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

BY

MD. NOWUSHAD ALI

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APPROVED BY:

Prof. Dr. Kamal Uddin Ahamed
Department of Agricultural Botany
SAU, Dhaka
Supervisor

Md. Moinul Haque
Associate Professor
Department of Agricultural Botany
SAU, Dhaka
Co-Supervisor

Asim Kumar Bhadra
Associate Professor
&
Chairman
Examination Committee
Department of Agricultural Botany, SAU, Dhaka.

DEDICATED
TO
MY BELOVED PARENTS

DEPARTMENT OF AGRICULTURAL BOTANY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Memo No: SAU/ Agricultural Botany /

CERTIFICATE

This is to certify that the thesis entitled **"Influence of Different Genotypes on the Growth and Yield of Late Sown 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 **Md. Nowushad Ali**, Registration number: **04-01433** 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

Prof. Dr. Kamal Uddin Ahamed
Department of Agricultural Botany
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

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The Author

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ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2008 to April 2009 to observe the influence of different genotypes on the growth and yield of late sown wheat (*Triticum aestivum* L.). Normal irrigation was provided to observe the influence of late sown wheat experimentally. The experiment comprised of 19 wheat varieties 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 experiments was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 57 plots for the Experiment having the size of 2 m × 1.5 m. plots. 19 genotypes of wheat were randomly distributed in the plots. Data on different growth characters and yield attributes were recorded to find out the suitable variety in response to the effect of high temperature stress for late sowing with normal irrigation. All the genotypes were affected due to high temperature but Gourob was the less affected variety due to late planting . Plant height, no of leaf/plant , leaf area index which were higher than other genotypes . Among the 19 genotypes Gourob showed better performance in respect of ear length,1000 seed weight ,dry mater content/ plant,shoot dry matter content. Due to high temperature all the genotypes were affected but Gourob showed higher yield (2.55 ton/ha)than other genotypes and IVT -10 showed lower yield (1.47ton/ha). In the Experiment among the wheat genotypes Gourab was superior over the others in case of late sowing and IVT-10 was severely affected by high temperature in terms of different growth and yield contributing characters.

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Chapter I

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important cereal crop which contains high amount of protein and carbohydrate.About two third of the total world's population consume wheat as staple food (Majumder, 1991). It supplies mainly carbohydrate (69.60%) and also protein (12%), fat (1.72%), and minerals (16.20%) (BARI, 1997). 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 crop next to rice. It contributes 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.

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 genotypes, delayed sowing, fertilizer management, disease and insect infestation and improper irrigation facilities. Late planting of wheat is one of the major reasons of yield reductions, because about 60% of the wheat crop is cultivated at late sowing conditions after harvesting the transplanted aman rice (Badaruddin *et al.*, 1994). Generally wheat is sown in November to ensure optimal crop growth and avoid high temperature. Temperature is one of the major environmental factors affecting grain yields in wheat. Photosynthesis in wheat is maximum between 22^0C and 25^0C (Blum, 1986; 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).

Generally, wheat is grown during Rabi (winter) season in Bangladesh 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).

Different varieties respond differently to input supply, cultivation practices and the prevailing environment during the growing season.Genotype plays an important role in producing high yield and good quality wheat. 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 high temperature tolerant have not yet been well studied.

With the selection of superior variety with proper irrigation 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). Information on the effect of high temperature and irrigation on the yield attributes of our modern wheat varieties is inadequate.There are different varieties and genotypes of wheat with good yield potential.So far it is known their performances in late sowing condition,when temperature becomes high with long light duration have not been tested widely. So, the present piece of research work was carried out with the following objectives-

i. To find out the Comparative growth and yield performances of different wheat genotypes.

ii. To determine the response of different wheat genotypes in late sown condition.

Chapter II

REVIEW OF LITERATURE

Wheat is an important cereal crop which attracted less concentration in respect of various agronomic aspects especially than the high yielding boro rice. One of the major reasons of about 60% yield reduction of wheat is due to the cultivation at late sowing condition after the harvesting of late transplanting aman rice. The farmers of our country mainly depends on rainfall during the cultivation of wheat. Selection of suitable variety is another problem for wheat cultivation. Very few research works related to growth, yield and development of wheat variety due to temperature stress, application of irrigation and varietal performance in these relations have been carried out in our country. The research work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works and research findings related to the temperature stress, irrigation and varieties of wheat, so far been done at home and abroad on this crop, have been reviewed in this chapter under the following heads-

2.1 Effect of temperature on growth and yield of wheat

Temperature is one of the major environmental factors affecting grain yield and high temperature is generally considered as detrimental to yield (Eastin, 1976). Hexaploid wheat is of temperate origin (Harlan and Zohary, 1966). The optimum temperature for wheat crop is about 20^0C (A1-Khalib and Paulsen, 1984). Like most species of temperate origin, wheat does not tolerate prolonged exposures to temperatures exceeding 35^0C (Gusta and Chen, 1987). Heat stress adversely affects the plant growth and thus limits wheat productivity in many region of the world, particularly countries in the tropical belt between 23^0N and 23^0S latitude (Fischer and Byerlee, 1991).

Crop growth resource components like leaf area development (LAD) and tillering are determined during GS_1 phase (emergence to double ridge). Sensitivity to heat stress during this phase is expressed as decreased duration of GS1, reduced LAD, number of leaves and spike bearing tillers (Shpiler and Blum, 1986). Mean temperature of 16 to 20^0C is favorable for tillering. Duration of GS_1 was reduced by about 34d with concomitant loss (82%) of leaf area index and total spike /m^2 when mean seasonal temperature changed from 12.2 to 27^0C (Acevedo *et al.*, 1991). High temperatures accelerate organ production without any increase in net photosynthesis (Begga and Rawson, 1977) resulting in smaller organs.

Chowdhury and Wardlaw (1978) observed that temperature affected the rate of grain growth of sorghum independently of the duration of grain filling. The rate of grain growth increased to its maximum at the threshold mean temperature of 25^0C, while the rate of development (1/time from anthesis to maturity) continued to increase linearly with increasing temperature to 33.5^0C. Consequently, above 25^0C, both grain size and grain yield were reduced by high temperature. Kiniry and Musser (1988) similarly observed in another phytotron study, that grain size and the duration of grain-filling were reduced as temperature increased from 22.5 to 30^0C.

Bhatta *et al.* (1994) evaluated the variation of twelve spring wheat genotypes of similar maturity in grain yield, morpho-physiological characters, and the relationship between grain yield and plant traits over two planting periods. Most characters were altered when planting was delayed by one month from the normal seedling date. Declines in grain yield, kernels per spikelet and 100 grain weight were relatively of small magnitude.

The stage of grain development most sensitive to high temperature was 7-12 d after anthesis (Tashiro and Wardlaw, 1989). The greatest reduction of individual grain weight in response to high temperature occurred at different times for different spikelet and floret positions. High temperature (up to $30/25^0$C day/night) after anthesis reduced grain yield of wheat by reducing weight per grain, rather than grain number (Wardlaw *et al.*, 1989).

Productivity of wheat and other temperate species falls markedly at high temperatures (Bbullar and Jenner, 1983; Rawson, 1986; Shpiler and Blum, 1986; Wardlaw *et al.*, 1980). Genotypes within species differ in response to high temperatures, however, indicating substantial genetic variability for the trait. Wheat genotypes for instance, incur differential injury from high temperatures during vegetative growth (Shpiler and Blum, 1986), reproductive growth (Bhullar and Jenner, 1983; Wardlaw *et al.*, 1980), or both periods (Rawson, 1986). Many wheat genotypes can be considered high temperature tolerant (Rawson, 1986).

Grain number per ear is limited by the number of spikelets per ear and 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). Shpiler and Blum (1986) 0bserved that the cultivars that sustained the highest yield in hot environments were able to maintain the longest duration of GS_2 and had the highest number of grain per spike. This is the most sensitive stage and its duration is drastically reduced due to heat stress. There is a corresponding decrease in spikelet/floret number per spike and grain number per unit area. Assuming that grain number is solely controlled by prevailing temperature. Abrol *et al.* (1991) observed a linear regression of grain number on the mean temperature from sowing to anthesis. The regression shows a reduction of 5.5% in grain number for every 1^0C increase in temperature. Acevedo*et 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.

High temperature (41^0C) causes a decrease in the potential photosynthetic rate in both heat resistant and susceptible varieties although the decrease was smaller are recovery ability higher in the resistance variety (Volkova and Koshkin, 1984).

Kanani and Jadon (1985) assessed 110 wheat genotypes for ability to withstand high temperatures when sown early to fit into a rotation with groundnut 18, including Hindi 62, C306, K65, NP846, HJ72-6, HJ72-50, HJ-65, HI617 and W6357, were superior. These genotypes had higher values for yield and 5 yield related traits when sown early than when sown late, for example, Hindi 62 yielded twice as much with earlier as with late sowing. Correlation studies indicates that flag leaf sheath length, extrusion length, plant height, spike length, kernel per spike and biological yield are important determinants of grain yield in wheat under Los Banos conditions (Fischer and Maurer 1976).

Fokarb *et al.* (1998) observed significant variation among five wheat cultivars in the reduction in grain weight per ear, Kennel number and single kennel weight under heat stress. Differences in grain weigh per ear among cultivars were ascribed to variation to variation in the reduction in both kennel number and kennel weight under heat stress.

Grain yield of wheat decreases and grain protein increases with the increasing temperature stress duration (Ahmad *et al.*, 1989).

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 Nonember 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. Evans *et al.* (1975) and Mudhokar (1981) reported that higher temperature at grain filing stage was one of the important reasons for lower grain yield in wheat crop.

Chinoy (1947) compared grain weight per plant and 1000 grains weight of wheat varieties grouped into eight classes according to flowering time, which ranged from-90-100 to 160-170 days. With delay in flowering, grain developed at increasingly higher temperatures and lower humidity, with the consequence that both 1000 grain weight and grain yield per plant diminished progressively. Pal and Butant (1947) also concluded that 1000 grain wt. was reduced for late sowing because of the high temperatures prevalent at the time of grain ripening. Chinoy and Sharma (1957, 1958) found that external conditions such as temperature were mainly responsible for under developed or empty grain, and not genetic factor as previously held.

