefg	0.89 bcde	2.41 de	6.29 def	2.09 de
Sonora	0.72 cdefg	0.87 cdefg	2.27 efgh	5.94 efgh	1.99 efgh
Sourab	0.69 efg	0.86 defg	2.25 efgh	5.86 efgh	1.98 efgh
Prodip	0.73 cdefg	0.88 bcdef	2.35 efg	6.14 efg	2.04 efg
Fang-66	0.65 fgh	0.82 efg	2.03 gh	5.29 gh	1.83 gh
Gourab	0.83 a	0.99 a	3.01 a	7.84 a	2.50 a
BAW-917	0.74 bcde	0.89 bcde	2.31 efgh	6.10 efg	2.02 efgh
IVT-9	0.73 cdef	0.87 cdefg	2.41 de	6.24 def	2.09 de
Sufi	0.81 abc	0.96 ab	2.82 ab	7.36 ab	2.37 ab
Shatabdi	0.69 efg	0.82 efg	2.05 fgh	5.35 fgh	1.84 fgh
Kanchan	0.65 gh	0.80 fg	2.04 gh	5.24 gh	1.83 gh
Pavan-76	0.59 h	0.79 g	1.97 h	5.08 h	1.79 h
IVT-10	0.65 fgh	0.82 efg	2.03 gh	5.30 gh	1.83 gh
Bijoy	0.71 defg	0.87 cdefg	2.36 efg	6.13 efg	2.05 efg
BL-1022	0.80 abcd	0.96 ab	2.75 abc	7.22 abc	2.32 abc
Kalyan Sona	0.82 ab	0.95 abc	2.73 abcd	7.13 abcd	2.31 abcd
BAW-1051	0.75 bcde	0.90 bcde	2.45 cde	6.39 cde	2.11 cde
$LSD_{(0.05)}$	0.074	0.074	0.301	0.804	0.210
Level of Significance	**	**	**	**	**
CV(%)	5.87	9.91	7.67	7.84	6.07

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

4.1.28.3 Dry matter content in leaf sheath

Significant difference was found in terms of dry matter content in leaf sheath for different wheat genotypes (Table 4.1.12). The highest dry matter content in leaf sheath (0.99 g) was found from wheat variety Gourab which was statistically identical (0.96 g) with wheat variety Sufi and BL-1022, whereas the lowest weight (0.79 g) was recorded from wheat variety Pavan-76.

4.1.28.4 Dry matter content in ear

Significant difference was observed for dry matter content in ear for different wheat genotypes (Table 4.1.12). The highest dry matter content in ear (7.84 g) was recorded from wheat variety Gourab which was statistically similar (7.36 g) to Sufi, again the lowest weight (5.08 g) was observed from wheat variety Pavan-76.

4.1.28.5 Dry matter content in seeds per plant

Statistically significant difference was observed for dry matter content in seeds per plant for different wheat genotypes (Figure 4.1.4). The highest dry matter content in seeds per plant (4.06 g) was obtained from wheat variety Pavan-76 and IVT-10 which was statistically similar (4.05 g) to Fang-66 and the lowest weight (3.38 g) was recorded from wheat variety Gourab.

4.1.28.6 Dry matter content in husk

Dry matter content in husk varied significantly for different wheat genotypes (Table 4.1.12). The highest dry matter content in husk (2.50 g) was observed from wheat variety Gourab which was statistically similar (2.37 g) to Sufi, whereas the lowest weight (1.79 g) was found from wheat variety Pavan-76.

