EFFICACY OF DIFFERENT GENOTYPES ON THE GROWTH AND YIELD OF WHEAT (*Triticum aestivum* L.)

BY

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CERTIFICATE

This is to certify that the thesis entitled **"Efficacy of Different Genotypes on the Growth and Yield 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 result of a piece of bonafide research work carried out by **Mir Mohammad Salim**, Registration number: **04-01282** 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:
Dhaka, Bangladesh

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The Author

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ABSTRACT

The experiment was conducted to observe the efficacy of different genotypes on the growth and yield of wheat (*Triticum aestivum* L.) at the Agricultural Botany experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2008 to March 2009. The experiment comprised of 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. The maximum days to starting emergence of seedling (6.00 days) was recorded from wheat genotype IVT-10 and the lowest days to start emergence of seedling (4.67 days) for BL-1883, Sourab, BAU-917, Sufi, Shatabdi and Kanchan. At 30, 40, 50, 60, 70 DAS and harvest the longest plant (24.53 cm, 49.29 cm, 71.24 cm, 89.51 cm, 94.23 cm and 98.33 cm) was obtained from the wheat genotype Gourab and the shortest plant (19.80 cm, 41.88 cm, 62.19 cm, 76.12 cm, 77.63 cm and 80.96 cm) was recorded from the wheat genotype Pavan-76. The maximum number of fertile tillers per plant (5.50) was observed in the wheat genotype Gourab and the minimum number (3.63) was recorded from the wheat genotype Pavan-76. The maximum number of leaves per plant (6.27) was found from the wheat genotype Gourab, whereas the minimum number (4.83) was recorded from the wheat genotype Pavan-76. The highest leaf area of flag leaf (39.99 cm^2) was obtained from the wheat genotype Gourab and the lowest (20.65 cm^2) was recorded from the wheat genotype Pavan-76. The longest ear (17.21 cm) was found from the wheat genotype Gourab and the shortest length (13.52 cm) was obtained from the wheat genotype Pavan-76. The maximum number of spikelets per spike (23.07) was found from the wheat genotype BL-1883, while the minimum number (17.97) was recorded from the wheat genotype IVT-10. The maximum number of filled grains per spike (56.47) was found from the wheat genotype Gourab, again the minimum number (29.77) was obtained from the wheat genotype Pavan-76. The highest weight of 1000 seeds (51.34 g) was recorded from the wheat genotype Gourab and the lowest weight (39.99 g) was found from the wheat genotype Pavan-76. The highest weight of grain per hectare (4.14 ton) was obtained from the wheat genotype Gourab and the lowest weight (3.43 ton) from the wheat genotype Pavan-76. The highest weight of straw per hectare (5.79 ton) was obtained from the wheat genotype Gourab, while the lowest weight (3.86 ton) was found in the wheat genotype Pavan-76.

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CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important protein containing cereal with high amount of carbohydrate which is cultivated throughout the world. It is a staple food of most of the countries of the world. About two third of the total world's population consume wheat as staple food (Majumder, 1991). The crop is grown under different environmental conditions ranging from humid to arid, subtropical to temperate zone (Saari, 1998). Dubin and Ginkel (1991) reported that the largest area of wheat cultivation in the warmer climates exists in the South-East Asia including Bangladesh, India and Nepal. In Bangladesh, wheat is the second most important cereal crops that contribute to the national economy by reducing the volume of import of cereals for fulfilling the food requirements of the country (Razzaque *et al.*, 1992). Besides these, wheat and straw are also used as animal feed. Wheat straw is also used as fuel or house building materials of the poor man of Bangladesh. BARI (1997) reported that wheat supplies mainly carbohydrate (69.60%) and reasonable amount of protein (12%), fat (1.72%), and also minerals (16.20%).

Wheat is a well adapted cereal crop for its vegetative growth and development in our native climatic condition. Though the crop was introduced in Bangladesh during the former East Pakistan in 1967, its reputation increased after 1975. Now the popularity of wheat as staple food is rising day by day in our country. Wheat cultivation has been increased manifolds to meet up the food shortage in the country. But, inspite of its importance, the yield of the crop in our country is low (2.2 t ha^{-1}) in comparison to other countries of the world, where average yield estimated was 2.69 t ha^{-1} (FAO, 1997). The area, production and yield of wheat have been increasing dramatically during the last two decades, but its present yield is too low in comparison to some developed countries like Japan, France, Germany and UK producing 3.76, 7.12, 7.28, and 8.00 t ha^{-1}, respectively (FAO, 2000). 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).

Yield and quality of seeds of wheat are very low in Bangladesh. The low yield of wheat in Bangladesh however is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons viz. unavailability of quality seeds of high yielding varieties, delay sowing after harvested transplanted aman rice, fertilizer management, disease and insect infestation and improper or limited irrigation facilities. Generally wheat is sown in November to ensure optimal crop growth and avoid high temperature. After that if wheat is sown in the field it faces high range of temperature for its growth and development as well as yield potential. Temperature is one of the major environmental factors that governed grain yields in wheat significantly. Photosynthesis in wheat is maximum between 22 and 25^0C (Kobza and Edwards, 1987) and decreases sharply above 35^0C (Rawson, 1986; Al-Khatib and Paulsen, 1990). But major wheat area under rice-wheat cropping system is late planted (Badruddin *et al.*, 1994) including Bangladesh. Late planted wheat plants face a period of high temperature stress during reproductive stages causing reduced kernel number $spike^{-1}$ (Bhatta *et al.*, 1994; Islam *et al.*, 1993) and reduced kernel weight (Acevedo *et al.*, 1991) and the net effect is the reduction of seed yield (Islam *et al.*, 1993).

Good quality wheat variety for producing high yield plays an important and major role. In varietal demonstration at different districts of Bangladesh by BARI (1993) revealed that mean yield of Kanchan, Akbar, Agrani and Sonalika were 3.59, 3.29, 3.12 and 2.81 t ha^{-1}, respectively. Different varieties respond differently to sowing time, supply of irrigation, 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. Considering above mentioned situation the present piece of research work was undertaken with following objectives-

i. To investigate the performance of different wheat genotypes;

ii. To investigate the morphological and physiological characters of different wheat genotypes.

CHAPTER II

REVIEW OF LITERATURE

Major reasons of yield reduction of wheat because of about 60% of the crop is cultivated at late sowing condition after harvesting the transplanted aman rice. During the cultivation of wheat farmers of our country mainly depends on rainfall. Selection of suitable variety is another problem for wheat cultivation. Very few research works related to growth, yield and development of wheat genotypes 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 genotypes of wheat done at home and abroad on this crop have been reviewed in this chapter.

Maiksteniene *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.

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.

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}).

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.

Irrigation during the stage of grain filling caused the kernel weight to be as high as under three irrigations. The lowest value corresponded to the treatment with irrigation during grain filling and that under rainfed conditions. Similar finding were reported by Sarker *et al.* (1999).

Bazza *et al.* (1999) conducted two experiments in Morocco on wheat and sugar beet with irrigation management practices through water-deficit irrigation. In the case of wheat, high water deficit occurred during the early stages. Irrigation during these stages was the most beneficial for the crop. One water application during the tillering stage allowed the yield to be lower only than that of the treatment with three irrigations.

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.

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}. Rahman (1997) reported that irrigated plants had always greater TDM $plant^{-1}$ than the rainfed plants.

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. A drastic reduction in grain yield was observed when the crop was sown on December 5 or later.

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. Gaffer (1995) reported that increased in TDM due to increased number of irrigation in millet.

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.

Islam *et al.* (1993) evaluate the performance of the existing (Sonalika) and released wheat varieties (Ananda, Kanchan, Barkat, Akbar, Aghrani) seeded from 1 November to 15 January at 15 days interval. Grain yield, spike/m^2, grain/spike and 1000-grain weight were significantly affected by sowing date and variety. The highest grain yield was obtained with variety Kanchan when sown on 15 November which was identical to Akbar and Barkat. Ahgrani performed better than all other varieties when sown in December and January. Sonalika variety also showed lower yield than the other varieties when seeding was done in December and January. Different yield component of these 6 varieties at maturity rested differently to late seeded conditions. Delay sowing caused significant reduction in grain weight due to higher temperature at grain filing stage.

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).

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.

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.

Wheat variety HD 2428 and Kalyansona were compared by Shukla *et al.* (1992) for adaptability under pot culture by exposure to high temperature treatments (8^0C above) ambient in week 1 though 4 after anthesis. Dry matter accumulation of grain in the top, middle and bottom spikelets of the spike, at 7-grain locations was recorded in weeks 2 and 3. The treatments adversely affect grain weight for HD2428 at all 3 spikelet positions, with up to 35% reduction in the first 5 grain location. Kalyansona was only marginally affected. This indicates that the characteristic adaptability of Kalyansona to different agro-climatic regions is associated with the tolerance of physiologically old grains to higher temperature.

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. The 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). Acevedo *et al.* (1991) observed detrimental effects of high temperature on grain number and the duration of spike development during GS2 stage.

Al-Khatib and Paulesn (1990) evaluated the yield performance of 10 wheat genotypes grown under moderate (22/17^{0}C, day/night) and high (32/7^{0}C, day/night) temperature. Yield component of 10 genotypes at maturity reacted differently to high temperature. Spike per plant significantly decreased in 3 genotypes and increased in one genotype as the temperature increased where as kernel per spike decreased in four genotypes. Kernel weight decreased significantly in all genotypes, whereas the reduction range was about 10% to 30%. Grain yield means declined from 0.75 to 0.58 g per tiller or 23% from 22/17 to 32/27^{0}C, temperature. Yields were constant for 3 genotypes and decreased > 40% for three genotypes. Harvest index of all 10 genotypes was affected little by temperature, but individual, but individual genotypes responded very differently.

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.

Grain number per ear is limited by the number of spikelets per ear can the number of viable florets per spikelet (Tashiro and Warslaw, 1989). In general, number of outer floret grains was reduced more by high temperature than the basal floret grains, irrespective of their growth stage. Number of grains per spike is determined during GS2 phase (double ridge to anthesis).

Jhala and Jadon (1989) studied that grain growth rate (mg/spike per day) from the 1st to the 8th week after anthesis (WAA) in 15 wheat cultivars sown on 15 November (optimum date) or 30 November. There were significant differences among cultivars for grain growth rate especially during 1 st 4 W AA. Grain growth rate was the highest in the 3rd and 2nd W AA for crop sown on 15 November and 30 November respectively. Grain growth rate was higher in crops sown on 15 November than in those sown on 30 November. Cv. Lok 1, WH 147, H-1784, Kalyansana and HJ 74-27 had initial higher grain growth rate and could be used for breeding cultivars suitable for late sown conditions.

In a trial with cultivar Balaka in Joydepur and Jesore, 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.

CHAPTER III

MATERIALS AND METHODS

To observe the efficacy of different genotypes on the growth and yield of wheat (*Triticum aestivum* L.) the present experiment was carried out at the Agricultural Botany experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2008 to March 2009. The details of the materials and methods those were followed to conduct the study have been presented below under the following headings:

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 $23^{0}74^{\prime}$N latitude and $90^{0}35^{\prime}$E longitude with an elevation of 8.2 meter from sea level.

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 I.

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 II.

3.2 Experimental details

The experiment comprised with 19 wheat varieties. Name and origin of these varieties are:

Variety	Origin	Variety	Origin
BL-1883	BSMRAU	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	BSMRAU
Gourab	BARI	Kalyan Sona	BARI
BAU-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 × 1.5 m and 19 genotypes of wheat were randomly distributed in these plots.