Harvest index increased essentially linearly during grain growth and then planted at the maximum value with increasing temperature (Muchow, 1990) in sorghum. The increase in harvest index closely mirrored the increase in grain size. In a series of pot experiments Asana and Saini (1962) compared the 1000-grain weight for two varieties of wheat, cv. C. 281 and N. P. 720. They observed that 13.9 and 17.8% losses in grain weight for cv. C. 281 and N.P. 720 respectively for a 5^0C rise in the mean temperature and assuming that yield attribute is determined solely by temperature.

2.2 Effect of irrigation on growth and yield of wheat

Zhai *et al.* (2003) conducted a pot experiment with winter wheat to determine water stress on the growth, yield contributing characters and yield of wheat and reported that water stress significantly inhibited the growth and yield of winter wheat.

Wang *et al.* (2002) conducted a pot experiment in a green house to study the effects of water deficit and irrigation at different growing stages of winter wheat and observed that water deficiency retarded plant growth. Irrigation increased yield of wheat significantly than under control condition.

Debelo *et al.* (2001) conducted a field experiment in Ethiopia on bread wheat and reported that plant height and thousand-kernel weight showed positive and strong association with grain yield, indicating considerable direct or indirect contribution to grain yield under low moisture conditions.

Gupta *et al.* (2001) reported that 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. Among the yield attributes, number of leaves and number of tillers were positively correlated at the anthesis stage whereas leaf area and shoot dry weight significantly correlated with grain and biological yield at both the stages.

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. 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.

Meena *et al.* (1998) conducted a field experiment during 1993-95 at New Delhi on bread wheat (cv. HD 2265) with no irrigation or irrigation at flowering and/or crown root initiation stages and reported that wheat grain yield was the highest with 2 irrigations (2.57 t/ha in 1993 and 2.64 t/ha in 1995).

Islam (1997) reported that plant height increased with increasing number of irrigations. The maximum plant height was obtained by three irrigations applied at 25, 50 and 70 days after sowing.

Boogaard *et al.* (1996) carried out an experiment in a Mediterranean environment in North Syria with wheat under rainfed and irrigated conditions and reported that under rainfed conditions harvest index was increased.

Islam (1996) observed that irrigation significantly influenced the plant heights, number of effective tillers per plant, grain and straw yields but it had no influence of grains per ear and 1000-grain weight. The highest grain yield (3.71 t/ha) was obtained with three irrigations (25, 45 and 60 DAS) and the lowest with no irrigations (2.61 t/ha) was obtained.

Naser (1996) reported that the effect of different irrigations on yield and yield attributing characters were statistically significant. Two irrigations at 30 and 50 DAS significantly increased grain and straw yields over control. The highest grain and straw yields, the maximum number of tillers per plant, the highest spike length, and the maximum number of grains per spike were recorded when two irrigations were applied. The control treatment showed the lowest result in all plant parameters.

Razi-us-Shams (1996) observed that the effect of irrigation treatments on yield and yield contributing characters (cv. Sonalika) were statistically significant.

Irrigation increased the grain and straw yields, number of tillers, panicle length, and number of grains per panicle over the control.

Yadav *et al.* (1995) reported that two irrigations scheduled at CRI (Crown Root Initiation) and milk stages gave the maximum plant height (1.026 m), maximum number of grain/ear (65), straw weight (4500 kg/ha) and grain yield (3158 kg/ha) of wheat.

BARI (1993) reported that maximum grain and straw yields were recorded with three irrigation, applied at CRI, maximum tillering and grain filling stages of crop. Irrigation given at CRI+ Maximum tillering (MT), CRI + Booting (BT) and CRI + Grain filling (GR) were at per in respect of number of spikes/m^2 and grains/spikes, but had higher spikes and grains over CRI + MT stages.

Upadhyaya and Dubey (1991) conducted an experiment in India with three irrigation frequencies eg. one irrigation (at CRI stage), two irrigations (on each at CRI and booting stage) and four irrigation (one each at CRI, booting, flowering and milking stages). Four irrigations produced the maximum grain yield, which was significantly higher than one to two irrigations. The increased yield was due to the favourable effect of treatments on yield attributing characters.

Singh and Singh (1991) conducted a field experiment at Lakhaoti, Uttar pradesh, India during 1983-84 and 1984-85 with irrigation at 20, 27, 34 and 41 DAS and reported that spike length increased significantly when irrigation was applied at 20 and 27 DAS.

Sah *et al.* (1990) found the maximum grain yield of wheat with two irrigations but the maximum grain protein content was obtained with three irrigations. Sharma *et al.* (1990) obtained higher yield with three irrigations given at CRI, tillering and milking stages of wheat than other treatments with three irrigations. They also found maximum water use efficiency with three irrigations given at CRI, tillering and milking stages.

Khola *et al.* (1989) observed that wheat grown with 5 and 7 irrigations (with 600 mm water) gave yields of 3.27 and 3.05 t/ha respectively, and with 4, 2 and 1 irrigations wheat yields were 3.66 and 2.97 and 2.11 t/ha, respectively. English and Nakarume (1989) reported that wheat yield was decreased with increasing number of irrigation. They found the highest grain yield of 3.6 t ha^{-1}.

2.3 Effect of variety on growth and yield of wheat

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.

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.

Chapter III

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2008 to April 2009 to observe the influence of different genotypes on the growth and yield of late sown wheat. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

The research work was conducted in the experimental field of 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.

3.1.2 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.

3.1.3 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.

3.2 Experimental details

The experiment was conducted to observe the influence of different genotypes on the growth and yield of late sown wheat. This experiment comprised of 19 wheat genotypes. Name and sources of these genotypes were:

Genotypes	Sourse	Genotypes	Sourse
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 60	WRC	BL-1022	BSMRAU
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 for this Experiment having the plot size of 2 m × 1.5 m. 19 genotypes of wheat were randomly distributed in the plots.

3.3 Growing of crops

3.3.1 Seed collection

The seeds of different wheat genotypes for this experiment 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 plot selected for the experiment was opened in the third week of December 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 methods 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

3.3.4 After care

After the emergence 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

Two Flood irrigation was provided in this experiment. 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 from the first week of April, 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} in plot wise. 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 was estimated by observing absolute visibility of seedlings of the experimental plot and expressed in days.

3.5.2 Plant height

The height of plant was recorded in centimeter (cm) at 20, 30, 40, 50, 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. The height was measured from the ground level to the tip of the plant.

3.5.3 Days to booting

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

3.5.4 Days to emergence of spike

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

3.5.5 Days to anthesis

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

3.5.6 Days to maturity

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

3.5.7 Days to ripening

Days to 50% and 100% ripening was recorded by calculating the number of days from sowing to 50% and 100% plant attained harvesting condition.

3.5.8 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.

3.5.9 Leaf area

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

3.5.10 Leaf area index

Leaf area index was calculated as the ratio of leaf area and ground area of a plant.

3.5.11 Number of effective tillers/plant

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

3.5.12 Ear length

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

3.5.13 Number of spikelets per spike

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.

3.5.14 Number of fertile florets per spike

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.

3.5.15 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.

3.5.16 Grain weight per 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}.

3.5.17 Grain weight per hectare

Grains obtained from one m^{22} were converted into t ha^{-1} grain weight.

3.5.18 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 leaf sheath, leaf lamina, dry husk weight and dry grain weight per plant was recorded. By adding the entire recorded dry weight of different parts of the plant total shoot dry matter per plant was estimated and recorded.

3.5.19 Number of tillers per plant

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

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 influence of different genotypes on the growth and yield of late sown wheat. Data on different growth characters and yield were recorded to find out the response of different genotypes due to the effect of high temperature for late sowing with normal irrigation. The results have been presented and discussed, and possible interpretations have been given under the following headings:

4.1 The results of this experiment have been presented in the tables 4.1.1-4.1.7, figures 4.1.1-4.1.5 and the ANOVA III-X for different characters in the Appendices.

4.1.1 Emergence of seedlings

4.1.1.1 Days to starting emergence of seedlings

Statistically significant variation was recorded for days to starting emergence of seedlings for different wheat genotypes at late sowing at high temperature condition with normal irrigation (Table 4.1.1). The maximum days to starting emergence of seedlings (6.00 days) was recorded from wheat variety Kanchan, Pavan and IVT-10, while the minimum days to starting emergence of seedlings (3.67 days) was obtained from wheat variety BAW-1064. Days to starting emergence of seedlings varied for different varieties might be due to genetical and environmental influences as well as management practices.

Table 4.1.1 Emergence of seedling percentage of different wheat genotypes

Variety/Treatment	Days to starting emergence of seedlings	Days to 50% emergence of seedlings	Days to 100% emergence of seedlings
BL 1883	4.33 cd	9.00 d	14.33 bc
BAW-1104	4.67 bcd	10.00 bc	15.00 ab
BAW-1064	3.67 d	10.00 bc	15.33 a
Sonora	5.33 abc	9.33 cd	14.00 cd
Sourab	4.33 cd	11.00 a	15.33 a
Prodip	4.67 bcd	10.00 bc	14.00 cd
Fang 60	5.00 abc	10.00 bc	14.67 abc
Gourab	4.33 cd	9.67 bcd	14.33 bc
BAW-917	4.67 bcd	10.00 bc	15.00 ab
IVT-9	5.00 abc	10.33 ab	14.67 abc
Sufi	5.00 abc	10.00 bc	14.33 bc
Shatabdi	5.00 abc	10.33 ab	14.67 abc
Kanchan	6.00 a	10.33 ab	14.00 cd
Pavan-76	6.00 a	10.33 ab	14.33 bc
IVT-10	6.00 a	10.00 bc	13.33 d
Bijoy	5.00 abc	10.33 ab	14.67 abc
BL-1022	5.67 ab	10.33 ab	14.33 bc
Kalyan Sona	5.00 abc	9.67 bcd	14.33 bc
BAW-1051	4.67 bcd	9.67 bcd	14.33 bc
$LSD_{(0.05)}$	1.090	0.699	0.838
Level of Significance	0.01	0.01	0.01
CV (%)	13.25	4.22	6.50

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 probability

Faster speed of emergence of seedlings at prevailing higher temperature might be due to rapid hydrolysis and mobilization of seed reserves through alpha amylase activity at higher temperature. The close relation between germination of wheat seed and alpha amylase activity at various temperatures was reported by Sultana *et al* (2000). In respect to speed of germination following emergence of seedlings of all wheat genotypes behaved almost similar at prevailing higher temperature and genotype difference in speed of germination due to prevailing higher temperature did not appear clearly.