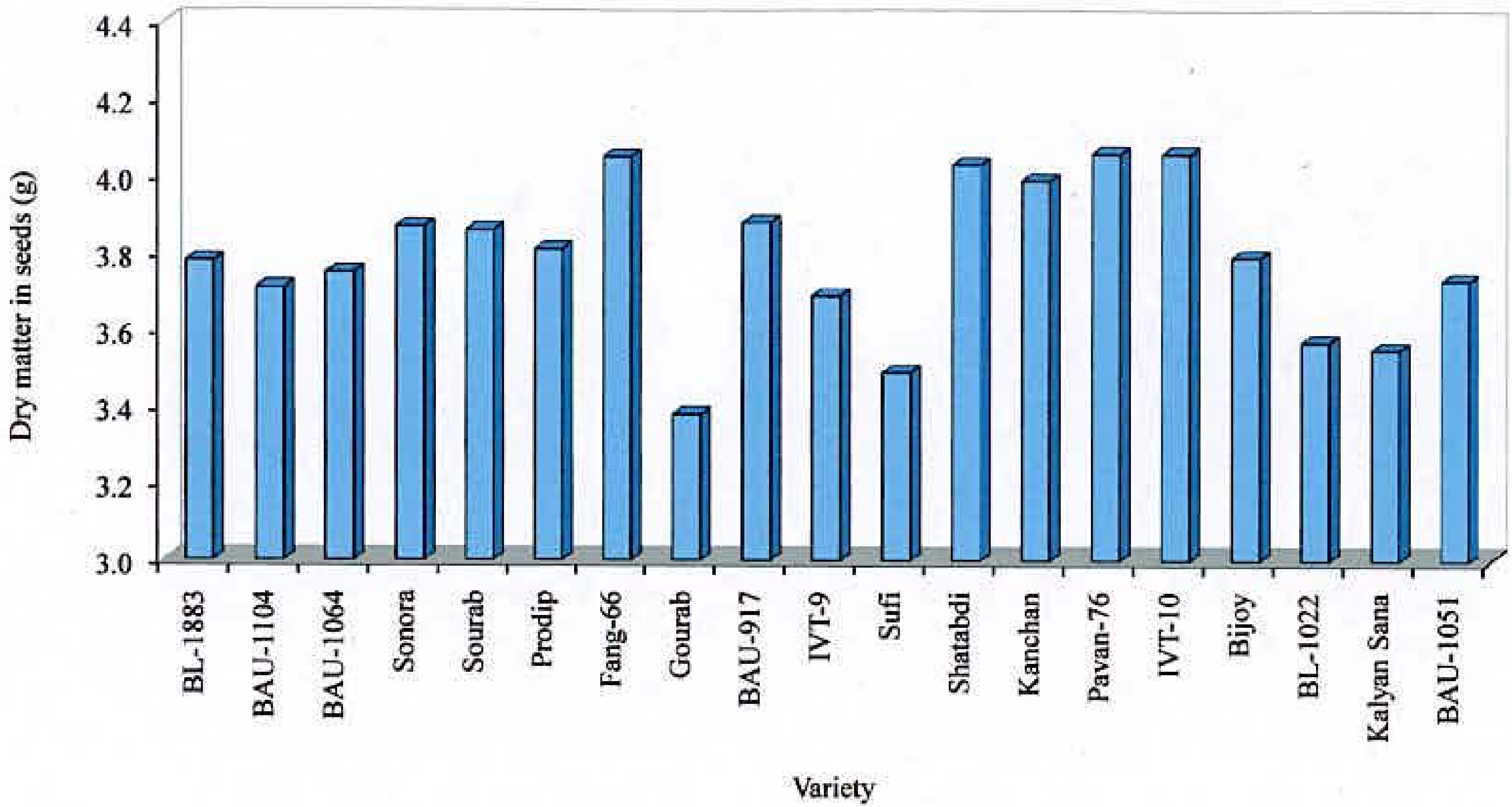

Figure 4.1.4. Dry matter in seeds of different wheat varietyies in response to normal sowing with one irrigation

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2008 to March 2009 to observe the effect of genotypes on the yield performance of wheat. The experiments were conducted to observe the effect of genotypes on yield performance of wheat. The experiment comprised with 19 wheat genotypes such as BL-1883, BAW-1104, BAW-1064, Sonora, Sourab, Prodip, Fang 60, Gourab, BAW-917, IVT-9, Sufi, Shatabdi, Kanchan, Pavan-76, IVT-10, Bijoy, BL-1022, Kalyan Sona and BAW-1051. The experiment was laid out in randomized complete block design (RCBD) with three replications. There were 57 plots for having size 2 m × 1.5 m. 19 genotypes of wheat were randomly distributed in the plots. Data on different growth characters and yield of different genotypes were recorded to find out the performance and better variety with normal sowing date.