3.3 Growing of crops

3.3.1 Seed collection

The seeds of different wheat genotypes and varieties were collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur; Wheat Research Centre (WRC) and Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur.

3.3.2 Preparation of the main field

The piece of land 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 dose and method of application of fertilizer are shown in Table 3.1.

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

Fertilizers	Dose (per 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

3.3.4 After care

After the germination of seeds, 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

Three flood irrigations at early stage of crop growth, tillering stage and panicle initiation stage were provided. 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 was 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 starting 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 plot wise from 1 m^2 area. 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 emergence. Days to 50% and 100% emergence were expressed in days and that were estimated by observing absolute visibility of seedlings of the experimental plot.

3.5.2 Plant height

The height of plant was recorded in centimeter (cm) at 30, 40, 50, 60, 70 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 that were tagged earlier. The height was measured from the ground level to the tip of the plant by a meter scale.

3.5.3 Tillers plant^{-1}

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

3.5.4 Fertile tillers plant^{-1}

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

3.5.5 Sterile tillers plant^{-1}

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

3.5.6 Total tillers plant^{-1}

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

3.5.7 Leaves plant^{-1}

The total number of leaves plant^{-1} 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

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 calculating the number of days from sowing to starting of booting, 50% and 100% plant attained their booting condition by keen observation the experimental plots.

3.5.13 Days to ear emergence

Days to starting of ear emergence, 50% and 100% emergence of ear was recorded by calculating the number of days from sowing to starting of ear emergence, 50% and 100% plant completed spike emergence by keen observation of the experimental plots during the experimental period.

3.5.14 Days to anthesis

Days to starting of anthesis, 50% and 100% anthesis was recorded by calculating the number of days from sowing to starting of anthesis, 50% and 100% spikes completed their anthesis by keen observation of the experimental plot.

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 by ken observing the experimental plot.

3.5.16 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 Fertile florets spike^{-1}

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

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

3.5.22 Grain yield ha^{-1}

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

3.5.23 Straw yield m^{-2}

Straw obtained from m^{-2} from each unit plot were 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 was converted this into t ha^{-1}.

3.5.24 Straw weight ha^{-1}

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

3.5.25 1000 seeds weight

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 from 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 was recorded.

3.6 Statistical Analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to observe the efficacy of different genotypes on the growth and yield of wheat (*Triticum aestivum* L.). Data on different growth and yield contributing characters were recorded to find out the suitable genotypes. The results have been presented in the Tables 4.1-4.9 Figures 4.1-4.4 and the ANOVA for different characters in the appendices III-XI. The results have been presented and discussed, and possible interpretations have been given under the following headings:

4.1 Emergence of seedlings

4.1.1 Days to starting of emergence of seedlings

Significant variation was recorded for days to starting of seedling emergence of different wheat genotypes under the present trial (Table 4.1). The maximum days to starting of seedling emergence (6.00 days) was recorded from wheat genotype IVT-10 which was followed by other wheat genotypes and the lowest days to start seedling emergence (4.67 days) for BL-1883, Sourab, BAW-917, Sufi, Shatabdi and Kanchan. Germination is a genetical characters and different genotypes need different days to starting seedling emergence but management factor, soil moisture content and weather condition influence days to starting seedling emergence of the genotypes.

Table 4.1 Percentage of seedling emergence of different wheat genotypes

Genotypes	Days to emergence		
	Starting of seedlings	50% seedlings	100% seedlings
BL-1883	4.67 b	10.00 abc	14.33 bcd
BAW-1104	5.00 b	10.33 ab	14.67 abcd
BAW-1064	5.00 b	9.33 bcd	15.67 abc
Sonora	5.00 b	9.33 bcd	15.33 abc
Sourab	4.67 b	10.33 ab	14.67 abcd
Prodip	5.00 b	9.67 bc	16.00 ab
Fang-66	5.00 b	10.00 abc	14.67 abcd
Gourab	5.00 b	9.67 bc	15.00 abcd
BAW-917	4.67 b	9.67 bc	14.00 cd
IVT-9	6.00 a	10.67 a	16.33 a
Sufi	4.67 b	10.23 ab	15.97 ab
Shatabdi	4.67 b	8.67 d	13.33 d
Kanchan	4.67 b	9.67 bc	14.33 bcd
Pavan-76	5.00 b	9.67 bc	14.00 cd
IVT-10	5.00 b	10.33 ab	14.67 abcd
Bijoy	5.00 b	10.00 abc	14.00 cd
BL-1022	5.00 b	10.67 a	15.00 abcd
Kalyan Sona	5.00 b	9.00 cd	15.33 abc
BAW-1051	5.00 b	9.67 bc	15.33 abc
$LSD_{(0.05)}$	0.544	0.848	1.541
Level of Significance	0.01	0.01	0.05
CV(%)	9.65	5.21	6.25

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

4.1.2 Days to 50% emergence of seedlings

Different wheat genotypes showed significant variation for days to 50% emergence of seedlings (Table 4.1). The maximum days to 50% seedling emergence (10.67 days) was recorded from wheat genotype IVT-9 and BL-1022, whereas the minimum days to 50% seedling emergence (8.67 days) were recorded from wheat genotype Shatabdi which was statistically similar (9.00 days and 9.33 days) to Kalyan Sona, BAW-1064 and Sonora, respectively.

4.1.3 Days to 100% emergence of seedlings

Different wheat genotypes showed statistically significant differences in terms of days to 100% emergence of seedling (Table 4.1). The maximum days to 100% emergence of seedlings (16.33 days) was observed from the wheat genotype IVT-9, while the minimum days (13.33 days) was found from the wheat genotype Shatabdi.

4.2 Plant height

Significant differences was observed for plant height at 30, 40, 50, 60, 70 DAS and at harvest for different wheat genotypes (Table 4.2). At 30, 40, 50, 60, 70 DAS and harvest the tallest plant (24.53 cm, 49.29 cm, 71.24 cm, 89.51 cm, 94.23 cm and 98.33 cm) was obtained from wheat genotype Gourab and the shortest plant (19.80 cm, 41.88 cm, 62.19 cm, 76.12 cm, 77.63 cm and 80.96 cm) was recorded from wheat genotype Pavan-76. Different genotypes produced different plant height on the basis of their varietal characters.

Table 4.2 Plant height of different wheat genotypes at different days after sowing (DAS)

Genotypes	Plant height (cm) at					
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	Harvest
BL-1883	22.49 abcd	47.16 ab	68.91 ab	85.79 ab	88.70 abcd	92.74 abc
BAW-1104	22.93 abc	47.62 ab	69.67 ab	86.44 ab	89.65 abc	93.67 abc
BAW-1064	20.85 cdef	44.12 bc	64.67 bc	79.90 bc	82.31 bcde	85.97 bcde
Sonora	22.03 bcde	45.90 ab	67.73 ab	84.17 ab	87.74 abcd	91.68 abcd
Sourab	21.42 bcdef	44.96 bc	65.92 abc	81.53 bc	84.27 bcde	88.05 bcde
Prodip	23.10 ab	47.57 ab	69.42 ab	86.54 ab	90.83 ab	94.94 ab
Fang-66	20.04 ef	41.88 c	61.96 c	76.13 c	79.95 de	83.42 de
Gourab	24.53 a	49.29 a	71.24 a	89.51 a	94.23 a	98.33 a
BAW-917	21.94 bcdef	46.97 ab	68.40 ab	85.45 ab	85.38 bcde	89.35 abcde
IVT-9	21.11 bcdef	44.04 bc	65.55 bc	79.90 bc	87.71 abcd	91.50 abcd
Sufi	22.13 bcde	46.45 ab	67.38 abc	83.60 abc	88.72 abcd	92.59 abc
Shatabdi	21.02 bcdef	43.72 bc	64.48 bc	79.49 bc	81.76 cde	85.58 cde
Kanchan	20.45def	44.05 bc	64.50 bc	80.09 bc	81.76 cde	85.39 cde
Pavan-76	19.80 f	41.88 c	62.19 c	76.12 c	77.63 e	80.96 e
IVT-10	20.57 def	44.02 bc	64.99 bc	80.05 bc	84.24 bcde	88.01 bcde
Bijoy	22.96 abc	47.79 ab	69.72 ab	86.95 ab	89.68 abc	93.75 abc
BL-1022	22.22 bcde	46.64 ab	68.44 ab	84.94 ab	88.89 abc	92.82 abc
Kalyan Sona	22.20 bcde	46.98 ab	67.73 ab	85.34 ab	90.34 abc	94.24 abc
BAW-1051	22.29 bcd	46.56 ab	68.24 ab	84.86ab	88.46 abcd	92.39 abcd
$LSD_{(0.05)}$	1.860	3.433	4.718	6.588	7.431	7.710
Level of Significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	5.15	8.54	11.26	7.79	5.19	6.16

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

4.3 Tillers plant^{-1}

4.3.1 Tillers at different days after sowing

Different wheat genotypes showed statistically significant differences for number of tillers plant^{-1} at 30, 40, 50, 60 and 70 DAS (Table 4.3). At 30, 40, 50, 60 and 70 DAS the maximum number of tillers plant^{-1} (2.60, 3.60, 4.03, 4.97 and 5.70) was observed from wheat genotype Gourab and the minimum number of tillers plant^{-1} (1.83, 3.07, 3.33, 3.97 and 4.40) was found from wheat genotype Pavan-76. Management practices influence the number of tillers at different days after sowing but genotypes itself manipulated the number.

4.3.2 Effective tillers plant^{-1}

Number of effective tillers plant^{-1} showed statistically significant difference for different wheat genotypes (Table 4.3). The maximum number of fertile tillers plant^{-1} (5.50) was observed from wheat genotype Gourab which was statistically similar (5.27) to IVT-9 and the minimum number (3.63) was recorded from wheat genotype Pavan-76.

4.3.3 Non-effective tillers plant^{-1}

Different wheat genotypes showed significant difference under the present trial (Table 4.3). The minimum number of non-effective tillers plant^{-1} (0.53) was recorded from wheat genotype Gourab which was statistically similar (0.63) to BAW-1104 and the maximum number (0.90) was observed from wheat genotype Pavan-76.