4.1.1.2 Days to 50% emergence of sedlings

Different wheat varieties at late sowing high temperature condition with normal irrigation showed significant variation for days to 50% emergence of seedlings (Table 4.1.1). The maximum days to 50% emergence of seedlings (11.00 days) was found from wheat variety Sourab, again the minimum days to 50% emergence of seedlings (9.00 days) was obtained from BL 1883.

4.1.1.3 Days to 100% emergence of seedlings

Days to 100% emergence of seedlings for different wheat varieties at late sowing high temperature condition with normal irrigation showed statistically significant variation (Table 4.1.1). The maximum days to 100% emergence of seedlings (15.33 days) was observed from wheat variety BAW-1064 and Sourab, whereas the minimum days (13.33 days) was found from wheat variety IVT-10. Rate of emergence of seedlings was significantly influenced by the effect of high temperature in case of different genotypes.

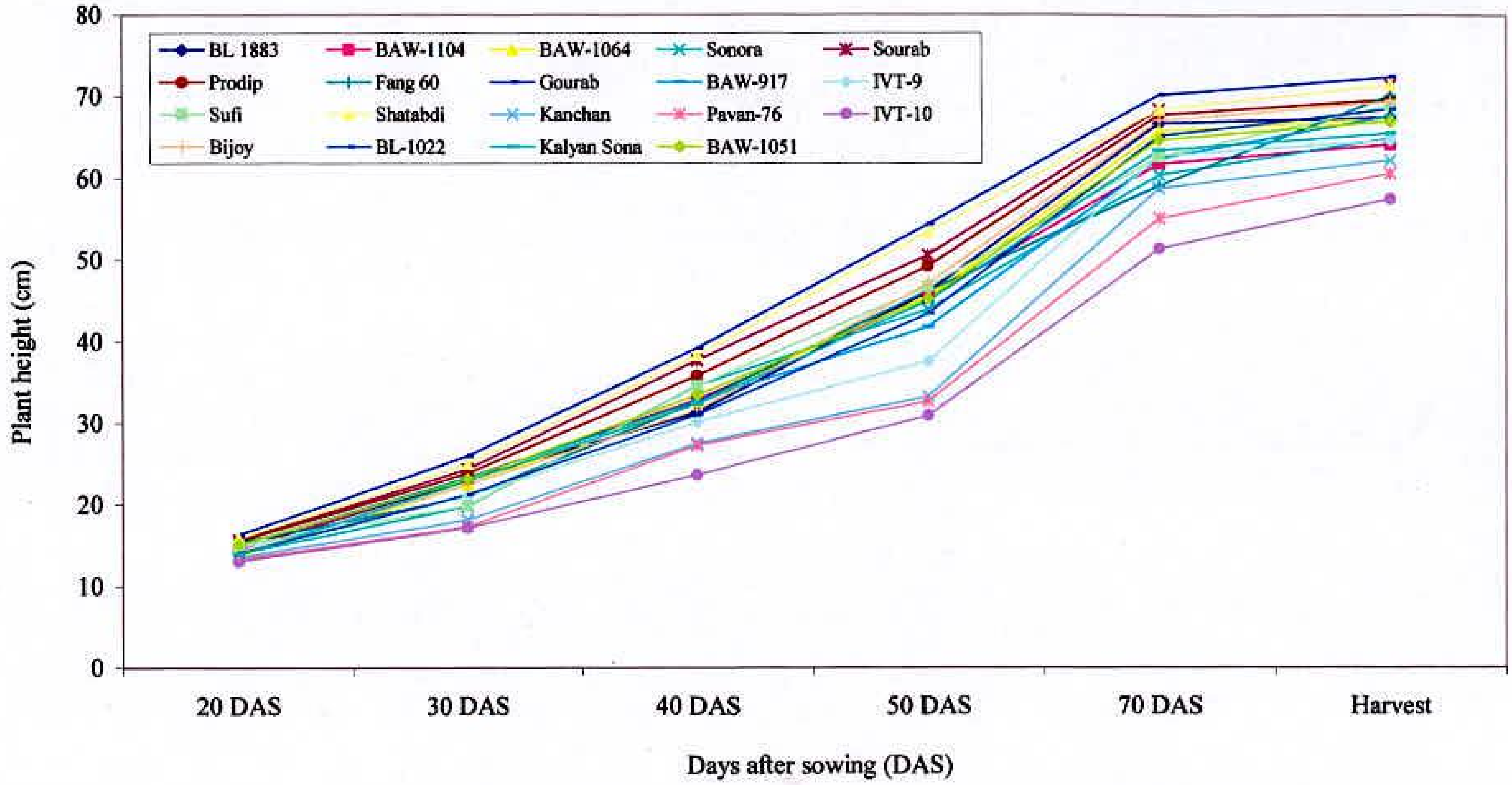

Figure 4.1.1. The increasing trend of plant height of different wheat varieties at different DAS as affected by late sowing with normal irrigation

4.1.2 Plant height

Significant differences were observed for plant height at 20, 30, 40, 50, 70 DAS and at harvest for different wheat genotypes at late sowing high temperature codition with normal irrigation (Figure 4.1.1). At 20, 30, 40, 50, 70 DAS and harvest the tallest plant (16.33 cm, 25.97 cm, 39.17 cm, 54.37 cm, 70.17 cm and 72.33 cm) was obtained from wheat variety Gourab which was statistically identical to Shatabdi, Sourab and Prodip and followed by Bijoy and Sufi. On the other hand, the shortest plant (13.07 cm, 17.17 cm, 23.67 cm, 30.87 cm, 51.33cm and 57.40 cm) was recorded from the wheat variety IVT-10 which was similar to Pavan-76 and Kanchan. Zhai *et al.* (2003) reported that water stress significantly inhibited the growth of winter wheat. Gupta *et al.* (2001) reported that water stress at booting stage caused a greater reduction in plant height. Campbell and Read 1968 Bhatta et al(1994), Begga and Rawson (1977) also found shorter plant height due to late showing.

4.1.3 Days to booting

4.1.3.1 Days to 50% booting

Different wheat varieties at late sowing high temperature condition with normal irrigation showed statistically significant differences for days to 50% booting (Table 4.1.2). The maximum days to 50% booting (54.00 days) was obtained from the wheat genotype IVT-9 and similar to IVT-10 and Kanchan, again the minimum days to 50% booting (44.67 days) was observed from the wheat genotype BL 1883. The lowest days taken to attain booting stage in late sowing with normal irrigation might be due to higher temperature condition in this period which hastens to attain booting period. Similar result was also reported by Hafiz (2007) in barley and pal *et al.* (1996) in wheat.

4.1.3.2 Days to 100% booting

Significant variation was recorded for different wheat genotypes at late sowing high temperature condition with normal irrigation in terms of days to 100% booting (Table 4.1.2). The maximum days to 100% booting (56.67 days) was recorded from the wheat genotype IVT-9 which was similar to IVT-10, Kanchan and BAW-917, while the minimum days to 100% booting (49.33 days) was recorded from the wheat genotypes Fang 60, Shatabdi, Kalyan Sona and BAW-1051. Due to late showing the lowest number of days was taken to attain booting stage. Moisture stage condition might be water deficit condition due to high temperature in this period which hasten to attain earlier booting period.

4.1.4 Days to emergence of spike

4.1.4.1 Days to 50% emergence of spike

Days to 50% emergence of spike showed significant variation for different wheat varieties at late sowing high temperature condition with normal irrigation (Table 4.1.2). The maximum days to 50% emergence of spike (61.00 days) was found from wheat genotype IVT-10, which was similar to the wheat genotype IVT-9. On the other hand, the minimum days to 50% emergence of spike (50.33 days) was recorded from the wheat genotypes Fang 60, Shatabdi, Kalyan Sona and BAW-1051.

Table 4.1.2 Percentage of days to booting and emergence of spike of different wheat genotypes at late sowing with normal irrigation

genotype/Treatment	Days to 50% booting	Days to 100% booting	Days to 50% emergence of spike	Days to 100% emergence of spike
BL 1883	44.67 g	51.00 ef	52.00 ef	57.00 fg
BAW-1104	48.67 def	52.00 de	53.00 def	58.00 ef
BAW-1064	50.67 bcd	53.67 bcd	55.00 bcde	60.00 cd
Sonora	49.00 def	52.00 de	53.00 def	58.00 ef
Sourab	48.00 def	51.00 ef	52.00 ef	57.00 fg
Prodip	50.67 bcd	53.67 bcd	54.67 bcde	59.67 d
Fang 60	46.33 fg	49.33 f	50.33 f	55.33 h
Gourab	49.67 cde	52.67 de	53.67 cdef	58.67 de
BAW-917	52.33 abc	55.33 abc	56.33 bcd	61.33 bc
IVT-9	54.00 a	56.67 a	58.00 ab	63.00 a
Sufi	46.67 efg	49.67 f	50.67 f	55.67 gh
Shatabdi	46.33 fg	49.33 f	50.33 f	55.33 h
Kanchan	53.00 ab	55.67 ab	57.00 bc	62.00 ab
Pavan-76	50.67 bcd	53.33 cde	54.67 bcde	62.33 ab
IVT-10	53.67 ab	56.33 a	61.00 a	62.67 ab
Bijoy	49.00 def	53.33 cde	54.00 cdef	59.00 de
BL-1022	50.67 bcd	53.33 cde	54.67 bcde	59.67 d
Kalyan Sona	46.33 fg	49.33 f	50.33 f	55.33 h
BAW-1051	46.33 fg	49.33 f	50.33 f	55.33 h
$LSD_{(0.05)}$	2.869	2.074	3.253	1.502
Level of Significance	0.01	0.01	0.01	0.01
CV (%)	7.51	9.39	6.66	10.55

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 probability

4.1.4.2 Days to 100% emergence of spike

Different wheat genotypes at late sowing high temperature condition with normal irrigation showed statistically significant differences for days to 100% emergence of spike (Table 4.1.2). The maximum days to 100% emergence of spike (63.00 days) was observed from the wheat genotype IVT-9, which was similar to Kanchan, Pavan-76 and IVT-10, again the minimum days to 100% emergence of spike (55.33 days) was obtained from the wheat genotypes Fang 60, Shatabdi, Kalyan Sona and BAW-1051. High temperature influenced water deficit condition might have taken less time for emergence of spike than normal condition.