The maximum days to starting of seedling emergence (6.00 days) was recorded from wheat genotypes IVT-10 which was followed by other variety except BAW-917 which would start seedling emergence with minimum days (4.33 days).The maximum days to 50% seedling emergence (10.67 days) was found from the wheat genotypes IVT-9, again the minimum days to 50% seedling emergence (8.67 days) was recorded from wheat genotypes BAW-917 and Kalyan Sona. The maximum days to 100% seedling emergence (17.33 days) was observed from the wheat genotypes BAW-917, whereas the minimum days (13.67 days) were found from wheat genotypes BL-1883 and BAW-917. At 30, 40, 50, 60 DAS and harvest the longest plant (22.65 cm, 47.06 cm, 68.64 cm, 85.41 cm and 90.46 cm) was obtained from wheat variety Gourab and the shortest plant (17.99 cm, 37.32 cm, 56.07 cm, 68.31 cm and 70.70 cm) was recorded from wheat variety Pavan-76. At 30, 40, 50, 60 and 70 DAS the maximum number of tillers per plant (2.45, 3.27, 3.83, 5.27 and 5.46) was attained from wheat variety Gourab and the minimum number of tillers per plant (1.40, 2.60, 2.83, 3.87 and 4.07) was found from wheat variety Pavan-76. The maximum number of fertile tillers per plant

(5.67) was observed from wheat variety Gourab and the minimum number (1.77) was recorded from wheat variety Pavan-76. The minimum number of sterile tillers per plant (0.83) was recorded from the wheat variety Gourab and the maximum number (1.17) was observed from wheat the variety Pavan-76. The maximum number of total tillers per plant (6.50) was obtained from the wheat variety Gourab and the minimum number (2.93) was recorded from the wheat variety Pavan-76. The maximum number of leaves per plant (5.87) was found from wheat variety Gourab, whereas the minimum number (4.43) was recorded from wheat variety Pavan-76. The longest flag leaf (19.20 cm) was observed from wheat variety Gourab, while the shortest (14.98 cm) was found from wheat variety Pavan-76. The highest breadth (1.47 cm) was recorded from wheat variety Prodip and the lowest breadth (1.06 cm) was obtained from the wheat variety IVT-10. The highest leaf area of flag leaf (26.95 cm^2) was obtained from the wheat variety Gourab and the lowest (16.04 cm^2) was recorded from wheat variety Pavan-76. The longest ear (15.51 cm) was found from wheat variety Gourab and the shortest length (11.29 cm) was observed from wheat variety Pavan-76. The maximum days to starting of booting (48.33 days) was recorded from wheat genotypes IVT-9 and the minimum (42.33 days) was recorded from wheat genotypes BL-1883 and BAW-917. The maximum days to 50% booting (63.00 days) was found from wheat variety Gourab and the minimum (47.67 days) was recorded from wheat variety Pavan-76. The maximum days to 100% booting (63.67 days) was obtained from wheat variety Gourab, whereas the minimum (54.00 days) was observed from wheat variety Pavan-76. The maximum days to starting of ear emergence (61.00 days) was recorded from wheat variety Gourab, while the minimum (49.33 days) was recorded from the wheat variety Pavan-76. The maximum days to 50% ear emergence (68.00 days) was found from the wheat variety Gourab, again the minimum (51.33 days) was observed from the wheat variety Pavan-76. The maximum days to 100% ear emergence (77.00 days) was found from wheat variety Gourab, whereas the minimum (55.00 day) was observed from the wheat variety Pavan-76. The maximum days to starting of anthesis (81.87 days) was obtained from the wheat genotypes BL-1022, while the minimum (58.33 days) was recorded from the wheat variety Pavan-76. The maximum days to 50% anthesis (80.00 days) was found from the wheat variety Gourab and the minimum (62.67 days) was observed from the wheat variety Pavan-76. The maximum days to 100% anthesis (85.00 days) was recorded from the wheat variety Gourab, whereas the minimum (64.33 days) was recorded from Kalyan Sona wheat variety. The maximum days to starting maturity (95.00 days) was observed from wheat variety Gourab, again the minimum (80.00 days) was recorded from wheat variety Fang-66. The maximum days to 50% maturity (110.33 days) was found from the wheat variety Gourab, while the minimum (85.67 days) was recorded from wheat variety Kanchan. The maximum days to 100% maturity (109.67 days) was obtained from the wheat genotypes IVT-9, while the minimum (90.00 days) was recorded from wheat genotypes BAW-917 and Kalyan Sona. The maximum number of spikelets per spike (19.73) was found from wheat variety Prodip, while the minimum number (15.30) was recorded from the wheat genotypes IVT-10. The maximum number of fertile florets per spike (2.97) was recorded from wheat variety Gourab and the minimum number (2.07) from Pavan-76. The maximum number of filled grains per spike (52.73) was found from wheat variety Gourab, again the minimum number (25.90) was observed from wheat variety Pavan-76. The maximum number of unfilled grains per spike (5.80) was obtained from wheat variety Pavan-76, whereas the minimum number (3.77) from Gourab wheat variety. The maximum number of total grains per spike (56.50) was recorded from wheat variety Gourab, while the minimum number (31.70) was found from wheat variety Pavan-76. The highest weight of grain/m^2 (331.56 g) was observed from wheat variety Gourab, whereas the lowest weight (263.59 g) was recorded from wheat variety Pavan-76. The highest weight of grain per hectare (3.32 ton) was obtained from wheat variety Gourab and the lowest weight (2.67 ton) was recorded from wheat variety Pavan-76. The highest weight of straw/m^2 (522.64 ton) was found from wheat variety Gourab and the lowest weight (314.86 g) was obtained from wheat variety Pavan-76. The highest weight of straw per hectare (5.23 ton) was obtained from the wheat variety Gourab, while the lowest weight (3.15 ton) from wheat variety Pavan-76. The highest weight of 1000 seeds (49.10