Table 4.3 Number of total tillers plant^{-1} of different wheat genotypes

Genotypes	Number of tillers plant^{-1} at							
	Days after sowing					Harvest		
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	Effective	Non-effective	Total
BL-1883	2.37 abcd	3.37 abcd	3.97 ab	4.73 abcd	5.03 bcd	4.70 abcde	0.80 abc	5.50 abcd
BAW-1104	2.37 abcd	3.50 ab	3.97ab	4.83 ab	5.37 ab	5.17 abc	0.63 de	5.80 abc
BAW-1064	2.00 cde	3.20 cde	3.63 bcd	4.23 cde	4.70 cdef	4.83 abcd	0.80 abc	5.63 abcd
Sonora	2.20 abcde	3.43 abc	3.90 ab	4.63 abcd	5.03 bcd	4.33 bcde	0.67 cd	5.00 abcd
Sourab	2.13 abcde	3.27 bcde	3.77 abc	4.40 abcde	4.77 bcdef	4.07 cde	0.84 ab	4.90 bcd
Prodip	2.53 ab	3.43 abc	4.03 a	4.80 abc	5.27 abc	4.83 abcd	0.77 abcd	5.60 abcd
Fang-66	1.90 de	3.10 de	3.43 cd	3.93 e	4.37 f	3.70 de	0.83 ab	4.53 d
Gourab	2.60 a	3.60 a	4.03 a	4.97 a	5.70 a	5.50 a	0.53 e	6.03 a
BAW-917	2.17 abcde	3.33 abcd	3.90 ab	4.67 abcd	5.00 bcde	4.30 bcde	0.77 abcd	5.07 abcd
IVT-9	2.07 bcde	3.37 abcd	3.73 abc	4.37 bcde	4.97 bcdef	5.27 ab	0.67 cd	5.93 ab
Sufi	2.27 abcde	3.37 abcd	3.83 ab	4.60 abcd	5.07 bcd	4.77 abcde	0.67 cd	5.43 abcd
Shatabdi	2.10 bcde	3.27 bcde	3.77 abc	4.30 bcde	4.60 def	4.77 abcde	0.77 abcd	5.53 abcd
Kanchan	2.07 bcde	3.17 cde	3.63 bcd	4.20 de	4.70 cdef	4.03 cde	0.87 a	4.90 bcd
Pavan-76	1.83 e	3.07 e	3.33 d	3.97 e	4.40 ef	3.63 e	0.90 a	4.53 d
IVT-10	2.23 abcde	3.30 bcde	3.77 abc	4.27 bcde	4.73 bcdef	3.80 de	0.80 abc	4.60 d
Bijoy	2.40 abc	3.43 abc	4.03 a	4.83 ab	5.13 abcd	4.57 abcde	0.80 abc	5.37 abcd
BL-1022	2.37 abcd	3.40 abc	3.90 ab	4.67 abcd	5.17 abcd	4.67 abcde	0.70 bcd	5.37 abcd
Kalyan Sona	2.27 abcde	3.40 abc	3.83 ab	4.77 abcd	5.00 bcde	4.63 abcde	0.77 abcd	5.40 abcd
BAW-1051	2.30 abcde	3.37 abcd	3.90 ab	4.67 abcd	5.10 abcd	4.10 cde	0.70 bcd	4.80 cd
$LSD_{(0.05)}$	0.399	0.228	0.327	0.483	0.537	0.957	0.117	0.938
Level of Significance	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.05
CV(%)	10.87	7.17	5.21	6.45	6.84	12.82	9.39	10.77

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

4.3.4 Total tillers plant^{-1}

Statistically significant difference was recorded for number of total tillers plant^{-1} for different wheat genotypes (Table 4.3). The maximum number of total tillers plant^{-1} (6.03) was attained from wheat genotype Gourab which was statistically similar (5.93) to IVT-9 and the minimum number (4.53) was recorded from wheat genotype Pavan-76, Fang-66 and IVT-10.

4.4 Days to booting

4.4.1 Days to starting of booting

Days to booting for different wheat genotypes varied significantly (Table 4.4). The maximum days to starting of booting (48.33 days) was recorded from wheat genotype BAW-1064 and the minimum (42.67 days) was recorded from wheat genotype BAW-1104, BAW-917 and Bijoy which was statistically similar (43.00 days) to IVT-10. Days to starting booting varied for different genotypes might be due to genetical and environmental influences as well as management practices.

4.4.2 Days to 50% booting

Different wheat genotypes showed significant difference for days to 50% booting (Table 4.4). The maximum days to 50% booting (63.00 days) was found from wheat genotype Gourab which was statistically similar (59.00 and 59.33 days) to Bijoy and Prodip, whereas the minimum (48.67 days) was recorded from the wheat genotype Pavan-76.

Table 4.4 Days required for booting and ear emergence of different wheat genotypes

Genotypes	Days required for					
	Starting of booting	50% booting	100% booting	Starting of ear emergence	50% ear emergence	100% ear emergence
BL-1883	43.67 bc	57.67 abc	61.67 ab	58.33 ab	64.67 ab	71.33 abc
BAW-1104	42.67 c	58.67 ab	62.00 ab	59.00 ab	65.00 ab	72.33 abc
BAW-1064	48.33 a	52.33 bcde	58.33 bc	54.00 bcd	58.33 bc	65.00 bcde
Sonora	45.00 abc	56.00 bcd	60.33 ab	57.00 abcd	62.67 ab	70.33 abcd
Sourab	44.33 bc	54.00 bcde	59.33 bc	55.33 abcd	60.00 bc	66.67 bcd
Prodip	45.67 abc	59.33 ab	61.67 ab	59.00 ab	65.00 ab	73.33 ab
Fang-66	45.67 abc	49.67 de	56.33 c	51.33 d	54.67 c	62.33 de
Gourab	44.67 abc	63.00 a	63.67 a	60.67 a	68.00 a	76.67 a
BAW-917	42.67c	55.67 bcd	61.33 ab	57.67 ab	64.00 ab	67.67 bcd
IVT-9	46.00 abc	53.33 bcde	58.33 bc	55.00 abcd	58.67 bc	70.00 abcd
Sufi	46.77 ab	56.30 abcd	60.53 ab	56.73 abcd	62.10 abc	71.43 abc
Shatabdi	44.67 abc	52.67 bcde	58.00 bc	54.00 bcd	58.00 bc	64.33 cde
Kanchan	45.00 abc	51.00 cde	58.33 bc	53.67 bcd	58.67 bc	64.33 cde
Pavan-76	44.33 bc	48.67 e	56.33 c	51.67 cd	54.67 c	58.00 e
IVT-10	43.00 c	51.33 cde	58.33 bc	54.33 bcd	58.67 bc	66.67 bcd
Bijoy	42.67 c	59.00 ab	62.00 ab	59.33 ab	65.67 ab	72.00 abc
BL-1022	45.67 abc	56.33 abcd	61.00 ab	57.67 ab	63.33 ab	71.33 abc
Kalyan Sona	45.00 abc	56.67 abcd	61.33 ab	57.33 abc	63.67 ab	73.00 abc
BAW-1051	46.33 abc	56.67 abcd	61.00 ab	57.67 ab	63.33 ab	71.00 abcd
$LSD_{(0.05)}$	3.117	5.900	3.431	4.849	6.685	7.438
Level of Significance	0.05	0.01	0.01	0.01	0.01	0.01
CV(%)	10.20	6.46	7.45	5.20	6.56	6.53

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

4.4.3 Days to 100% booting

Significant difference was found for days to 100% booting of different wheat genotypes (Table 4.4). The maximum days to 100% booting (63.67 days) was obtained from wheat genotype Gourab, whereas the minimum (56.33 days) was observed from wheat genotype Fang-66 and Pavan-76.

4.5 Days to ear emergence

4.5.1 Days to starting of ear emergence

Statistically significant difference was observed for days to starting of ear emergence for different wheat genotypes under the trail (Table 4.4). The maximum days to starting of ear emergence (60.67 days) was recorded from wheat genotype Gourab, while the minimum (51.33 days) was recorded from wheat genotype Fang-66 which was statistically identical (51.67 days) to Pavan-76.

4.5.2 Days to 50% ear emergence

Significant variation was recorded for days to 50% ear emergence for different wheat genotypes (Table 4.4). The maximum days to 50% ear emergence (68.00 days) was found from wheat genotype Gourab, again the minimum (54.67 days) was observed from wheat genotype Fang-66 and Pavan-76.

4.5.3 Days to 100% ear emergence

Different wheat genotypes varied significantly in terms of days to 100% ear emergence (Table 4.4). The maximum days to 100% ear emergence (76.67 days) was found from the wheat genotype Gourab which was statistically similar (73.33 days) to Prodip, whereas the minimum (58.00 day) was observed from the wheat genotype Pavan-76.

4.6 Days to anthesis

4.6.1 Days to starting of anthesis

Significant difference was observed for days to starting of anthesis for different wheat genotypes (Table 4.5). The maximum days to starting of anthesis (80.33 days) was obtained from wheat genotype Gourab which was statistically similar (79.00 days and 78.00 days) to Prodip and BL-1022, while the minimum (60.67 days) was recorded from wheat genotype Pavan-76.

4.6.2 Days to 50% anthesis

Significant difference was observed for days to 50% anthesis for different wheat genotypes (Table 4.5). The maximum days to 50% anthesis (81.33 days) was found from the wheat genotype Prodip and Gourab which was statistically similar (78.33 days) to BAW-1104 and Bijoy, while the minimum (67.00 days) was observed from the wheat genotype Pavan-76.

Table 4.5 Days required for anthesis and maturity of different wheat genotypes

Genotypes	Days required for					
	Starting of anthesis	50% anthesis	100% anthesis	Starting of maturity	50% maturity	100% maturity
BL-1883	75.33 abcd	77.00 abc	83.00 a	89.67 abcd	96.67 abc	104.00 bcd
BAW-1104	72.67 abcde	78.33 ab	82.33 a	92.00 ab	99.33 ab	103.67 bcd
BAW-1064	68.33 abcde	71.33 bcde	73.00 bcd	81.33 de	90.33 bcd	101.00 cd
Sonora	74.67 abcd	76.67 abc	80.00 ab	88.33 abcd	95.00 abc	99.33 de
Sourab	68.67 abcde	73.00 bcde	76.00 abcd	83.33 bcde	92.00 abcd	103.67 bcd
Prodip	79.00 ab	81.33 a	84.33 a	91.00 abc	101.67 a	110.33 a
Fang-66	68.00 abcde	70.00 cde	68.33 cd	75.00 e	84.00 d	100.67 cd
Gourab	80.33 a	81.33 a	84.00 a	94.33 a	96.33 abc	100.67 cd
BAW-917	66.67 bcde	76.00 abc	81.00 ab	88.67 abcd	96.00 abc	103.67 bcd
IVT-9	65.00 cde	75.00 abcd	76.33 abcd	83.67 bcde	95.33 abc	104.00 bcd
Sufi	74.03 abcd	75.80 abc	78.63 ab	87.80 abcd	98.70 abc	104.10 bcd
Shatabdi	64.67 cde	73.33 bcde	77.00 abc	81.67 de	88.00 cd	95.00 e
Kanchan	63.67 de	68.33 de	72.00 bcd	82.67 cde	90.00 bcd	100.67 cd
Pavan-76	60.67 e	67.00 e	67.67 d	84.00 bcd	90.00 bcd	99.67 de
IVT-10	70.33 abcde	73.00 bcde	75.67 abcd	83.67 bcde	90.67 abcd	104.67 bcd
Bijoy	76.33 abc	78.33 ab	83.67 a	91.33 abc	100.00 ab	105.67 abc
BL-1022	78.00 ab	76.33 abc	80.00 ab	89.00 abcd	98.00 abc	106.67 ab
Kalyan Sona	68.67 abcde	76.33 abc	78.67 ab	90.33 abcd	96.00 abc	102.67 bcd
BAW-1051	73.67 abcd	76.33 abc	80.00 ab	88.33 abcd	100.00 ab	103.33 bcd
$LSD_{(0.05)}$	10.43	5.905	7.872	7.638	9.369	4.677
Level of Significance	0.01	0.01	0.01	0.01	0.05	0.01
CV(%)	8.87	9.75	6.10	5.32	5.98	7.75

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

4.6.3 Days to 100% anthesis

A statistically significant difference was observed for days to 100% anthesis for different wheat genotypes (Table 4.5). The maximum days to 100% anthesis (84.33 days) was recorded from the wheat genotype Sourab which was statistically similar (84.00 days, 83.67 days, 83.00 days and 82.33 days) to Gourab, Bijoy, BL-1883 and BAW-1104, whereas the minimum (67.67 days) was recorded from Pavan-76 which was statistically similar (68.33 days) to Fang-66 wheat genotype.