4.1.5 Days to anthesis

4.1.5.1 Days to 50% anthesis

Significant variation was found for days to 50% anthesis for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.3). The maximum days to 50% anthesis (66.00 days) was recorded from IVT-9 and Kanchan, which was similar to BAW-1064, BAW-917, Pavan-76, IVT-10 and Kalyan Sona, while the minimum (58.33 days) from genotypes Sufi and Shatabdi. The rising in temperature accelerate the development of phenophases, which progressed linearly with the increase in temperature. The findings of present work confirm the result of Pal *et al.* (1996).

4.1.5.2 Days to 100% anthesis

Days to 100% anthesis showed statistically significant variation for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.3). The maximum days to 100% anthesis (68.00 days) was recorded from the wheat genotypes IVT-9 and Kanchan, which was similar to Prodip, BAW-917, IVT-9, Pavan-76, IVT-10 and Kalyan Sona, whereas the minimum days to 100% anthesis (60.67 days) was found from genotypes Sufi, Shatabdi and BAW-1051.

Due to deficient soil moisture condition in higher temperature and late planting it has taken less time to attain anthesis where as well aerated and duely sowing of wheat has taken more time to attain anthesis.

4.1.6 Days to maturity

4.1.6.1 Days to 50% maturity

Different wheat genotypes at late sowing high temperature condition with normal irrigation showed statistically significant variation for days to 50% maturity (Table 4.1.3). The maximum days to 50% maturity (75.00 days) was observed from the wheat genotypes Pavan-76 and IVT-10, which was similar to BAW-917, IVT-9 and Kanchan, again the minimum (65.67 days) was recorded from the wheat variety Sonora. The reduction in crop duration mainly might be happened due to rapid increase in temperature and water stress i.e., moisture scarcity in later sowing. The late sown crop experienced increased temperature which forced the plants to mature earlier. Similar results were also reported by Saini and Dadwal (1986) and Blue *et al.* (1996).

Table 4.1.3 Percentage of days to anthesis, maturity and ripening of different genotypes at late sowing with normal irrigation

Genotype/ Treatment	Days to 50% anthesis	Days to 100% anthesis	Days to 50% maturity	Days to 100% maturity	Days to 50% ripening	Days to 100% ripening
BL 1883	61.00 defg	64.00 cde	69.33 bc	75.67 bc	82.67 bcd	90.33 ef
BAW-1104	62.33 cde	64.67 bcd	68.67 bc	75.33 bc	82.33 bcd	90.67ef
BAW-1064	65.33 abc	67.33 a	67.33 bc	73.67 bc	80.67 cde	90.00 f
Sonora	61.00 defg	63.67 de	65.67 c	72.00 c	79.00 e	90.00 f
Sourab	60.00 efg	63.00 de	69.33 bc	75.67 bc	82.67 bcd	90.67 ef
Prodip	62.67 bcde	66.00 abc	69.67 bc	76.67 b	83.67 bc	90.00 f
Fang 60	61.00 defg	62.00 ef	67.00 bc	73.33 bc	80.33 de	90.00 f
Gourab	61.67 def	64.33 cd	67.33 bc	73.67 bc	80.67 cde	90.33 ef
BAW-917	63.67 abcd	67.00 a	74.33 a	80.67 a	87.00 a	92.00 de
IVT-9	66.00 a	67.67 a	74.00 a	80.67 a	87.00 a	94.33 b
Sufi	58.33 g	60.67 f	66.00 bc	72.67 bc	79.67 de	90.00 f
Shatabdi	58.33 g	60.67 f	67.33 bc	74.00 bc	81.00 cde	91.00 def
Kanchan	66.00 a	68.00 a	74.00 a	80.67 a	87.00 a	94.00 bc
Pavan-76	65.67 ab	67.33 a	75.00 a	81.00 a	87.33 a	91.67 def
IVT-10	65.67 ab	67.33 a	75.00 a	81.67 a	88.00 a	96.00 a
Bijoy	62.33 cde	64.00 cde	66.67 bc	73.67 bc	80.67 cde	90.00 f
BL-1022	62.33 cde	64.33 cd	70.00 b	76.67 b	85.33 ab	92.67 cd
Kalyan Sona	65.00 abc	66.67 ab	67.67 bc	74.33 bc	81.33 cde	90.00 f
BAW-1051	58.67 fg	60.67 f	69.00 bc	75.33 bc	82.33 bcd	90.00 f
$LSD_{(0.05)}$	2.767	1.928	3.562	3.415	2.807	1.548
Level of Significance	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	12.67	11.80	13.09	8.71	6.04	5.02

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 probability

4.1.6.2 Days to 100% maturity

Significant variation was recorded for days to 100% maturity for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.3). The maximum days to 100% maturity (81.67 days) was obtained from the wheat genotype IVT-10, which was similar to BAW-917, IVT-9, Kanchan and Pavan-76 while the minimum (72.00 days) was found from the wheat variety Sonora. Well irrigated condition and duely sowing of wheat required more time to maturity whereas water deficit and high temperature stress condition required comparatively less time to maturity.

4.1.7 Days to ripening

4.1.7.1 Days to 50% ripening

Statistically significant difference was found for different wheat genotypes at late sowing high temperature condition with normal irrigation in terms of days to 50% ripening (Table 4.1.3). The maximum days to 50% ripening (88.00 days) was recorded from the wheat genotypes IVT-10, which was similar to BAW-917, IVT-9 and Kanchan, Pavan-76 and BL-1022, whereas the minimum (79.00 days) was observed from the wheat variety Sonora.

4.1.7.2 Days to 100% ripening

Days to 100% ripening varied significantly for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.3). The maximum days to 100% ripening (96.00 days) was recorded from the wheat genotype IVT-10, again the minimum (90.00 days) was attained by the wheat genotypes BAW-1064, Sonora, Prodip, Fang 60, Sufi, Bijoy, Kalayn Sona and

BAW-1051. Due to late sowing high temperature ripening was severely affected . Increase in temperature shorten the ripening period.

4.1.8 Number of leaves per plant

Different wheat genotypes at late sowing high temperature condition with normal irrigation varied significantly for number of leaves per plant (Table 4.1.4). The maximum number of leaves per plant (5.53) was found from the wheat genotype Gourab, which was statistically identical with Shatabdhi and Sourab, whereas the minimum number (4.63) was recorded from the wheat genotype IVT-10. Due to genetical factor and high temperature the number of leaves of wheat was greately affected. Maximum leaf number was found at 60-70 days and then declined generally till maturity.

4.1.9 Leaf area

A statistically significant variation was observed for leaf area for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.4). The highest leaf area (25.18 cm^2) was observed from the wheat variety Gourab and the lowest (11.73 m^2) was found from the wheat genotype IVT-10. Due to late planting and high temperature stress condition leaf area was decreased than normal sowing.

Table 4.1.4 Leaf characteristics of different wheat genotypes as affected by late sowing with normal irrigation

genotype/Treatment	No. of leaves/plant	Leaf area (cm^2)	Leaf area index (LAI)
BL 1883	4.97 bcd	16.63 h	0.17 h
BAW-1104	5.07 bcd	16.50 h	0.17 h
BAW-1064	5.00 bcd	20.47 cde	0.20 cde
Sonora	5.00 bcd	20.00 cdef	0.20 cdef
Sourab	5.20 abc	18.67 defg	0.19 efg
Prodip	5.13 bc	18.17 fgh	0.18 fgh
Fang 60	4.90 bcd	18.57 efg	0.19 fg
Gourab	5.53 a	25.18 a	0.25 a
BAW-917	4.90 bcd	17.23 gh	0.17 gh
IVT-9	4.90 bcd	13.60 i	0.14 i
Sufi	5.10 bc	22.50 b	0.23 b
Shatabdi	5.30 ab	20.83 bc	0.20 bc
Kanchan	5.00 bcd	13.37 ij	0.13 ij
Pavan-76	4.80 cd	13.07 ij	0.13 ij
IVT-10	4.63 d	11.73 j	0.12 j
Bijoy	4.83 cd	19.70 cdef	0.20 cdef
BL-1022	5.07 bcd	20.53 cd	0.21 cd
Kalyan Sona	4.90 bcd	22.33 b	0.22 b
BAW-1051	4.80 cd	18.92 cdefg	0.19 defg
$LSD_{(0.05)}$	0.368	1.712	0.017
Level of Significance	0.01	0.01	0.01
CV (%)	4.44	5.65	5.65

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 probability

4.1.10 Leaf area index

Significant variation was recorded for leaf area index for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.4). The highest leaf area index (0.25) was recorded from the wheat variety Gourab and the lowest (0.12) was recorded from the wheat genotype IVT-10. Leaf area index depends on the environmental and genetical factors. Leaf area index decreased at late planting and high temperature than normal condition.

4.1.11 Number of effective tillers/ plant

Number of effective tillers plant^{-1} varied significantly for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.5). The maximum number of effective tillers plant^{-1} (3.07) was obtained from wheat variety Gourab, which was identical to BL 1883, BAW-1104, BAW-1064, Sonora, Sourab, Prodip, BAW-917, IVT-9, Sufi, Shatabdi, Bijoy, BL-1022 and Kalyan Sona, again the minimum number (2.07) was found from wheat genotype IVT-10. Gupta *et al.* (2001) reported that water stress at booting stage caused a greater reduction in number of tillers. Number of tillers per plant was highly affected due to late planting.