g) was recorded from wheat variety Gourab and the lowest weight (36.98 g) from wheat variety Pavan-76. The highest biological yield (8.54 ton/ha) was obtained from wheat variety Gourab, while the lowest yield (5.78 ton/ha) from wheat variety Pavan-76. The highest harvest index (45.61%) was calculated from the wheat genotypes IVT-10, whereas the lowest (38.82%) from wheat variety Gourab. The highest dry matter content in stem (3.01 g) was obtained from wheat variety Gourab, again the lowest weight (1.97 g) was recorded from wheat variety Pavan-76. The highest dry matter content in lamina (0.83 g) was found from wheat variety Gourab, while the lowest weight (0.59 g) was observed from wheat variety Pavan-76. The highest dry matter content in leaf sheath (0.99 g) was found from wheat variety Gourab, whereas the lowest weight (0.79 g) was recorded from wheat variety Pavan-76. The highest dry matter content in ear (7.84 g) was recorded from wheat variety Gourab, again the lowest weight (5.08 g) from wheat variety Pavan-76. The highest dry matter content in seeds per plant (4.06 g) was obtained from wheat genotypes Pavan-76 and IVT-10 and the lowest weight (3.38 g) was recorded from wheat variety Gourab. The highest dry matter content in husk (2.50 g) was recorded from the wheat variety Gourab, whereas the lowest weight (1.79 g) from wheat variety Pavan-76.

From this experiment it can be calculated that the variety Gourab performed better followed by BL-1022, Sufi and Kolyan Sona in respect of yield. This shows that this genotypes can provide better yield per hectare even if only one irrigation is provided usually in this field two or three irrigation showed better yield in case of wheat. The genotypes Pavan-76 was the lowest grain yield in one irrigation condition followed by Kanchan, IVT-10, Shatabdi and Sonora.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.
2. Another experiment may be carried out with different sowing times.

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APPENDICES

Appendix I. Characteristics of experimenatl field soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Central Fram , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix II. Monthly record of air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from November 2008 to March 2009

Month	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
November, 2008	21.7	14.2	77	00	6.7
December, 2008	22.4	13.5	74	00	6.3
January, 2009	24.5	12.4	68	00	5.7
February, 2009	27.1	16.7	67	30	6.7
March, 2009	31.4	19.6	54	11	8.2

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. **Analysis of variance of the data on germination of different wheat varieties**

Source of variation	Degrees of freedom	Mean square		
		Days to germination		
		Starting germination	50% germination	100% germination
Replication	2	0.053	0.439	0.158
Variety	18	0.343**	1.199**	2.669*
Error	36	4.561	0.494	1.362

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix IV. **Analysis of variance of the data on plant height at different days after sowing (DAS) of different wheat varieties**

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.387	2.150	2.320	1.337	1.739
Variety	18	4.083**	14.690**	23.361**	49.205**	68.508**
Error	36	1.373	5.267	10.102	19.163	20.022

**: Significant at 0.01 level of significance

Appendix V. **Analysis of variance of the data on number of tillers per hill at different days after sowing (DAS) of different wheat varieties**

Source of variation	Degrees of freedom	Mean square				
		Number of tillers per plant at				
		30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.027	0.008	0.012	0.002	0.080
Variety	18	0.163**	0.070**	0.150**	0.343**	0.349**
Error	36	0.071	0.024	0.049	0.102	0.153