4.7 Days to maturity

4.7.1 Days to starting of maturity

Days to starting of maturity varied for different wheat genotypes under the present trial (Table 4.5). The maximum days to starting of maturity (94.33 days) was observed from wheat genotype Gourab which was statistically similar (92.00 days) to BAW-1104, again the minimum (75.00 days) was recorded from the wheat genotype Fang-66.

4.7.2 Days to 50% maturity

Significant variation was recorded for days to 50% maturity for different wheat genotypes (Table 4.5). The maximum days to 50% maturity (101.67 days) was found from the wheat genotype Prodip, while the minimum (84.00 days) was recorded from the wheat genotype Shatabdi.

4.7.3 Days to 100% maturity

Significant difference was observed for days to 100% maturity of different wheat genotypes (Table 4.5). The maximum days to 100% maturity (110.33 days) was obtained from the wheat genotype Prodip which was statistically similar (106.67 days) to BL-1022, while the minimum (95.00 days) was recorded from the wheat genotype Shatabdi.

4.8 Leaves plant^{-1}

Number of leaves plant^{-1} for different wheat genotypes showed statistically significant differences (Figure 4.1). The maximum number of leaves plant^{-1} (6.27) was found from wheat genotype Gourab which was statistically similar (5.90) to BAW-1104, whereas the minimum number (4.83) was recorded from wheat genotype Pavan-76 which was statistically similar (4.97 and 5.00) to Kanchan and Fang-66.

4.9 Length of flag leaf

A statistically significant difference was observed for length of flag leaf for different wheat genotypes (Table 4.6). The longest flag leaf (26.71 cm) was observed from wheat genotype Gourab which was statistically similar (23.39 cm) to BAW-917 wheat genotype, while the shortest (17.05 cm) was found from wheat genotype Sourab.

Table 4.6 Number, length, breadth and area of leaf of different wheat genotypes

Genotypes	Leaf plant^{-1}	Length of flag leaf (cm)	Breadth of flag leaf (cm)	Area of flag leaf (cm^2)	Ear length (cm)
BL-1883	5.50 bcde	21.56 bcd	1.57 a	33.77 ab	15.39 bcd
BAW-1104	5.90 ab	22.93 bc	1.51 a	34.60 ab	16.47 ab
BAW-1064	5.20 cdef	18.23 de	1.29 cdef	23.49 def	14.82 cde
Sonora	5.70 abcd	20.10 bcde	1.49 a	29.92 bcd	15.81 bc
Sourab	5.33 bcdef	17.05 e	1.33 bcd	22.91 ef	14.98 cd
Prodip	5.67 bcd	21.02 bcde	1.52 a	32.01 b	15.78 bc
Fang-66	5.00 ef	18.56 de	1.17 efg	21.73 f	14.05 de
Gourab	6.27 a	26.71 a	1.50 a	39.99 a	17.21 a
BAW-917	5.57 bcde	23.39 ab	1.49 a	34.89 ab	15.39 bcd
IVT-9	5.53 bcde	19.74 bcde	1.52 a	30.03 bcd	15.46 bc
Sufi	5.77 abc	20.33 bcde	1.44 abc	29.41 bcde	16.10 abc
Shatabdi	5.17 cdef	22.16 bcd	1.31 bcde	29.18 bcde	14.82 cde
Kanchan	4.97 ef	20.44 bcde	1.19 defg	24.25 cdef	14.81 cde
Pavan-76	4.83 f	18.06 de	1.14 fg	20.65 f	13.52 e
IVT-10	5.10 def	19.22 cde	1.12 g	21.61 f	14.81 cde
Bijoy	5.63 bcd	19.60 bcde	1.53 a	29.93 bcd	15.66 bc
BL-1022	5.73 abc	20.15 bcde	1.43 abc	28.98 bcde	15.74 bc
Kalyan Sona	5.63 bcd	21.00 bcde	1.46 ab	30.60 bc	16.22 abc
BAW-1051	5.67 bcd	21.15 bcd	1.42 abc	30.08 bcd	15.79 bc
$LSD_{(0.05)}$	0.526	3.429	0.139	6.037	1.199
Level of Significance	0.01	0.01	0.01	0.01	0.01
CV(%)	5.79	10.05	5.98	12.64	9.70

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

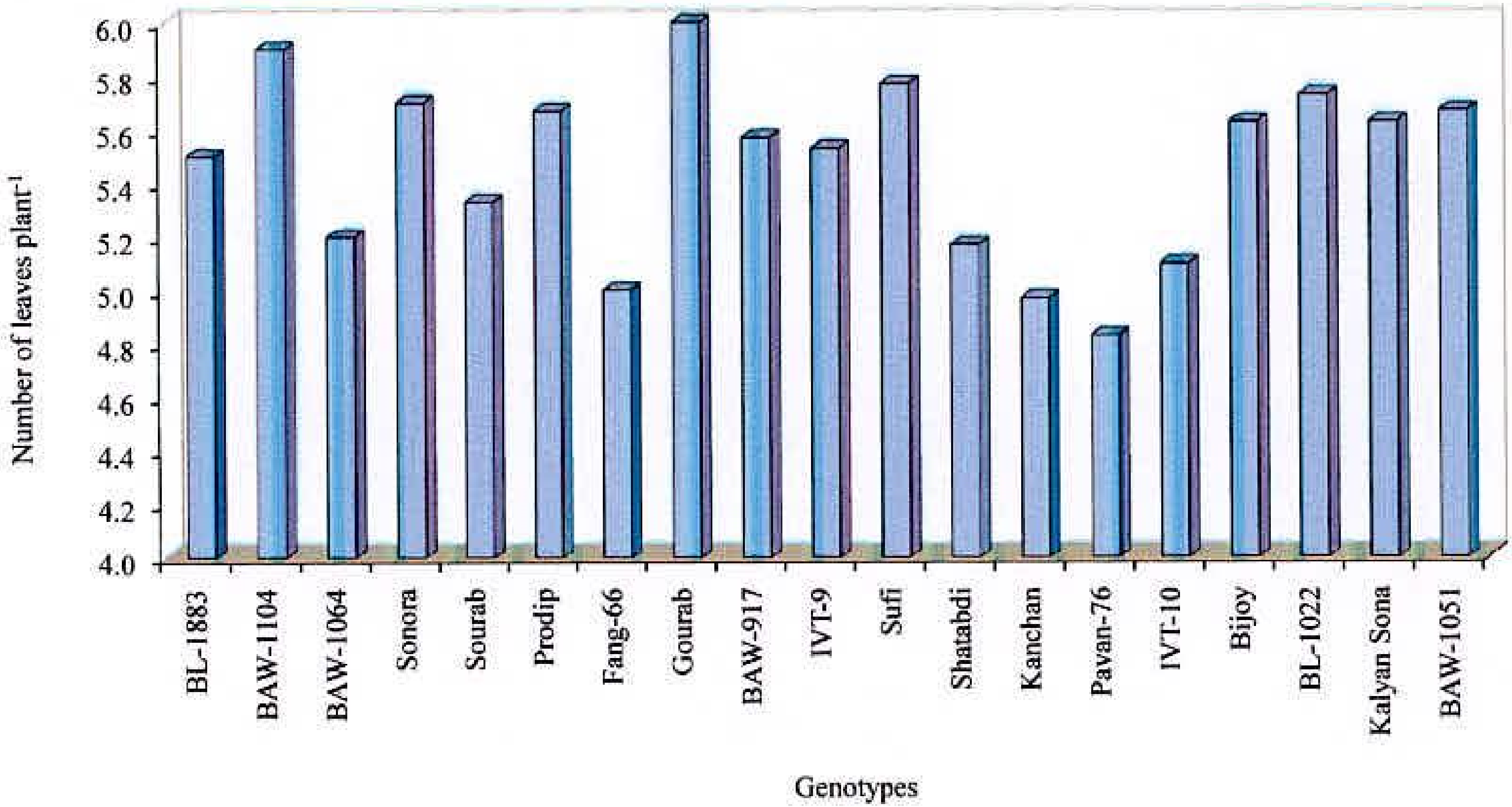

Figure 4.1 Number of leaves plant^{-1} of different wheat genotypes

4.10 Breadth of flag leaf

Significant variation was observed for breadth of flag leaf of different wheat genotypes (Table 4.6). The highest breadth (1.57 cm) was recorded from wheat genotype BL-1883 which was statistically identical (1.53 cm, 1.52 cm, 1.51 cm, 1.50 cm and 1.49 cm) to Bijoy, Prodip, IVT-9, BAW-1104, Gourab and BAW-917, respectively, again the lowest breadth (1.12 cm) was attained from wheat genotype IVT-10.

4.11 Leaf area of flag leaf

Leaf area of flag leaf for different wheat genotypes varied significantly (Table 4.6). The highest leaf area of flag leaf (39.99 cm^2) was obtained from wheat genotype Gourab and the lowest (20.65 cm^2) was recorded from wheat genotype Pavan-76 which was statistically similar (21.61 cm^2 and 21.73 cm^2) to IVT-10 and Fang-66.

4.12 Ear length

Significant difference was observed in terms of ear length of different wheat genotypes (Figure 4.2). The longest ear (17.21 cm) was found from wheat genotype Gourab which was statistically similar (16.47 cm) to BAW-1104 and the shortest length (13.52 cm) was observed from wheat genotype Pavan-76.