4.1.12 Ear length

Significant difference was found for ear length for different wheat genotypes at late sowing high temperature condition with normal irrigation (Figure 4.1.2). The longest ear (13.70 cm) was obtained from the wheat variety Gourab, which was identical to Sourab, Prodip, BAW-917, Sufi, Shatabdi and Bijoy. On the other hand, the

Table 4.1.5 Yield attributes of different wheat genotypes as affected by late sowing with normal irrigation

Genotype/ Treatment	No. of effective tillers/plant	No. of spikelet/ spike	No. of fertile floret/spike	Yield/ha (ton)
BL 1883	2.90 abc	16.47 def	23.20 cdefgh	1.94 def
BAW-1104	2.83 abc	16.53 def	27.57 abcdef	2.12 bcde
BAW-1064	2.83 abc	17.37 bcdef	22.93 defgh	2.28 abcd
Sonora	2.90 abc	16.37 def	31.27 abcde	2.03 cde
Sourab	2.97 abc	18.63 abc	32.57 ab	2.51 ab
Prodip	2.93 abc	18.13 abcd	28.93 abcdef	2.50 ab
Fang 60	2.60 cd	16.57 def	22.37 efgh	2.24 abcd
Gourab	3.07 a	19.60 a	35.73 a	2.55 a
BAW-917	3.00 abc	17.03 cdef	26.73 bcdef	2.04 cde
IVT-9	2.67 abcd	16.67 def	25.90 bcdefg	2.04 cde
Sufi	2.93 abc	17.70 bcdef	31.90 abcd	2.35 abcd
Shatabdi	3.03 ab	19.00 ab	33.00 ab	2.53 a
Kanchan	2.63 bcd	16.13 ef	21.53 fgh	1.64 fg
Pavan-76	2.30 de	15.90 f	17.34 gh	1.56 g
IVT-10	2.07 e	15.90 f	15.70 h	1.47 g
Bijoy	2.93 abc	17.73 bcde	32.07 abc	2.37 abc
BL-1022	2.67 abcd	17.33 bcdef	25.90 bcdefg	2.10 cde
Kalyan Sona	2.77 abc	17.07 cdef	24.07 bcdefgh	2.08 cde
BAW-1051	2.60 cd	16.50 def	23.93 bcdefgh	1.82 efg
$LSD_{(0.05)}$	0.355	1.516	7.710	0.351
Level of Significance	0.01	0.01	0.01	0.01
CV(%)	7.75	5.33	17.60	10.08

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 probability

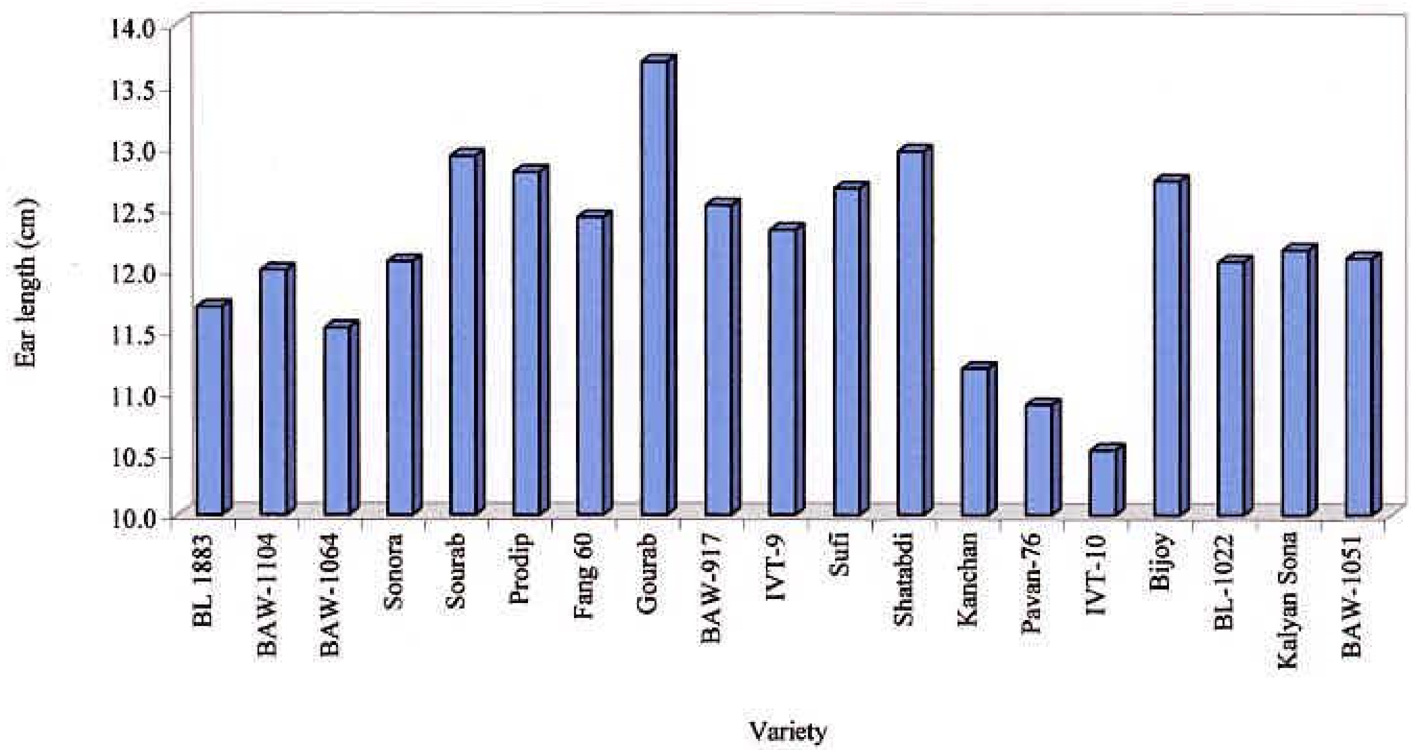

Figure 4.1.2. Ear length of different wheat varieties as affected by late sowing with normal irrigation

shortest ear (10.53 cm) was recorded from the wheat genotype IVT-10. Ear length had positive relationships to yield which Jalleta (2004) reported to be one of the main criteria for adaptation of wheat varieties.

4.1.13 Number of spikelet spike^{-1}

Different wheat genotypes at late sowing high temperature condition with normal irrigation showed significant differences for number of spikelet spike^{-1} (Table 4.1.5). The maximum number of spikelet spike^{-1} (19.60) was obtained from the wheat variety Gourab, which was identical to the varieties Sourab, Prodip and Shatabdi, while the minimum number (15.90) was obtained from the wheat genotype IVT-10 and Pavan-76. Irrigation conforms favorable environment for grain formation. Yadav *et al.* (1995) also reported similar findings earlier from their experiment.

4.1.14 Number of fertile floret spike^{-1}

Significant difference was found for number of fertile floret spike^{-1} for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.5). The maximum number of fertile floret spike^{-1} (35.73) was found from the wheat variety Gourab, which was identical to BAW-1104, Sonora, Sourab, Prodip, sufi, Shatabdi and Bijoy, again the minimum number (15.70) was obtained from the wheat genotype IVT-10. Zhai *et al.* (2003) reported that water stress significantly inhibited the yield components of winter wheat. Zhai *et al.* (2003) reported that water stress significantly inhibited the filled grains spike^{-1} of winter wheat.

4.1.15 Weight of 1000 seeds

Weight of 1000 seeds showed significant difference was recorded for different wheat genotypes at late sowing high temperature condition with normal irrigation (Figure 4.1.3). The highest weight of 1000 seeds (45.18 g) was obtained from the wheat variety Gourab, which was identical to BL 1883, BAW-1104, Sourab, Prodip, BAW-917, IVT-9, sufi, Shatabdi, Bijoy and BL-1022, whereas the lowest weight (17.87 g) was recorded from the wheat genotype IVT-10.

It was seen that due to high temperature and water deficit condition grain size , grain shape and seed weight were affected than normal condition .

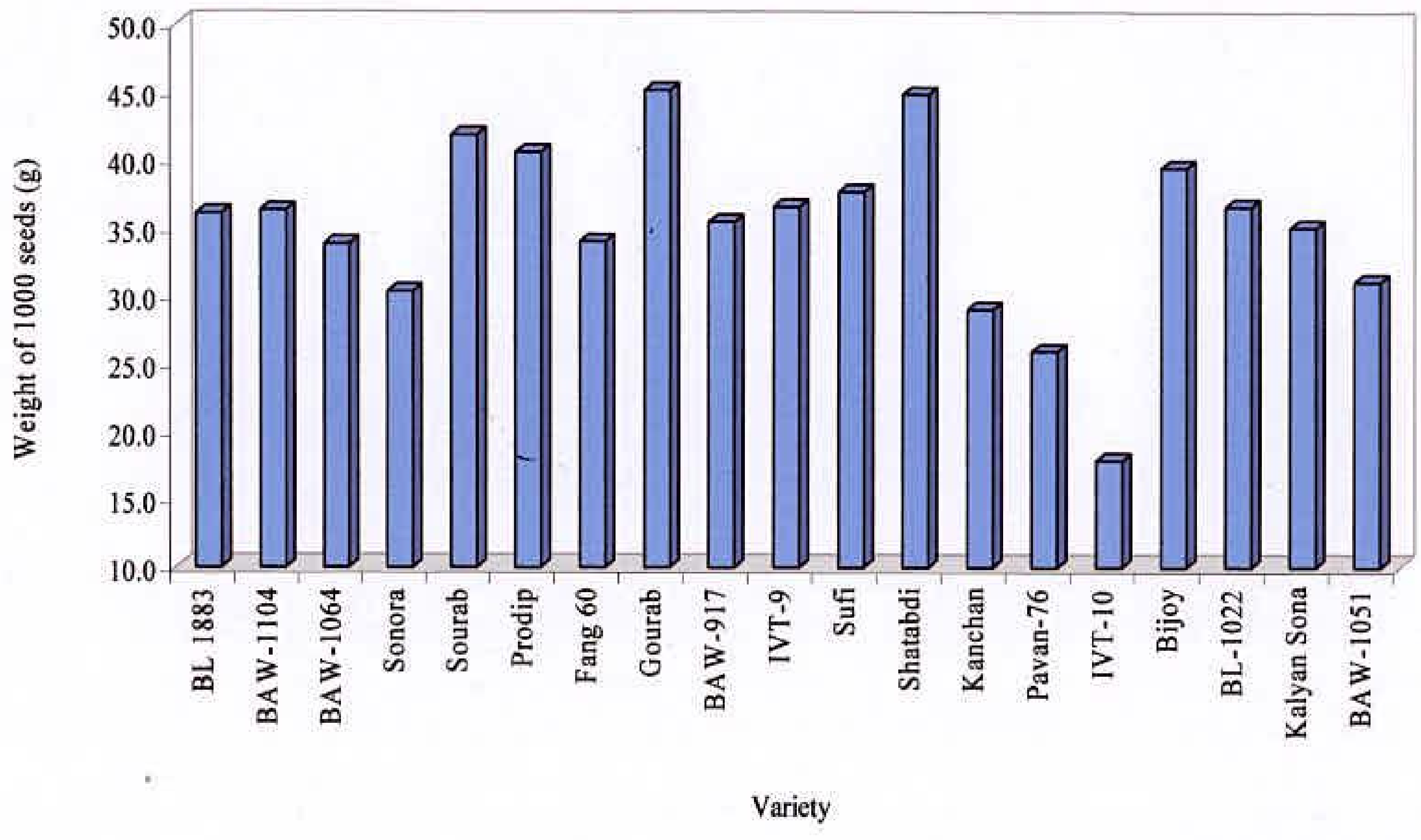

Figure 4.1.3. Weight of 1000 seeds of different wheat varieties as affected by late sowing with normal irrigation