**: Significant at 0.01 level of significance

Appendix VI. Analysis of variance of the data fertile, sterile and total tillers/hill of different wheat varieties

Source of variation	Degrees of freedom	Mean square		
		Number of tillers/hill		
		Fertile tillers/hill	Sterile tiller/hill	Totale tillers/hill
Replication	2	0.064	0.003	0.053
Variety	18	4.427**	0.022**	3.897**
Error	36	0.547	0.004	0.494

**: Significant at 0.01 level of significance

Appendix VII. Analysis of variance of the data on length, breadth and area of flag leaf and ear length of different wheat varieties

Source of variation	Degrees of freedom	Mean square				
		No. of Leaf	Length of flag leaf (cm)	Breadth of flag leaf (cm)	Area of flag leaf (cm^2)	Ear length (cm)
Replication	2	0.028	0.122	0.001	0.905	0.144
Variety	18	0.464**	2.496**	0.067**	36.232**	2.486**
Error	36	0.075	0.475	0.007	4.488	0.477

**: Significant at 0.01 level of significance

Appendix VIII. Analysis of variance of the data on days required for booting of different wheat varieties

Source of variation	Degrees of freedom	Mean square		
		Days to booting		
		Starting of booting	50% booting	100% booting
Replication	2	2.965	3.912	3.015
Variety	18	10.491**	41.774**	14.270**
Error	36	4.298	13.949	5.166

**: Significant at 0.01 level of significance

Appendix IX. **Analysis of variance of the data on days required for ear emergence of different wheat varieties**

Source of variation	Degrees of freedom	Mean square		
		Days to ear emergence		
		Starting to ear emergence	Starting to ear emergence	Starting to ear emergence
Replication	2	2.263	1.105	0.859
Variety	18	21.088*	45.943**	78.705**
Error	36	10.374	19.087	18.879

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix X. **Analysis of variance of the data on days required for anthesis of different wheat varieties**

Source of variation	Degrees of freedom	Mean square		
		Days to anthesis		
		Starting of anthesis	Starting of anthesis	Starting of anthesis
Replication	2	9.807	1.477	11.912
Variety	18	112.587**	53.582**	74.663**
Error	36	35.288	14.826	30.060

**: Significant at 0.01 level of significance

Appendix XI. **Analysis of variance of the data on spike lets/spike, number of fertile, unfertile and total grains of different wheat varieties**

Source of variation	Degrees of freedom	Mean square				
		Spikelets/ spike	No. of fertile floret/ spikelet	Filled grains/ spike	Unfilled grains/ Spike	Total grains/ Spike
Replication	2	0.012	0.007	1.513	0.096	2.345
Variety	18	8.544**	0.187**	209.225**	0.784**	187.269**
Error	36	0.888	0.033	25.875	0.139	23.645

**: Significant at 0.01 level of significance

Appendix XII. Analysis of variance of the data on grain and straw yield of different wheat varieties

Source of variation	Degrees of freedom	Mean square			
		Grain		Straw	
		Yield (g/m^2)	Yield (t/ha)	Yield (g/m^2)	Yield (t/ha)
Replication	2	66.851	0.007	337.040	0.034
Variety	18	1111.258**	0.111**	10317.704**	1.032**
Error	36	186.439	0.019	1319.393	0.132

**: Significant at 0.01 level of significance

Appendix XIII. Analysis of variance of the data on weight of 1000 seeds, biological yield, harvest index of different wheat varieties

Source of variation	Degrees of freedom	Mean square		
		Weight of 1000 seeds (g)	Biological Yield (t/ha)	Harvest Index (%)
Replication	2	3.368	0.070	0.200
Variety	18	30.858**	1.810**	11.846**
Error	36	4.541	0.236	1.792

**: Significant at 0.01 level of significance

Appendix XIV. Analysis of variance of the data on dry matter content of different parts of different wheat varieties

Source of variation	Degrees of freedom	Mean square					
		Dry matter content (g)					
		Lamina	Leaf Sheath	Stem	Ear	Seed	Husk
Replication	2	0.001	0.001	0.008	0.070	0.002	0.004
Variety	18	0.012**	0.010**	0.258**	1.810**	0.118**	0.123**
Error	36	0.002	0.002	0.033	0.236	0.018	0.016

**: Significant at 0.01 level of significance