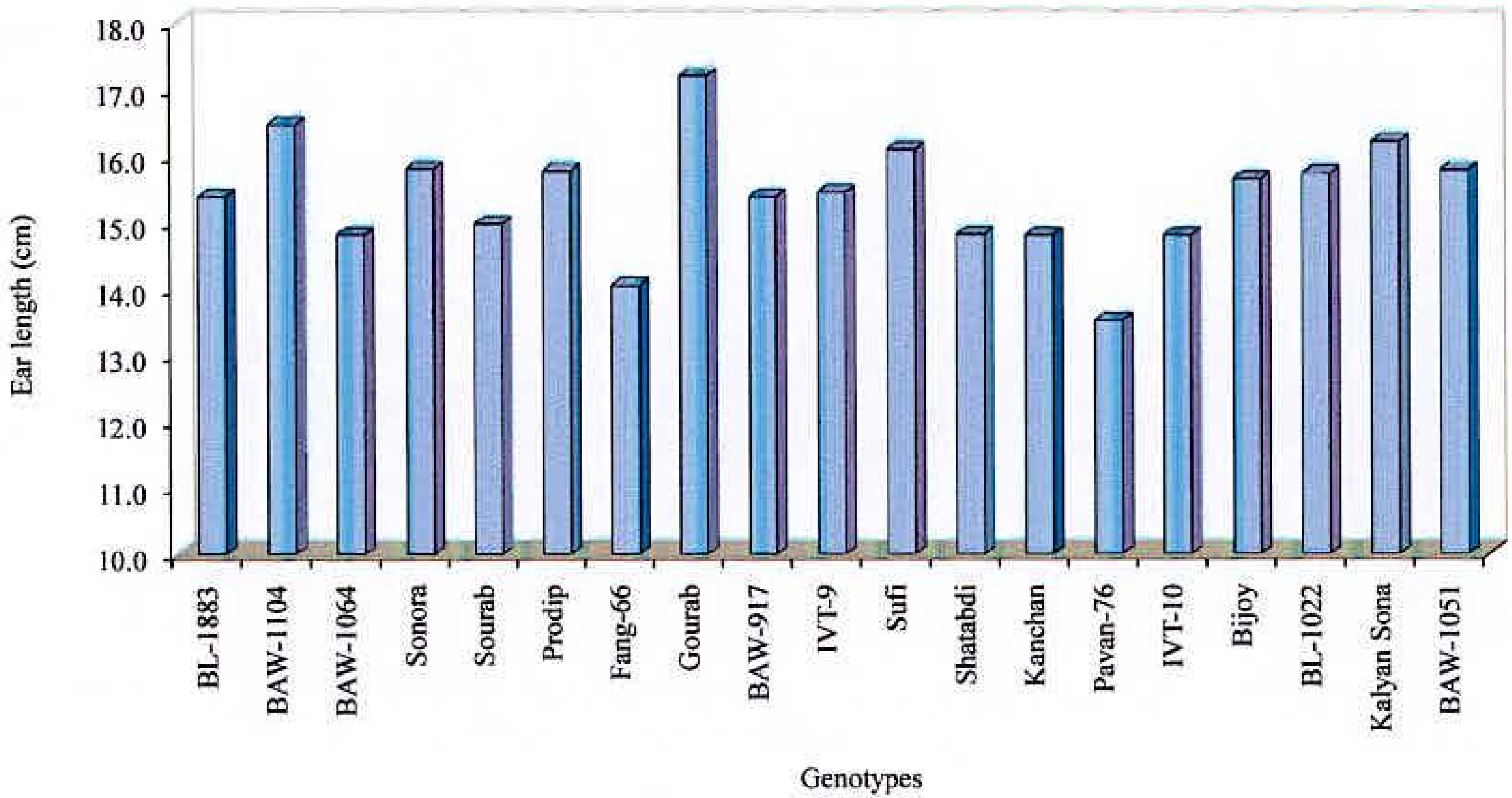

Figure 4.2 Ear length of different wheat genotypes

4.13 Spikelet spike^{-1}

Spikelet spike^{-1} for different wheat genotypes showed statistically significant difference (Table 4.7). The maximum number of spikelet spike^{-1} (23.07) was found from wheat genotype BL-1883 which was statistically similar (22.67, 22.63, 22.60 and 22.50) to Bijoy, Prodip, IVT-9 and BAW-1104, while the minimum number (17.97) was recorded from wheat genotype IVT-10. Nibedita, D. (2009) also reported similar results by using 5 wheat varieties.

4.14 Fertile floret spike^{-1}

Significant difference was observed for number of fertile floret spike^{-1} for different wheat genotypes (Table 4.7). The maximum number of fertile floret spike^{-1} (3.00) was recorded from wheat genotype Gourab which was statistically similar (2.97) to Kalyan Sona and the minimum number (2.27) was recorded from wheat genotype Pavan-76.

4.15 Filled grains spike^{-1}

Significant difference was observed for number of filled grains spike^{-1} due to different wheat genotypes (Table 4.7). The maximum number of filled grains spike^{-1} (56.47) was found from wheat genotype Gourab which was statistically similar (51.77 and 50.50) to BAW-1104 and Kalyan Sona, again the minimum number (29.77) was observed from wheat genotype Pavan-76 which was statistically similar (30.57, 31.00 and 32.67) to Fang-66, IVT-10 and Kanchan.

Table 4.7 Spikelet spike^{-1}, fertile, unfertile & total grains and weight of 1000 seeds of different wheat genotypes

Genotypes	Spikelets Spike^{-1}	Fertile floret Spikelet^{-1}	Filled grains Spike^{-1}	Unfilled grains Spike^{-1}	Total grains Spike^{-1}	1000 seeds weight (g)
BL-1883	23.07 a	2.63 bcdefghi	46.57 abcde	4.30 bcd	50.87 abcde	46.36 bcdef
BAW-1104	22.50 a	2.93 abc	51.77 ab	3.53 fg	55.30 ab	49.55 ab
BAW-1064	20.27 cde	2.47 efghi	38.17 def	4.43 abc	42.60 def	43.78 efgh
Sonora	22.27 ab	2.73 bcdefg	48.40 abc	3.57 efg	51.97 abcd	47.94 abcde
Sourab	20.60 bcde	2.50 defghi	39.70 cdef	4.40 bc	44.10 cdef	44.94 defg
Prodip	22.63 a	2.83 abcde	49.50 abc	4.30 bcd	53.80 abc	48.32 abcd
Fang-66	18.40 fg	2.33 hi	30.57 f	4.73 ab	35.30 f	41.58 gh
Gourab	22.37 ab	3.00 a	56.47 a	3.00 g	59.47 a	51.34 a
BAW-917	22.30 ab	2.57 cdefghi	43.57 bcde	4.27 bcde	47.83 bcde	47.01 abcdef
IVT-9	22.60 a	2.73 bcdefg	47.97 abcd	3.67 def	51.63 abcd	46.40 bcdef
Sufi	21.77 abc	2.87abcd	49.27 abc	3.83 cdef	53.10 abc	48.18 abcd
Shatabdi	19.83 def	2.57 cdefghi	37.87 ef	4.20 bcdef	42.07 ef	45.07 cdefg
Kanchan	19.27 efg	2.37 ghi	32.67 f	4.74 ab	37.40 f	41.65 fg
Pavan-76	18.83 efg	2.27 i	29.77 f	5.10 a	34.87 f	39.99 h
IVT-10	17.97 g	2.43 fghi	31.00 f	4.53 abc	35.53 f	43.46 fgh
Bijoy	22.67 a	2.70 bcdefghi	47.87 abcd	4.23 bcdef	52.10 abcd	47.68 abcdef
BL-1022	21.67 abc	2.80bcdef	48.17 abcd	3.89 cdef	52.06 abcd	47.79 abcdef
Kalyan Sona	22.03 abc	2.97 ab	50.50 ab	4.20 bcdef	54.70 ab	49.37 abc
BAW-1051	21.53 abcd	2.73 bcdefg	46.73 abcde	3.90 cdef	50.63 abcde	47.61 abcdef
$LSD_{(0.05)}$	1.609	0.323	8.704	0.613	8.278	3.722
Level of Significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	8.59	7.31	12.08	8.94	10.49	6.86

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

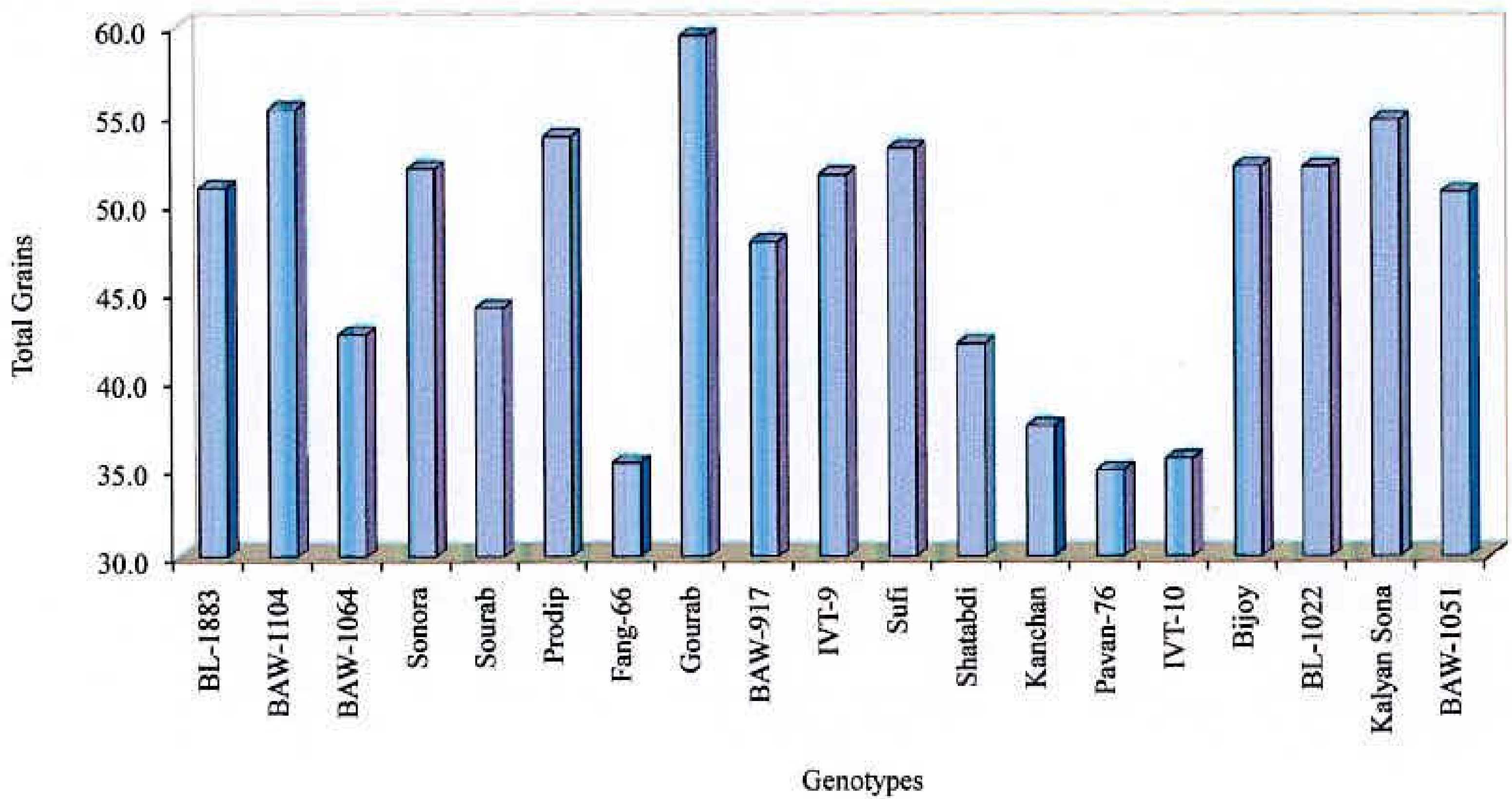

Figure 4.3. Total grain yield of different wheat genotypes

4.16 Unfilled grains spike^{-1}

Significant difference was recorded in terms of number of unfilled grains spike^{-1} for different wheat genotypes (Table 4.7). The maximum number of unfilled grains spike^{-1} (5.10) was obtained from wheat genotype Pavan-76 which was statistically similar (4.74 and 4.73) to Kanchan and Fang-76, whereas the minimum number (3.00) was recorded from wheat genotype Gourab.

4.17 Total grains per spike

Total grains spike^{-1} for different wheat genotypes varied significantly (Figure 4.3). The maximum number of total grains spike^{-1} (59.47) was recorded from wheat genotype Gourab which was statistically similar (55.30 and 54.70) to BAW-1104 and Kalyan Sona, while the minimum number (34.87) was found from wheat genotype Pavan-76 which was statistically similar (35.30, 35.53 and 37.40) to Fang-66, IVT-10 and Kanchan. Wheat Research Center (2003) reported that the variety Shatabdi produced maximum grain spike^{-1}.

4.18 1000 seeds weight

Significant difference was observed for 1000 seeds weight of different wheat genotypes (Table 4.7). The highest weight of 1000 seeds (51.34 g) was recorded from the wheat genotype Gourab which was statistically similar (49.55 g) to BAW-1104 and the lowest weight (39.99 g) was found from the wheat genotype Pavan-76. Wheat Research Center (2003) reported that the variety Shatabdi produced maximum 1000 grains weight.