4.1.16 Grain weight m^{-2}

Significant difference was recorded in terms of grain weight m^{-2} for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.4). The highest grain weight m^{-2} (254.67 g) was recorded from the wheat variety Gourab, which was identical to BAW-1104, Sourab, Prodip, Fang 60, sufi, Shatabdi and Bijoy, again the lowest (146.45 g) was recorded from the wheat genotype IVT-10. Debelo *et al.* (2001) reported considerable direct or indirect contribution of water to grain yield under low soil moisture conditions and high temperature stress condition.

4.1.17 Grain weight $hectare^{-1}$

Different wheat genotypes at late sowing high temperature condition with normal irrigation showed significant difference for grain weight $hectare^{-1}$ (Table 4.1.5). The highest grain weight /hectare (2.55 ton) was found from the wheat variety Gourab, which was identical to BAW-1104, Sourab, Prodip, Fang 60, sufi, Shatabdi and Bijoy, whereas the lowest (1.47 ton) was observed from the wheat genotype IVT-10. Zhai *et al.* (2003) reported that water stress significantly inhibited the yield of winter wheat. But the highest grain yield (3.71 t ha^{-1}) was obtained from the application of three irrigations (25, 45 and 60 DAS) and the lowest was from no irrigation (2.61 t ha^{-1}).

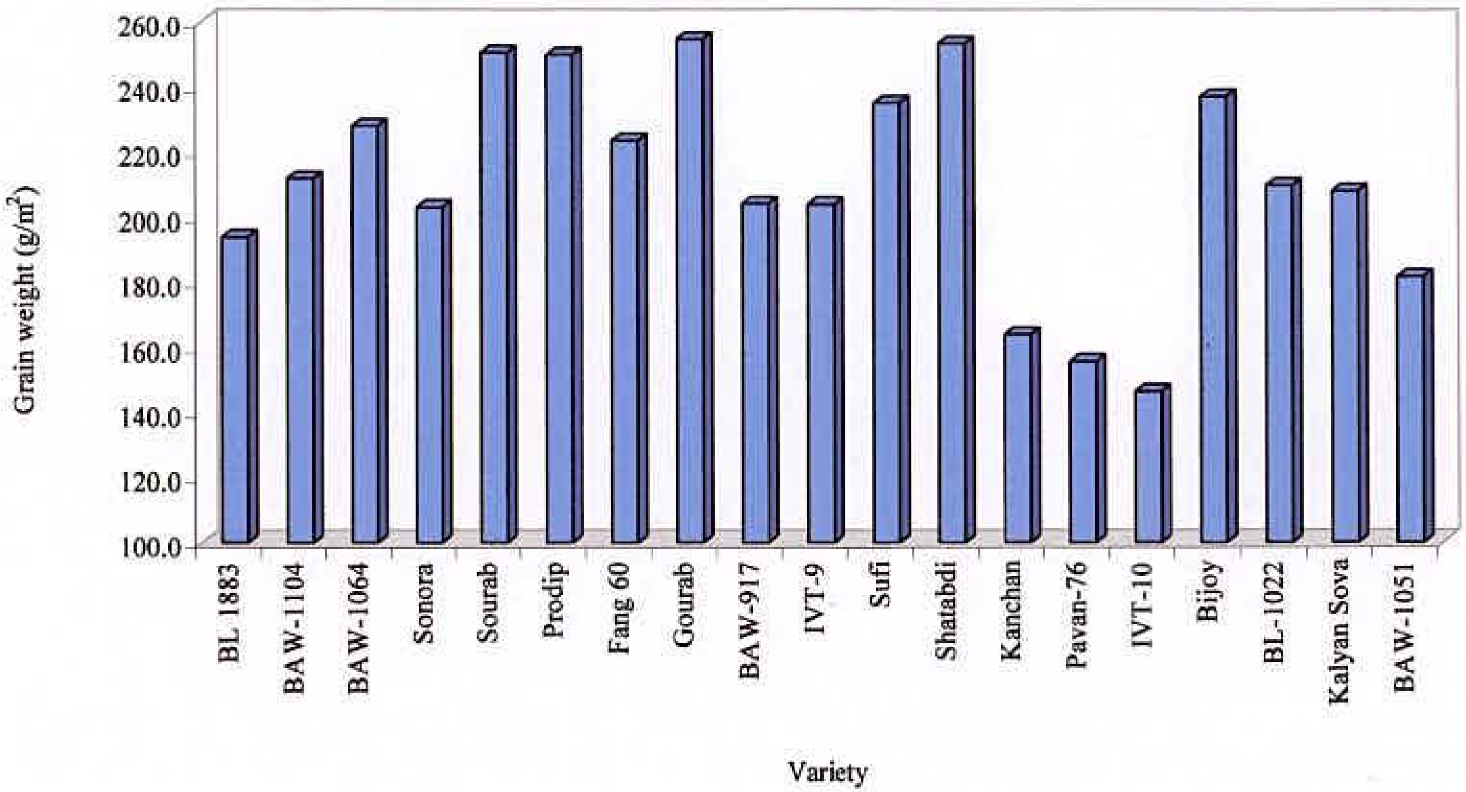

Figure 4.1.4 Grain weight per squre meter of different wheat varieties as affected by late sowing normal irrigation

4.1.18 Dry matter content

4.1.18.1 Dry matter content in stem

Significant difference was observed for dry matter content in stem for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.6). The highest dry matter content in stem (0.72 g) was obtained from wheat genotype BAW-1104, which was identical to BL 1883, BAW-1064, Sonora, Sourab, Prodip, Fang 60, Shatabdi, Kanchan, BL-1022, Kalyan Sona and BAW-1051, again the lowest (0.45 g) was found from the wheat genotype IVT-10.

4.1.18.2 Dry matter content in leaf sheath

Dry matter content in leaf sheath varied significantly for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.6). The highest dry matter content in leaf sheath (0.35 g) was recorded from the wheat variety Prodip, which was identical to BL 1883, BAW-1104, BAW-1064, Sonora, Sourab, Fang 60, Gourabm Shatabdi, Kanchan, Bijoy, BL-1022, Kalyan Sona and BAW-1051, whereas the lowest (0.17 g) was recorded from the wheat genotype IVT-10.

4.1.18.3 Dry matter content in leaf lamina

Significant variation was observed for dry matter content in leaf lamina for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.6). The highest dry matter content in leaf lamina (0.32 g) was observed from wheat variety Shatabdi, which was identical to BAW-1104, Sonora,

Table 4.1.6 Dry matter contents of different wheat genotypes as affected by late sowing with normal irrigation

Genotype/Treatment	Dry matter content in stem (g/plant)	Dry matter content in leaf sheath (g/plant)	Dry matter content in leaf lamina (g/plant)	Dry husk weight/plant (g/plant)	Dry grain weight/plant
BL 1883	0.60 abcdef	0.29 abcd	0.25 bcde	0.42 bcde	1.63 def
BAW-1104	0.72 a	0.31 abcd	0.28 abc	0.48 bcde	1.78 bcd
BAW-1064	0.65 abcde	0.32 abcd	0.26 bcde	0.69 a	1.92 abcd
Sonora	0.57 abcdef	0.32 abc	0.29 abc	0.38 de	1.71 cde
Sourab	0.63 abcde	0.32 abc	0.26 bcde	0.53 bcd	1.75 cd
Prodip	0.65 abcd	0.35 a	0.23 cde	0.49 bcd	2.14 a
Fang 60	0.66 abcd	0.34 a	0.24 cde	0.53 bcd	1.91 abcd
Gourab	0.69 ab	0.33 ab	0.22 de	0.56 abc	2.14 a
BAW-917	0.53 cdef	0.30 abcd	0.24 cde	0.44 bcde	1.37 efg
IVT-9	0.50 ef	0.28 abcd	0.25 bcde	0.40 cde	1.71 cde
Sufi	0.56 bcdef	0.28 abcd	0.22 de	0.52 bcd	2.01 abc
Shatabdi	0.62 abcde	0.26 cd	0.32 ab	0.49 bcde	2.14 a
Kanchan	0.67 abc	0.27 bcd	0.27 abcd	0.50 bcd	1.57 defg
Pavan-76	0.45 f	0.30 abcd	0.30 ab	0.45 bcde	1.27 g
IVT-10	0.51 def	0.17 e	0.20 e	0.32 e	1.76 cd
Bijoy	0.59 abcdef	0.25 cd	0.23 cde	0.46 bcde	1.78 bcd
BL-1022	0.67 abc	0.31 abcd	0.26 bcd	0.50 bcde	2.11 ab
Kalyan Sona	0.61 abcde	0.25 d	0.23 cde	0.44 bcde	2.01 abc
BAW-1051	0.69 ab	0.31 abcd	0.26 bcd	0.59 ab	1.30 fg
$LSD_{(0.05)}$	0.127	0.059	0.051	0.142	0.305
Level of Significance	0.01	0.01	0.01	0.01	0.01
CV(%)	10.54	12.40	12.27	17.77	10.34

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 probability

Kanchan and Pavan-76, again the lowest (0.20 g) was obtained from the wheat genotype IVT-10.