4.19 Dry matter content

4.19.1 Dry matter content in stem

Significant difference was observed for dry matter content in stem of different wheat genotypes (Table 4.8). The highest dry matter content in stem (2.94 g) was obtained from wheat genotype Gourab which was statistically similar (2.67 g) to BAW-1104, again the lowest weight (1.92 g) was recorded from wheat genotype Pavan-76 which was statistically similar (1.94 g, 1.95 g and 1.99 g) to Fang-66, Kanchan and IVT-10, respectively.

4.19.2 Dry matter content in lamina

Dry matter content in lamina for different wheat genotypes showed statistically significant difference (Table 4.8). The highest dry matter content in lamina (0.88 g) was found from wheat genotype Gourab which was statistically similar (0.85 g) to BAW-1104, while the lowest weight (0.65 g) was observed from wheat genotype Pavan-76.

4.19.3 Dry matter content in leaf sheath

Significant difference was found in terms of dry matter content in leaf sheath of different wheat genotypes (Table 4.8). The highest dry matter content in leaf sheath (1.04 g) was found from the wheat genotype Gourab which was statistically identical (0.99 g) to wheat genotype BAW-1104, whereas the lowest weight (0.83 g) was recorded from the wheat genotype Pavan-76 which was statistically similar (0.85 g) to wheat genotype Kanchan.

Table 4.8 Dry matter content of different parts of different wheat genotypes

Genotypes	Dry matter content plant^{-1} (g)					
	Stem	Lamina	Leaf Sheath	Ear	Seed	Husk
BL-1883	2.26 cdefg	0.78 bcdef	0.93 bcdef	5.04 bcdefgh	3.53 abc	2.13 cdefg
BAW-1104	2.67 ab	0.85 ab	0.99 ab	6.06 ab	3.24 de	2.41 ab
BAW-1064	2.14 defg	0.73 efgh	0.88 cdefg	4.66 defgh	3.57 abc	2.04 defg
Sonora	2.43 bcde	0.81 abcde	0.95 bcd	5.47 bcde	3.42 cd	2.24 bcde
Sourab	2.18 defg	0.75 defg	0.90 bcdefg	4.81 cdefg	3.56 abc	2.07 defg
Prodip	2.40 bcde	0.82 abcd	0.95 bcd	5.42 bcde	3.44 bcd	2.22 bcde
Fang-66	1.94 g	0.69 gh	0.85 efg	4.17 gh	3.75 a	1.91 g
Gourab	2.94 a	0.88 a	1.04 a	6.80 a	3.09 e	2.60 a
BAW-917	2.29 bcdefg	0.79 abcdef	0.94 bcde	5.13 bcdefg	3.51 abc	2.15 bcdefg
IVT-9	2.26 cdefg	0.78 bcdef	0.93 bcdef	5.06 bcdefgh	3.54 abc	2.13 cdefg
Sufi	2.54 bcd	0.82 abcd	0.96 abc	5.72 bcd	3.31 cde	2.32 bcd
Shatabdi	2.04 efg	0.76 cdefg	0.88 cdefg	4.44 efgh	3.69 ab	1.97 efg
Kanchan	1.95 g	0.69 gh	0.85 fg	4.16 gh	3.73 a	1.91 g
Pavan-76	1.92 g	0.65 h	0.83 g	4.04 h	3.72 a	1.89 g
IVT-10	1.99 fg	0.72 fgh	0.87 defg	4.31 fgh	3.73 a	1.94 fg
Bijoy	2.37 bcdef	0.81 abcdef	0.94 bcd	5.33 bcdef	3.44 bcd	2.21 bcdef
BL-1022	2.47 bcd	0.81 abcdef	0.96 abc	5.58 bcd	3.39 cd	2.27 bcd
Kalyan Sona	2.59 abc	0.84 abc	0.95 bcd	5.77 bc	3.20 de	2.36 abc
BAW-1051	2.43 bcde	0.81 abcdef	0.95 bcd	5.47 bcde	3.39	2.25 bcde
$LSD_{(0.05)}$	0.339	0.074	0.074	0.924	0.0228	0.234
Level of Significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	8.90	5.77	5.08	10.87	8.90	6.55

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

4.19.4 Dry matter content in ear

Significant difference was observed for dry matter content in the ear of different wheat genotypes (Table 4.8). The highest dry matter content in ear (6.80 g) was recorded from wheat genotype Gourab which was statistically similar (6.06 g) to BAW-1104, again the lowest weight (4.04 g) was observed from wheat genotype Pavan-76.

4.19.5 Dry matter content in seeds

Statistically significant difference was observed for dry matter content in seeds per plant of different wheat genotypes (Table 4.8). The highest dry matter content in seeds per plant (3.75 g) was obtained from the wheat genotype Fang-66 which was statistically similar (3.73 g and 3.72 g) to Kanchan, IVT-10 and Pavan-76 and the lowest weight (3.09 g) was recorded from the wheat genotype Gourab.

4.19.6 Dry matter content in husk

Dry matter content in husk varied significantly for different wheat genotypes (Table 4.8). The highest dry matter content in husk (2.60 g) was observed from the wheat genotype Gourab which was statistically similar (2.41 g) to BAW-1104, whereas the lowest weight (1.89 g) was found from the wheat genotype Pavan-76.

4.20 Grain yield m^{-2}

Statistically significant difference was found for grain yield m^{-2} of different wheat genotypes (Table 4.9). The highest weight of grain m^{-2} (413.62 g) was observed from wheat genotype Gourab which was statistically similar (396.33 g) to BAW-1104, whereas the lowest weight (343.36 g) was recorded from the wheat genotype Pavan-76 which was similar (349.52 g) to Kanchan.

4.21 Grain yield ha^{-1}

Grain yield ha^{-1} for different wheat genotypes varied significantly under the present trial (Table 4.9). The highest weight of grain ha^{-1} (4.14 ton) was obtained from wheat genotype Gourab which was statistically similar (3.96 ton) to BAW-1104 and the lowest weight (3.43 ton) was recorded from wheat genotype Pavan-76 which was statistically identical (3.50 ton) to Kanchan. Grain yield varied for different genotypes might be due to genetical and environmental influences as well as management practices. BARI (1993) revealed that mean yield of Kanchan, Akbar, Agrani and Sonalika were 3.59, 3.29, 3.12 and 2.81 t ha^{-1}, respectively.

4.22 Straw yield m^{-2}

Statistically significant variation was recorded for straw yield m^{-2} for different wheat genotypes (Table 4.9). The highest weight of straw m^{-2} (578.67 g) was found from the wheat genotype Gourab which was statistically similar (536.12 g) to BAW-1104, while the lowest weight (386.18 g) was obtained from the wheat genotype Pavan-76 which was statistically similar (391.44 g and 392.65 g) to Fang-66 and Kanchan.

Table 4.9 Grain and straw yield, biological yield and harvest index of different wheat genotypes

Genotypes	Grain		Straw		Biological Yield ($t\ ha^{-1}$)	Harvest Index (%)
	Yield ($g\ m^{-2}$)	Yield ($t\ ha^{-1}$)	Yield ($g\ m^{-2}$)	Yield ($t\ ha^{-1}$)		
BL-1883	375.76 bcde	3.76 bcdef	454.25 cdefg	4.54 cdefg	8.30 bcdefgh	45.28 abcd
BAW-1104	396.33 ab	3.96 ab	536.12 ab	5.36 ab	9.32 ab	42.57 ef
BAW-1064	361.47 cdef	3.61 cdefg	430.71 defg	4.31 defg	7.92 defgh	45.69 abc
Sonora	384.42 bcd	3.84 abcd	488.93 bcde	4.89 bcde	8.73 bcde	44.21 cde
Sourab	367.22 bcdef	3.67 bcdefg	439.35 defg	4.39 defg	8.07 cdefgh	45.60 abcd
Prodip	384.81 bcd	3.85 abcd	482.86 bcde	4.83 bcde	8.68 bcde	44.45 bcde
Fang-66	351.22 ef	3.51 efg	391.44 g	3.91 g	7.43 gh	47.29 a
Gourab	413.62 a	4.14 a	578.67 a	5.79 a	9.92 a	41.68 f
BAW-917	378.64 bcde	3.79 bcdef	460.84 bcdefg	4.61 bcdefg	8.39 bcdefg	45.11 abcd
IVT-9	377.40 bcde	3.77 bcdef	454.63 cdefg	4.55 cdefg	8.32 bcdefgh	45.37 abcd
Sufi	387.29 abc	3.87 abcd	510.59 abcd	5.11 abcd	8.98 abcd	43.23 def
Shatabdi	359.78 cdef	3.60 cdefg	410.08 efg	4.10 efg	7.70 efgh	46.75 ab
Kanchan	349.52 ef	3.50 fg	392.65 g	3.93 g	7.42 gh	47.10 a
Pavan-76	343.36 f	3.43 g	386.18 g	3.86 g	7.30 h	47.06 a
IVT-10	356.42 def	3.56 defg	400.34 fg	4.00 fg	7.57 fgh	47.10 a
Bijoy	381.66 bcd	3.82 bcde	477.44 bcdef	4.77 bcdef	8.59 bcdef	44.49 bcde
BL-1022	387.72 abc	3.88 abc	496.16 bcd	4.96 bcd	8.84 bcd	43.96 cde
Kalyan Sona	382.34 bcd	3.82 bcd	521.09 abc	5.21 abc	9.03 abc	42.32 ef
BAW-1051	383.45 bcd	3.83 bcd	489.08 bcde	4.89 bcde	8.73 bcde	44.02 cde
$LSD_{(0.05)}$	25.92	0.261	67.88	0.679	0.922	2.040
Level of Significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	7.18	7.18	8.85	8.85	6.65	7.74

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

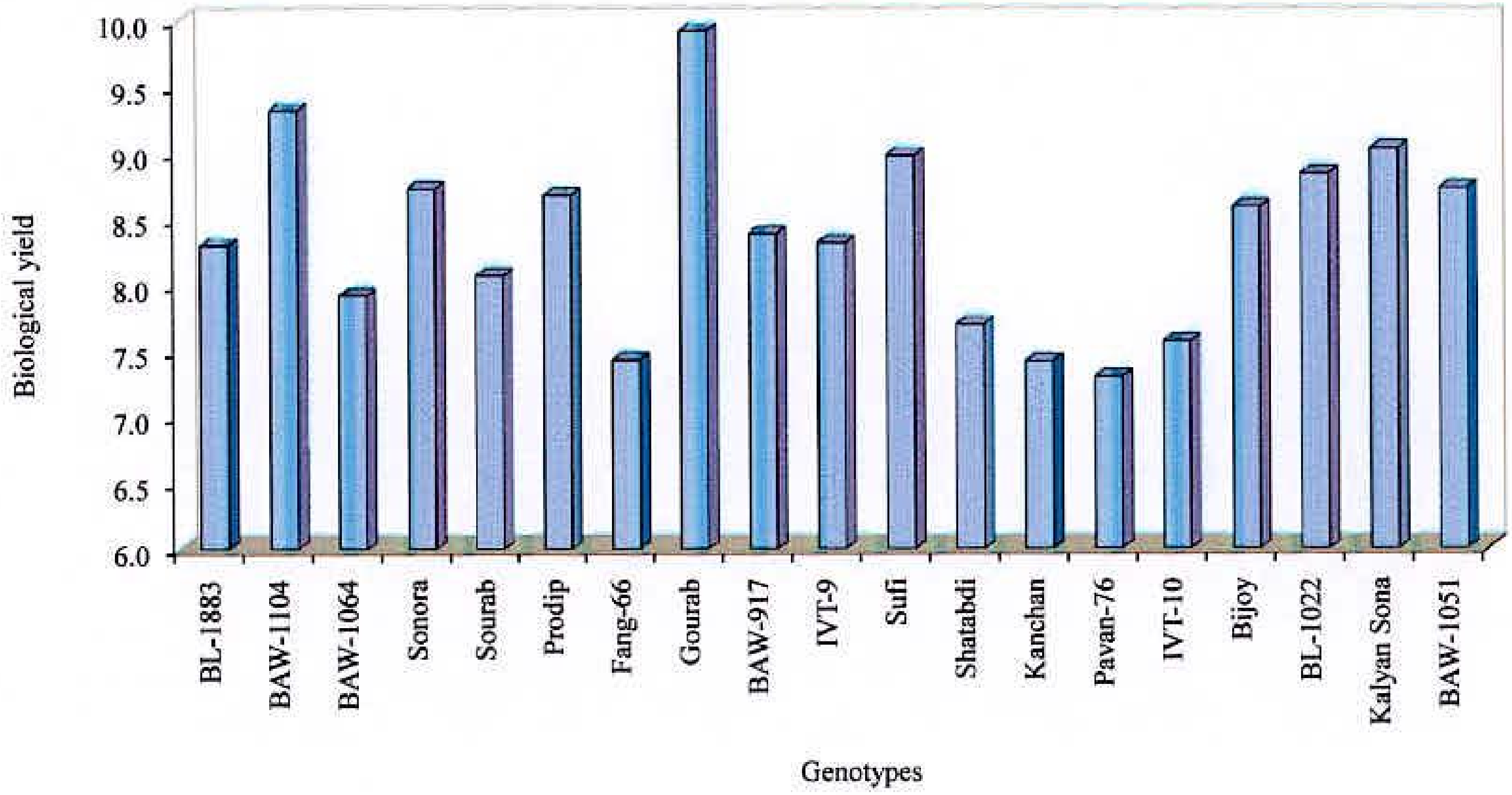

Figure 4.4 Biological yield of different wheat genotypes

4.23 Straw weight ha^{-1}

Different wheat genotypes showed significant difference in straw yield ha^{-1} (Table 4.9). The highest weight of straw ha^{-1} (5.79 ton) was obtained from the wheat genotype Gourab which was statistically similar (5.36 ton) to BAW-1104, while the lowest weight (3.86 ton) was found from the wheat genotype Pavan-76 which was statistically similar (3.91 ton and 3.93 ton) to Fang-66 and Kanchan.

4.24 Biological yield

Biological yield $hectare^{-1}$ varied significantly for different wheat genotypes under the present trial (Figure 4.4). The highest biological yield (9.92 t ha^{-1}) was obtained from the wheat genotype Gourab which was statistically similar (9.32 t ha^{-1}) to the genotype BAW-1104, while the lowest yield (7.30 t ha^{-1}) was found from wheat genotype Pavan-76.

4.25 Harvest index

Significant variation was observed in case of harvest index of different wheat genotypes (Table 4.9). The highest harvest index (47.29%) was calculated from the wheat genotype Fang-66 which was statistically similar (47.10% and 47.06%) to Kanchan, IVT-10 and Pavan-76, whereas the lowest harvest index (41.68%) was found from the wheat genotype Gourab.

CHAPTER V

SUMMARY AND CONCLUSION

To observe the efficacy of different genotypes on the growth and yield of wheat (*Triticum aestivum* L.) the present experiment was carried out at the Agricultural Botany experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2008 to March 2009. The experiment comprised of 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.

The maximum days to starting of emergence of seedlings (6.00 days) was recorded from the wheat genotype IVT-10 and the lowest days to start seedling emergence (4.67 days) was recorded from BL-1883, Sourab, BAU-917, Sufi, Shatabdi and Kanchan. The maximum days to 50% seedling emergence (10.67 days) was recorded from the wheat genotype IVT-9 and BL-1022, whereas the minimum days to 50% seedling emergence (8.67 days) was recorded from the wheat genotype Shatabdi The maximum days to 100% seedling emergence (16.33 days) was observed from the wheat genotype IVT-9, while the minimum days (13.33 days) was found from the wheat genotype Shatabdi. At 30, 40, 50, 60, 70 DAS and harvest the longest plant (24.53 cm, 49.29 cm, 71.24 cm, 89.51 cm, 94.23 cm and 98.33 cm) was obtained from the wheat genotype Gourab and the shortest plant (19.80 cm, 41.88 cm, 62.19 cm, 76.12 cm, 77.63 cm and 80.96 cm) was recorded from the wheat genotype Pavan-76. At 30, 40, 50, 60 and 70 DAS the maximum number of tillers plant^{-1} (2.60, 3.60, 4.03, 4.97 and 5.70) was observed from the wheat genotype Gourab and the minimum number of tillers plant^{-1} (1.83, 3.07, 3.33, 3.97 and 4.40) was found from the wheat genotype Pavan-76. The maximum number of fertile tillers plant^{-1} (5.50) was observed from the wheat genotype Gourab and the minimum number (3.63) was recorded from the wheat genotype Pavan-76. The minimum number of non-effective tillers plant^{-1} (0.53) was recorded from the wheat genotype Gourab and the maximum number (0.90) was observed from the wheat genotype Pavan-76. The maximum number of total tillers plant^{-1} (6.03) was obtained from the wheat genotype Gourab and the minimum number (4.53) was recorded from the wheat genotype Pavan-76, Fang-66 and IVT-10. The maximum days to starting of booting (48.33 days) were recorded from the wheat genotype BAW-1064 and the minimum (42.67 days) was recorded from the wheat genotype BAW-1104, BAU-917 and Bijoy. The maximum days to starting of ear emergence (60.67 days) were recorded from the wheat genotype Gourab, while the minimum (51.33 days) was recorded from the wheat genotype Fang-66. The maximum days to starting of anthesis (80.33 days) was obtained from the wheat genotype Gourab, while the minimum (60.67 days) was recorded from the wheat genotype Pavan-76. The maximum days to starting of maturity (94.33 days) was observed from the wheat genotype Gourab, again the minimum (75.00 days) was recorded from the wheat genotype Fang-66. The maximum number of leaves per plant (6.27) was found from the wheat genotype Gourab, whereas the minimum number (4.83) was recorded from the wheat genotype Pavan-76. The longest flag leaf (26.71 cm) was observed from the wheat genotype Gourab, while the shortest (17.05 cm) was found from the wheat genotype Sourab. The highest breadth (1.57 cm) was recorded from the wheat genotype BL-1883, again the lowest breadth (1.12 cm) was attained from the wheat genotype IVT-10. The highest leaf area of flag leaf (39.99 cm^2) was obtained from the wheat genotype Gourab and the lowest (20.65 cm^2) was recorded from the wheat genotype Pavan-76. The longest ear (17.21 cm) was found from the wheat genotype Gourab and the shortest length (13.52 cm) was observed from the wheat genotype Pavan-76. The maximum number of spikelets per spike (23.07) was found from the wheat genotype BL-1883, while the minimum number (17.97) was recorded from the wheat genotype IVT-10. The maximum number of fertile floret per spike (3.00) was recorded from the wheat genotype Gourab and the minimum number (2.27) was recorded from the wheat genotype Pavan-76. The maximum number of filled grains per spike (56.47) was found from the wheat genotype Gourab, again the minimum number (29.77) was observed from the wheat genotype Pavan-76. The maximum number of unfilled grains per spike (5.10) was obtained from the wheat genotype Pavan-76, whereas the minimum number (3.00) was recorded from the wheat genotype Gourab. The maximum number of total grains per spike (59.47) was recorded from the wheat genotype Gourab, while the minimum number (34.87) was found from the wheat genotype Pavan-76. The highest weight of 1000 seeds (51.34 g) was recorded from the wheat genotype Gourab and the lowest weight (39.99 g) was found from the wheat genotype Pavan-76. The highest weight of grain per hectare (4.14 ton) was obtained from the wheat genotype Gourab and the lowest weight (3.43 ton) was recorded from the wheat genotype Pavan-76. The highest weight of straw per hectare (5.79 ton) was attained from the wheat genotype Gourab, while the lowest weight (3.86 ton) from the wheat genotype Pavan-76. The highest biological yield (9.92 t ha^{-1}) was obtained from the wheat genotype Gourab, while the lowest yield (7.30 t ha^{-1}) was found from the wheat genotype Pavan-76. The highest harvest index (47.29%) was calculated from the wheat genotype Fang-66 and the lowest harvest index (41.68%) was found from the wheat genotype Gourab.

It was observed from the experiment that the wheat variety Gourab showed the highest performance in yield contributing characters and yield and the lowest performance was observed in case of genotype Pavan-76. The genotype BAW-1104 also showed better performance almost equivalent to the variety Gourab. The genotypes Gourab and BAW-1104 were superior to the variety Kanchan also. The varieties Sufi, Prodip, Sonora and the genotype BL-1022 also performed better in respect of yield.

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 performances.
2. Another experiment may be carried out with other genotypes.

REFERENCE

Acevedo, E., M. Nachit and G. O. Ferrana. (1991). Effects of heat stress on wheat and possible selection tools for use in breeding for tolerance. Pp. 401-420.

Al-Khatib, K. and G. M. Paulesn. (1990). Photosynthesis and productivity during high temperature stress of wheat genotypes from major world regions. *Crop Sci.* **30**: 1127-1132.

Arbinda, S., Begur, S. N., Rahman, A. K. M. and Salahuddin, A. B. M. (1994). Influence of sowing time on the performance of different wheat genotypes. Ann. Cent. Res. Agron. Div., Bangladesh Agril. Res. Inst., Joydebpur, Gazipur. pp. 45-49.

Badruddin, M., D. A. Sauders, A. B. Siddique, M. A. Hossain, M. O. Ahmed, M. M. Rahman and S. Parveen. (1994). Determining yield constraints for wheat production in Bangladesh. pp. 265-271.

BARI (Bangladesh Agricultural Research Institute). (1984). Annual Report 1981-82. Joydebpur, Gazipur.pp. 12-20.

BARI (Bangladesh Agricultural Research Institute). (1993). Annual Report 1991-92. Joydebpur, Gazipur.pp. 18-25.

BARI (Bangladesh Agricultural Research Institute). (1997). Increase wheat cultivation and decrease irrigation cost (A folder in Bengali). Wheat Res. Centre. Bangladesh Agril. Res. Inst. Nashipur, Dinajpur. pp. 12-15.

BARI (Bangladesh Agricultural Research Institute). (2006). Krishi Projukti Hat Boi. BARI. Joydevpur, Gazipur. p. 14.

Bazza, M. J., S. G. Sadaria, J. C. Patel. (1999). Wheat and sugar beet with irrigation management practices through water-deficit irrigation. *Indian J. Agril. Sci*., **69**(13): 431-435.

BBS (Bangladesh Bureau of Statistics). (2008). Monthly Statistical Bulletin, Bangladesh. Statistics Division. Ministry of Planning. Government of the Peoples Republic of Bangladesh. Dhaka. pp. 64.

Bhatta, M. R., J. E. Hernandez and J. S. Lales. (1994). Possibilities of selecting wheats with fast grain filling rate for warmer areas. Pp. 375-378. *In* D.A. Saunders and G. P. Hatel (ed.) Wheat in Heat-stressed Environments: Irrigated. Dry Areas and Rice-wheat Farming System. CIMMYT. Mexico D.F.

Chowdhury, M. Z. R. (2002). Effect of different sowing dates on morphopysiological feature yield and yield contributing characters of three modern wheat varieties. M. S. thesis, Dept. of crop botany, H. S. T. U, Dinajpur.