4.1.18.14 Dry matter content in husk

Significant difference was recorded for different wheat genotypes at late sowing high temperature condition with normal irrigation in terms of dry matter content in husk (Table 4.1.6). The highest dry matter content in husk (0.69 g) was found from wheat genotype BAW-1064, which was identical to Bijoy and BAW-1051, while the lowest (0.32 g) was recorded from the wheat genotype IVT-10.

Due to late planting and high temperature stress condition dry matter content in stem, leaf sheath, leaf lamina and in husk were highly affected than the normal planting of wheat.

4.1.18.5 Dry matter content in grains

Different wheat genotypes at late sowing high temperature condition with normal irrigation showed significant difference for dry matter content in grains (Table 4.1.6). The highest dry matter content in grains (2.14 g) was recorded from wheat variety Prodip, Shatabdi and Bijoy, which was identical to BAW-1064, Fang 60, Sufi, BL-1022 and Kalyan Sona, while the lowest (1.27 g) was observed from the wheat variety Pavan-76. The result suggested that dry matter content in grains adversely affected by heat and water deficit condition due to late planting.

4.1.18.6 Dry matter content in total shoot

Significant variation was attained for dry matter content in total shoot for different wheat genotypes at late sowing high temperature condition with normal irrigation (Figure 4.1.5). The highest dry matter content in total shoot (3.94 g) was obtained from wheat variety Gourab which was identical to BAW-1104, BAW-1064, Sourab, Prodip, Fang 60, Sufi, Shatabdi, BL-1022 and Kalyan Sona, whereas the lowest (0.2.79 g) was recorded from wheat variety Pavan-76.

Due to genetic variation and high temperature stress the total shoot dry matter content was reduced than the normal grown wheat genotypes.

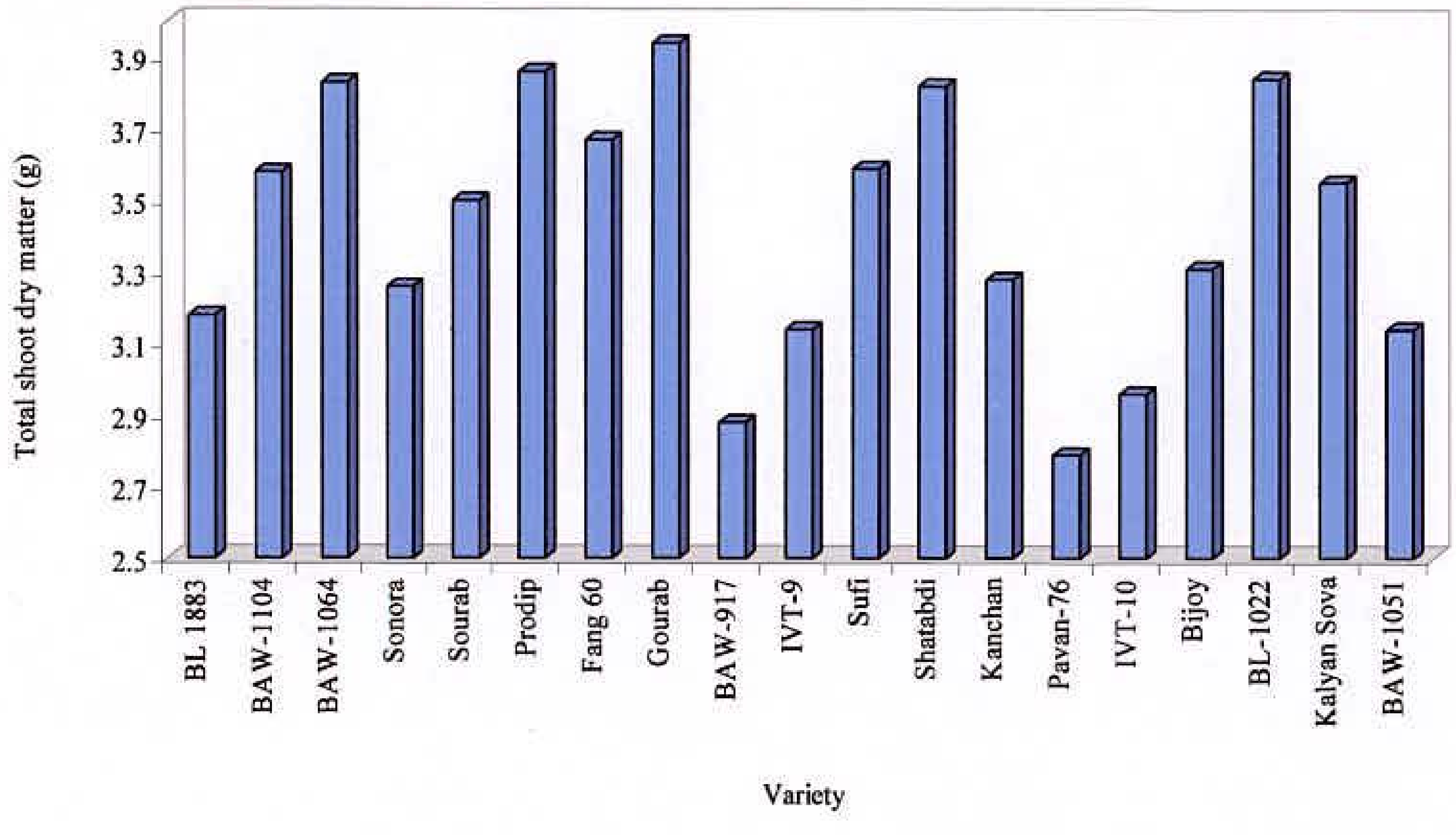

Figure 4.1.5. Shoot dry matter content of different wheat varieties as affected by late sowing with normal irrigation

4.1.19 Number of tillers plant^{-1}

A statistically significant variation was recorded for number of tillers per plant at 30, 50, 70 DAS and at harvest for different wheat genotypes at late sowing high temperature condition with normal irrigation (Table 4.1.7). At 30, 50, 70 DAS and harvest the maximum number of tillers plant^{-1} (2.80, 3.37, 5.10 and 4.50) was recorded from the wheat variety Gourab. On the other hand, the minimum number (1.93, 2.30, 3.00 and 2.93) was found from the wheat genotype IVT-10 which was similar to Pavan-76 and Kanchan. Previous findings suggested that management practices influences the number of tillers per plant but variety itself manipulated the number of tillers plant^{-1}. It was observed that wheat varieties differed significantly in producing various yield components and yield (Hasan, 1995).

Table 4.1.7 Number of tillers/plant of different wheat genotypes at different days after sowing as affected by late sowing with normal irrigation

Genotype/Treatment	No. of tillers/plant at			
	30 DAS	50 DAS	70 DAS	Harvest
BL 1883	2.27 bcde	2.60 cde	3.87 bcde	3.87 bcde
BAW-1104	2.07 cde	2.97 abcd	3.80 bcde	3.73 def
BAW-1064	2.33 bcde	3.03 abcd	3.67 bcde	3.70 ef
Sonora	2.53 ab	2.77 bcde	3.00 e	3.73 def
Sourab	2.47 abc	3.03 abcd	5.03 a	4.33 abc
Prodip	2.20 bcde	2.93 abcd	3.73 bcde	4.30 abcd
Fang 60	2.20 bcde	2.93 abcd	3.37 de	3.80 cde
Gourab	2.80 a	3.37 a	5.10 a	4.50 a
BAW-917	2.27 bcde	3.20 ab	4.63 abc	3.57 ef
IVT-9	2.40 bcd	3.10 abc	4.80 ab	3.77 cde
Sufi	2.20 bcde	2.73 bcde	3.83 bcde	3.90 bcde
Shatabdi	2.27 bcde	2.57 de	3.57 cde	4.40 ab
Kanchan	2.27 bcde	2.90 abcd	3.27 de	3.50 ef
Pavan-76	2.00 de	2.97 abcd	4.67 abc	3.17 fg
IVT-10	1.93 e	2.30 e	3.00 e	2.93 g
Bijoy	2.07 cde	2.67 cde	4.30 abcd	4.07 abcde
BL-1022	2.40 bcd	2.80 bcd	4.67 abc	3.83 bcde
Kalyan Sona	2.27 bcde	2.90 abcd	3.87 bcde	3.60 ef
BAW-1051	2.13 bcde	2.60 cde	4.57 abc	3.60 ef
$LSD_{(0.05)}$	0.346	0.425	0.994	0.503
Level of Significance	0.01	0.01	0.01	0.01
CV(%)	9.23	8.96	14.87	7.88

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 probability

Chapter V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2008 to April 2009 to observe the influence of different genotypes on the growth and yield of late sown wheat with normal irrigation (30 days delay). The experiment comprised with 19 wheat varieties 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 Sova and BAW-1051. 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 plots. 19 varieties of wheat were randomly distributed in the plots. Data on different growth characters and yield were recorded to find out the suitable variety due to the influence of high temperature for late sowing with normal irrigation. Statistically significant variation was recorded for different parameters of different wheat genotypes at late sowing high temperature condition with normal irrigation. The maximum days to starting of emergence of seedlings (6.00 days) was recorded from wheat genotypes Kanchan, Pavan and IVT-10, while the minimum days to starting of emergence of seedlings (3.67 days) was obtained from the wheat genotype BAW-1064. The maximum days to 50% emergence of seedlings (11.00 days) was found from the wheat variety Sourab, again the minimum days to 50% emergence of seedlings (9.00 days) were recorded from the wheat genotype BL