Dubin, B, M. R. and Ginkel, J. G. (1991). Wheat cultivation in the warmer climates. *J. Plant Nutri*. **24**(6): 899-919.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. 118 p.

Eissa, A. M. T., M. S. Eldin and A. M. Dawood. (1994). Planting rate in relation to yield and components of wheat in AL-Qassim region. *Arab Gulf. Sci. Res*. **12**(3): 449-464.

FAO. (1988). Production Year Book. Food and Agricultural of the United Nations Rome, Italy. **42**: 190-193.

FAO. (1997). Production Year Book. Food and Agricultural of the United Nations Rome, Italy. **51**: 212-215.

FAO. (2000). Production Year Book. Food and Agricultural of the United Nations Rome, Italy. **54**: 225-228.

Gaffer, M. A. (1995). Development of management practices of millets for higher prodution. BAU Res, Prog. Report 9: 30-33.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research (2^{nd} edn.). Int. Rice Res. Inst., A Willey Int. Sci., pp. 28-192.

Haider, S. A. (2002). Effect of water stress on the physiology and grain yiel of four bread wheat (Triticum aestivum L.) cultivars. Ph. D. thesis, Dept. of Botany, University of Rajshahi, Rajshahi, Bangladesh.

Harris, H. C., P. J. M. Copper and M. Pala. (1991). Soil and crop management for improved water use efficiency in rainfed area. Proc. Intl. Workshop. Ankara, tukey, 15-19 May, 1989. ICARDA, Aleppo, Syria.

Hossain, M. A., A. F. M. Maniruzaman and S. M. Farid. (1990). Effect of date sowing and rate of fertilizers on the yield of wheat under irrigated condition. *Bangladesh J. Agril.* **15**(2): 105-113.

Hossain, M. J. (2006). Growth and development of barley as affected by irrigation frequency. M. S. thesis, Dept. of crop botany, H. S. T. U. Dinajpur.

Islam, N. S. M., Ahmed, M. A., Razzaque. A., Sufian and Hossain, M. A. (1993). A study on the effect of seeding dates on the yield of wheat varieties. *Bangladesh. J. Agril. Res.* **18**(1): 102-107.

Jalleta, T. (2004). Participatory evaluation of the performance of some improved bread wheat (*Triticum aestivum*) varieties. *Exp. Agric.* **40**(1): 89-97.

Jhala, B. C. and Jadon, P. C. (1989). Grain growth in 15 wheat cultivars sown on different sowing date. *Bangladesh. J. Agril. Res.* **15**(2): 16-21.

Kobza, S. N. and Edwards, R. K. (1987). Response of wheat (*Triticum aestivum* L.) to irrigation and fertilizer mixture under late condition. *Bhartiya Krishi Anusandhan Patrika*. **3**(1): 37-42.

Litvinrnko, N. A., Braun, H. Y., Altay, F., Kronstad, W. E., Beniwal, S. P. S. and Nab, A. (1997). Breeding intensive winter bread wheat varieties for southern Vkranie. Wheat: Prospects for global improvement proceedings of the 5th international wheat conference, Anhara. Turkey, 10-14 June, 1996.

Maiksteniene, S., Kristaponyte, I. and Arlauskiene, A. (2006). Grain quality indicators of winter varieties as affected by urea application through leaves. *Zembirbyste, Moksol Darbai*. **93**(3): 141-157.

Majumder, A. R. (1991). Assessment of yield loss caused by common root rot in wheat a cultivar in Queensland *(Bipolaris sorokiniana)*. *Australian. J. Agril. Res*. **13**(3): 143-151.

Nibedita, D. (2009). Morphological performance of five selected wheat varieties. A Practicum Report of Internship Program. College of Agricultural Sciences. International University of Business Agriculture and Technology (IUBAT). 107 pp.

Oweis, T., H. Zeidan and A. Taimch. (1992). Modeling approach for optimizing supplemental irrigation management. Proc. Int. Conf. On Supplemental Irrigation and Drought water Management, Bari, Italy. 1st Agron. Mediterraneo, BARI.

Quarrie, S. A., J. Stojanovic and S. Pekic. (1999). Improving drought registance in Small-grained cereal. A case study, progress and prospects. *Plant Growth Regulation*. **29**(1-2):1-21.

Rahman, M. M. (1997). Effect of different levels of irrigation and nitrogen on the yield and yield contributing characters of foxtail millet. M. Sc. (Ag.) thesis, Dept. Agron, Bangladesh Agril. Univ., Mymensingh.

Rawson, T. H. (1986). Modeling approach for optimizing supplemental irrigation management. Proc. Int. Conf. On Supplemeral Irrigation and Drought water Management, Bari, Italy. 1st Agron. Mediterraneo, Bari.

Razzaque, A., Ryu, Y. H. C. G., Lee Y. W. (1992). The effects of sowing date on grain filling and related traits in winter barley. *Korean J. Crop Sci.* 37(1): 93-103.

Saari E. E. (1998). Leaf Blight Diseases and Associated Soil Borne Fungal Pathogens of Wheat in North and South East Asia. In: *Helminthosporium* Blights of Wheat: Spot Blotch and Tan Spot (eds.) by Duveiller E, Dubin HJ, Reeves J and Mc Nab A, CIMMYT, Mexico, D.F. pp. 37-51

Samson, N. B., Arabinda, S. and Saifuzzaman, M. (1995). Study of the growth stage of Newly developed wheat varieties. Ann. Central. Res. BARI. Joydebpur. Gazipur. pp. 19-21.

Sarker, S. S., K. Singh, S. R. Singh and A. P. Singh. (1999). Influence of initial profile water status and nitrogen doses on yield and evapotranspiration rate of dry land barley. *J. Indian Soc. Soil Sci.* **47**(1):22-28.

Sharma, R. C. (1993). Growth periods in relation to seedling time and performance of soring wheat. *J. Inst. Agric. Animal Sci.* **14**: 23-29.

Shukla, Y., P. J. M. Copper and M. Pala. (1992). Comparison of Wheat variety HD 2428 and Kalyansona. *Bangladesh J. Agric. Sci.* **19**: 23-27.

Sulewska, H. (2004). Characterization of 22 spelt (*Triticum aestivum* sp. Spelta) genotypes relating to some features. *Biuletyn Instytutu Hodowli Aklimatyzacji Roslin*. **231**: 43-53.

Tashiro, K. and P. Warslaw. (1989). Effect of temperature on wheat at different growth stage. *Bangladesh J. Agril.* **14**(1): 45-49.

Torofder, G. S., M. A. Hossain and M. M. Alam. (1993). Effect of tillage and irrigation on the yield of barley. *Bangladesh J. Agric. Sci.* **20**: 61-67.

Uppal, H. S., S. S. Cheema and S. Singh. (1998). Response of barley varieties to different levels of irrigation and nitrogen. *Crop Imp.* **15**: 142-145.

Wheat Research Center (WRC). (2003). Annual Report. 2002-2003. Wheat Res. Centre, Bangladesh Agril. Res. Inst. Nashipur, Dinajpur. pp. 6-36.

APPENDICES

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

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Central Farm , 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 III. Analysis of variance of the data on different percentage of seedling emergence of different wheat genotypes

Source of variation	Source of variation	Means square		
		Days to germination		
		Starting germination	50% germination	100% germination
Replication	2	0.053	0.402	0.321
Treatments	18	0.269**	0.851**	1.884*
Error	36	0.108	0.263	0.866

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

Appendix IV. Analysis of variance of the data on plant height for different days after sowing (DAS) of different wheat genotypes

Source of variation	Source of variation	Means square					
		Plant height (cm) at					
		30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	Harvest
Replication	2	0.521	2.171	3.496	4.700	0.830	0.801
Treatments	18	4.262**	12.758**	20.431**	42.651**	55.178**	60.144**
Error	36	1.262	4.299	8.119	15.827	20.135	21.677

**: Significant at 0.01 level of probability

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

Source of variation	Source of variation	Means square							
		Number of tillers per plant at							
		30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	Effective	Non-effective	Total
Replication	2	0.013	0.001	0.001	0.020	0.042	0.330	0.011	0.279
Treatments	18	0.121*	0.054**	0.113**	0.275**	0.324**	0.834**	0.025**	0.645*
Error	36	0.058	0.019	0.039	0.085	0.105	0.334	0.005	0.321

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

Appendix VI. **Analysis of variance of the data on booting and ear emergence of different wheat genotypes**

Source of variation	Source of variation	Means square					
		Starting of booting	50% booting	100% booting	Starting of ear emergence	50% ear emergence	100% ear emergence
Replication	2	0.128	4.314	2.695	3.874	4.407	1.209
Treatments	18	6.854*	40.594**	12.565**	20.746**	42.585**	62.397**
Error	36	3.543	12.694	4.294	8.574	16.296	20.176

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

Appendix VII. Analysis of variance of the data on anthesis and maturity of different wheat genotypes

Source of variation	Source of variation	Means square					
		Starting of anthesis	50% anthesis	100% anthesis	Starting of maturity	50% maturity	100% maturity
Replication	2	4.314	0.562	4.353	19.119	8.979	2.219
Treatments	18	93.792**	45.650**	74.714**	68.045**	68.263*	31.683**
Error	36	39.664	12.713	22.601	21.274	32.012	7.977

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

Appendix VIII. Analysis of variance of the data on number, length, breadth and area of leaf of different wheat genotype

Source of variation	Source of variation	Means 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	0.020	0.331	0.001	1.260	0.084
Treatments	18	0.395**	14.594**	0.064**	81.987**	2.190**
Error	36	0.101	4.287	0.007	13.289	0.524

**: Significant at 0.01 level of probability

Appendix IX. Analysis of variance of the data on spikelet per spike, fertile, unfertile & total grains and weight of 1000 seeds of different wheat genotypes

Source of variation	Source of variation	Means square					
		Spikelets/ spike	No. of fertile floret/ Spikelet	Filled grains/ Spike	Unfilled grains/ Spike	Total grains/ Spike	Weight of 1000 seeds (g)
Replication	2	0.108	0.002	0.489	0.171	0.234	1.292
Treatments	18	7.856**	0.169**	193.922**	0.742**	174.249**	27.228**
Error	36	0.944	0.038	27.630	0.137	24.993	5.053

**: Significant at 0.01 level of probability

Appendix X. Analysis of variance of the data on dry matter content of different parts of different wheat genotypes

Source of variation	Source of variation	Means square					
		Dry matter content/plant (g)					
		Stem	Lamina	Leaf Sheath	Ear	Seed	Husk
Replication	2	0.007	0.001	0.000	0.055	0.001	0.003
Treatments	18	0.230**	0.011**	0.009**	1.587**	0.112**	0.109**
Error	36	0.042	0.002	0.002	0.311	0.019	0.020

**: Significant at 0.01 level of probability

Appendix XI. Analysis of variance of the data on Grain and straw yield, biological yield and harvest index of different wheat genotypes

Source of variation	Source of variation	Means square					
		Grain		Straw		Biological Yield (t/ha)	Harvest Index (%)
		Yield (g/m^2)	Yield (t/ha)	Yield (g/m^2)	Yield (t/ha)		
Replication	2	51.660	0.005	310.437	0.031	0.061	0.165
Treatments	18	944.879**	0.094**	8645.128**	0.865**	1.516**	8.779**
Error	36	245.033	0.025	1680	0.168	0.310	1.517

**: Significant at 0.01 level of probability