1883. The maximum days to 100% emergence of seedlings (15.33 days) was observed from the wheat genotypes BAW-1064 and Sourab, whereas the minimum days (13.33 days) was found from the wheat genotype IVT-10. More time in the emergence of seedlings was taken due to high temperature due to late sowning than the normal sowing. At 20, 30, 40, 50, 70 DAS and harvest the tallest plant (16.33 cm, 25.97 cm, 39.17 cm, 54.37 cm, 70.17 cm and 72.33 cm) was obtained from the wheat variety Gourab and the shortest plant (13.07 cm, 17.17 cm, 23.67 cm, 30.87 cm, 51.33cm and 57.40 cm) was recorded from the wheat genotype IVT-10. The maximum days to 50% booting (54.00 days) was obtained from the wheat genotype IVT-9 and the minimum days to 50% booting (44.67 days) was observed from the wheat genotype BL 1883. The maximum days to 100% booting (56.67 days) was recorded from the wheat genotype IVT-9, while the minimum days to 100% booting (49.33 days) was recorded from the wheat genotype Fang 60, Shatabdi, Kalyan Sova and BAW-1051. The maximum days to 50% emergence of spike (61.00 days) was found from the wheat genotype IVT-10 and the minimum days to 50% emergence of spike (50.33 days) was recorded from the wheat varieties Fang 60, Shatabdi, Kalyan Sona and BAW-1051. The maximum days to 100% emergence of spike (63.00 days) was observed from the wheat genotype IVT-9, again the minimum days to 100% emergence of spike (55.33 days) was obtained from the wheat varieties Fang 60, Shatabdi, Kalyan Sova and BAW-1051. The maximum days to 50% anthesis (66.00 days) was recorded from the wheat genotypes IVT-9 and Kanchan, while the minimum (58.33 days) was found from the wheat varieties Sufi and Shatabdi. The maximum days to 100% anthesis (68.00 days) was recorded from wheat genotype IVT-9 and Kanchan, whereas the minimum days to 100% anthesis (60.67 days) was found from the wheat varieties Sufi, Shatabdi and BAW-1051. The maximum days to 50% maturity (75.00 days) was observed from the wheat varieties Pavan-76 and IVT-10, again the minimum (65.67 days) was recorded from the wheat variety Sonora. The maximum days to 100% maturity (81.67 days) were obtained from the wheat genotype IVT-10, while the minimum (72.00 days) was found from the wheat variety Sonora. The maximum days to 50% ripening (88.00 days) was recorded from the wheat genotype IVT-10, whereas the minimum (79.00 days) was observed from the wheat variety Sonora. The maximum days to 100% ripening (96.00 days) was recorded from the wheat genotype IVT-10, again the minimum (90.00 days) from the wheat genotypes BAW-1064, Sonora, Prodip, Fang 60, Sufi, Bijoy, Kalayn Sova and BAW-1051.

The maximum number of leaves per plant (5.53) was found from the wheat variety Gourab, whereas the minimum number (4.63) was recorded from the wheat genotype IVT-10. The highest leaf area (25.18 cm^2) was observed from the wheat variety Gourab and the lowest (11.73 m^2) was found from the wheat genotype IVT-10. The highest leaf area index (0.25) was recorded from the wheat variety Gourab and the lowest (0.12) was recorded from the wheat variety IVT-10. The maximum number of effective tillers $plant^{-1}$ (3.07) was obtained from the wheat variety Gourab, again the minimum number (2.07) was found from wheat variety IVT-10. The longest ear (13.70 cm) was observed from the wheat variety Gourab and the shortest ear (10.53 cm) was recorded from the wheat genotypes

IVT-10. The maximum number of spikelet spike^{-1} (19.60) was attained from wheat variety Gourab, while the minimum number (15.90) was observed from wheat genotype IVT-10 and Pavan-76. The maximum number of fertile florets spike^{-1} (35.73) was found from the wheat variety Gourab, again the minimum number (15.70) was obtained from the wheat genotype IVT-10. The highest weight of 1000 seeds (45.18 g) was obtained from the wheat variety Gourab, whereas the lowest weight (17.87 g) was recorded from the wheat genotype IVT-10. The highest grain weight m^{-2} (254.67 g) was recorded from wheat variety Gourab, again the lowest (146.45 g) was recorded from wheat genotype IVT-10. The highest grain weight per hectare (2.55 ton) was found from the wheat variety Gourab, whereas the lowest (1.47 ton) was observed from the wheat genotype IVT-10. The highest dry matter content in stem (0.72 g) was obtained from the wheat genotype BAW-1104, again the lowest (0.45 g) was found from the wheat genotype IVT-10. The highest dry matter content in leaf sheath (0.35 g) was recorded from the wheat variety Prodip, whereas the lowest (0.17 g) was recorded from the wheat genotype IVT-10. The highest dry matter content in leaf lamina (0.32 g) was observed from the wheat variety Shatabdi, again the lowest (0.20 g) was obtained from the wheat genotype IVT-10. The highest dry matter content in husk (0.69 g) was found from the wheat genotype BAW-1064, while the lowest (0.32 g) was recorded from the wheat genotype IVT-10. The highest dry matter content in grains (2.14 g) was recorded from the wheat varieties Prodip, Shatabdi and Bijoy, while the lowest (1.27 g) was observed from the wheat variety Pavan-76. The highest dry matter content in total shoot (3.94 g) was obtained from the wheat variety Gourab, whereas the lowest (0.2.79 g) was recorded from the wheat variety Pavan-76. At 30, 50, 70 DAS and harvest the maximum number of tillers $plant^{-1}$ (2.80, 3.37, 5.10 and 4.50) was recorded from the wheat variety Gourab and the minimum number (1.93, 2.30, 3.00 and 2.93) was found from the wheat genotype IVT-10. Finally Gourob showed better performance for most of the parameters in late planting and high temperature and water deficit condition. On the other hand IVT-10 showed the lowest performance. So we can say that Gourob is the high temperature suited variety and IVT-10 is susceptible variety to high temperature and water deficit condition.

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 for specific temperature effect.
3. Another experiment may be carried out with different levels of irrigation for specific water deficit.

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APPENDICES

Appendix I. Characteristics of Laboratory 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 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 II. Monthly record of air temperature, rainfall, relative humidity and Sunshine of the experimental site during the period from December 2008 to March 2009

Month	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
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 different wheat genotypes on days to germination due to effect of heat at late sowing with normal irrigation

Source of variation	Degrees of freedom	Mean square		
		Days to starting germination	Days to 50% germination	Days to 100% Germination
Replication	2	0.544	0.123	0.053
Treatment	18	1.181**	0.573**	0.715**
Error	36	0.433	0.178	0.256

**: Significant at 0.01 level of significance

Appendix IV. Analysis of variance of the data on different wheat genotypes on days to plant height due to effect of heat at late sowing with normal irrigation

Source of variation	Degrees of freedom	Mean square Plant height (cm) at					
		20 DAS	30 DAS	40 DAS	50 DAS	70 DAS	Harvest
Replication	2	1.788	5.933	18.172	8.281	19.790	17.380
Treatment	18	2.50**	18.82**	44.25**	127.05**	81.48**	41.91**
Error	36	1.070	3.950	6.597	10.877	15.748	16.631

**: Significant at 0.01 level of significance;

Appendix V. Analysis of variance of the data on different wheat genotypes on days to booting and emergence of spike of wheat due to effect of heat at late sowing with normal irrigation

Source of variation	Degrees of freedom	Mean square			
		Days to 50% booting	Days 100% booting	Days to 50% emergence of spike	Days to 100% emergence of spike
Replication	2	3.649	2.439	8.895	0.860
Treatment	18	22.922**	17.934**	25.910**	21.700**
Error	36	3.001	1.568	3.858	0.823

**: Significant at 0.01 level of significance

Appendix VI. Analysis of variance of the data on different wheat genotypes on days to anthesis, maturity and ripening of wheat due to effect of heat at late sowing with normal irrigation

Source of variation	Degrees of freedom	Mean square					
		Days to 50% anthesis	Days to 100% anthesis	Days to 50% maturity	Days to 100% maturity	Days to 50% ripening	Days to 100% ripening
Replication	2	2.737	2.596	3.386	1.754	2.596	1.596
Treatment	18	20.567**	18.774**	30.647**	30.199**	25.994**	9.550**
Error	36	2.792	1.356	4.627	4.254	2.874	0.874

**: Significant at 0.01 level of significance

Appendix VII. Analysis of variance of the data on different wheat genotypes of plant height at harvest, total tillers/plant, leaves/plant and leaf area due to effect of heat at late sowing with normal irrigation

Source of variation	Degrees of freedom	Mean square				
		Plant height at harvest (cm)	No. of total tillers/plant	No. of leaves/plant	Leaf area (cm^2)	Leaf area index (LAI)
Replication	2	17.380	1.105	0.491	0.229	0.128
Treatment	18	41.91**	53.402**	12.240**	37.822**	3.213**
Error	36	16.631	9.235	4.936	1.069	0.034

**: Significant at 0.01 level of significance;

Appendix VIII. Analysis of variance of the data on different wheat genotypes of effective tillers/plant, ear length, spikelet/spike, fertile floret/spike, 1000 seed weight, grain weight/m^2 and yield/ha due to effect of heat at late sowing with normal irrigation

Source of variation	Degrees of freedom	Mean square						
		No. of effective tillers/hill	Ear length (cm)	No. of spikelet / spike	No. of fertile floret/spike	Weight of 1000 seed (g)	Grain weight (g/m^2)	Yield/ha (ton)
Replication	2	8.439	0.592	0.038	11.515	51.598	479.687	0.654
Treatment	18	19.737**	1.78**	3.30**	88.898**	127.6**	3248.3**	2.651**
Error	36	4.605	0.387	0.838	21.676	26.151	437.705	0.219

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

Appendix IX. **Analysis of variance of the data on different wheat genotypes on dry matter content in stem, leaf sheath, leaf lamina, dry husk weight/plant, dry grain weight/plant and total shoot dry matter/plant due to effect of heat at late sowing with normal irrigation**

Source of variation	Degrees of freedom	Mean square					
		Dry matter content in stem (g/plant)	Dry matter content in leaf sheath (g/plant)	Dry matter content in leaf lamina (g/plant)	Dry husk weight/plant (g/plant)	Dry grain weight/plant	Total shoot dry matter/plant
Replication	2	1.197	0.031	0.068	0.012	0.0231	0.563
Treatment	18	1.645**	0.506**	0.309**	0.591**	1.092**	1.991**
Error	36	0.584	0.131	0.095	0.0154	0.0182	0.737

**: Significant at 0.01 level of significance

Appendix X. **Analysis of variance of the data on different wheat genotypes on days to no. of tiller/plant due to effect of heat at late sowing with normal irrigation**

Source of variation	Degrees of freedom	Mean square			
		No. of tillers/plant at			
		30 DAS	50 DAS	70 DAS	Harvest
Replication	2	4.281	40.228	0.228	0.317
Treatment	18	18.788**	133.380**	12.148**	11.981**
Error	36	236.77	36.061	4.376	2.671

**: Significant at 0.01 level of significance