EFFECT OF VARIETY AND SOWING DATES ON THE GROWTH AND YIELD OF WHEAT

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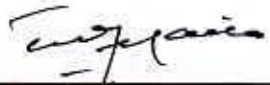

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Variety and Sowing Dates on the Growth and Yield of Wheat'** 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 **Agronomy**, embodies the result of a piece of *bonafide* research work carried out by **Israt Afrin Sonia**, Registration number: **08-02990** 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.

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DEDICATED
TO
MY BELOVED PARENTS

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The Author

EFFECT OF VARIETY AND SOWING DATES ON THE GROWTH AND YIELD OF WHEAT

ABSTRACT

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2013 to March 2014 to find out the effect of variety and sowing dates on the growth and yield of wheat. The experiment comprised of two factors; Factor A: Variety (4); V_1: BARI Gom 21,V_2: BARI Gom 23, V_3: BARI Gom 25, V_4: BARI Gom 26 and Factors B: Sowing date (4)-S_1: Sowing at 10 November, S_2: Sowing at 20 November, S_3: Sowing at 30 November, S_4: Sowing at 10 December, 2013. The experiment was laid out in a split plot design with three replications. In case of wheat varieties, at 30, 45, 60, 75 DAS and at harvest, the tallest plant (27.86, 60.91, 87.32, 95.98 and 102.38 cm, respectively) was found from V_2, while the shortest plant (25.68, 56.75, 81.58, 90.46 and 95.90 cm, respectively) was recorded from V_3. The highest number of spikelets spike^{-1} (21.24), the highest grain yield (3.72 t ha^{-1}) and the highest straw yield (5.32 t ha^{-1}) was recorded from V_2, the lowest number of spikelets spike^{-1} (19.49), the lowest grain yield (3.26 t ha^{-1}) and the lowest straw yield (4.73 t ha^{-1}) was recorded from V_3. For different sowing dates, at 30, 45, 60, 75 DAS and at harvest, the longest plant (28.18, 61.21, 86.62, 97.79 and 104.71 cm, respectively) was observed from S_2, whereas the shortest plant (25.32, 55.62, 81.14, 88.56 and 92.17 cm, respectively) was found from S_4. The highest number of spikelets spike^{-1} (21.10), the highest grain yield (3.77 t ha^{-1}) and the highest straw yield (5.61 t ha^{-1}) was observed from S_2, the lowest number of spikelets spike^{-1} (19.36), the lowest grain yield (3.12 t ha^{-1}) and the lowest straw yield (4.16 t ha^{-1}) was found from S_4. Due to the interaction effect of wheat varieties and sowing dates, at 30, 45, 60, 75 DAS and at harvest, the longest plant (29.97, 63.89, 89.42, 98.78 and 108.32 cm, respectively) was observed from V_2S_2 and the shortest plant (22.36, 54.14, 80.92, 84.15 and 88.17 cm, respectively) was obtained from the treatment combination V_3S_4. The highest number of spikelets spike^{-1} (22.23), the highest grain yield (3.94 t ha^{-1}) and the highest straw yield (5.88 t ha^{-1}) was observed from V_2S_2, whereas the lowest number of spikelets spike^{-1} (18.80), the lowest grain yield (3.04 t ha^{-1}) and the lowest straw yield (3.88 t ha^{-1}) was obtained from the treatment combination V_3S_4. BARI Gom 23 and sowing on 20 November was the best in wheat cultivation.

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CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum* L.) primarily grown across the exceptionally diverse range of environments is an important food crop (WRC, 2009). The largest area of wheat cultivation in the warmer climates exists in the South-East Asia including Bangladesh, India and Nepal (Dubin and Ginkel, 1991). Importance of wheat crop may be understood from the fact that it covers about 42% of total cropped area in rice-wheat system in South Asia (Iqbal *et al.*, 2002). 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). In Bangladesh, wheat is the second most important cereal crop (FAO, 1997). It occupies above 4% of the total cropped area and 11% of the area cropped in rabi and contributes 7% to the total output of food cereals (Anon., 2008). Generally wheat supplies carbohydrate (69.60%), protein (12%), fat (1.72%), minerals (16.20%) and also other necessary nutrients in trace amount (BARI, 1997).

Bangladesh had become highly dependent on wheat imports while dietary preferences were changing such that wheat was becoming a highly desirable food supplement to rice. Domestic wheat production rose to more than 1 million tons per year, but was still only 7-9% of total food grain production (BARI, 2010). Wheat cultivation has been increased manifolds to meet up the food shortage in the country. But, in spite of its importance, the yield of the crop in the context of our country is low (2.2 t ha^{-1}) in comparison to other wheat growing countries of the world (FAO, 1997). The area, production and yield of wheat have been increasing dramatically based on the demand of over increasing population of Bangladesh 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). In Bangladesh at present about 706.33 thousand hectares of land is covered by wheat with the annual production of 1,592 thousand tons (BBS, 2012).

Yield of wheat is very low in Bangladesh and the low yield of wheat 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, delayed sowing after the harvest of transplanted aman rice, fertilizer management, disease and insect infestation and improper or limited irrigation facilities. Among different factors, sowing time and lack of seeds of high yielding varieties of wheat are the major reasons of yield reduction in Bangladesh. 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. Major constraints to wheat grain yield in this region are inadequate rainfall and high temperatures during grain filling at the end of the season (Radmehr *et al.*, 2003; Andarzian *et al.*, 2008).

Late sowing of wheat is one of the major reasons of yield reduction in our country (Badaruddin *et al.*, 1994). Late planted wheat plants face a period of high temperature stress during reproductive stages causing reduced kernel number spike^{-1} and reduced kernel weight (Bhatta *et al.*, 1994 and Islam *et al.*, 1993) as well as the reduction of seed yield. The choice of sowing date is an important management option to optimize grain yield of wheat in such an environment (Radmehr *et al.*, 2003 and Turner, 2004). Numerous publications have been reported on increased wheat yield with early sowing and a reduction in yield when seeds sowing is delayed after the optimum time (Bassu *et al.*, 2009; Bannayan *et al.*, 2013). Many studies also confirm the adverse effects of late sowing (Singh and Dhaliwal, 2000; Wajid *et al.*, 2002; Singh and Pal, 2003; Kumar and Sharma, 2003) but on the same time sowing of wheat at the first available opportunity may not always be the best economically; rather cultivars need to be matched to sowing time according to their time of flowering and maturity. The response of wheat to sowing date depends on seasonal weather variability and varies a great deal across years and locations. Therefore, extrapolating the results obtained from a limited number of environments is not difficult but may be misleading (Timsina *et al.*, 2008).

Different varieties respond differently to sowing time and the prevailing environment condition during the growing season. Recently, efforts were taken to increase the yield of wheat in Bangladesh by releasing a number of high yielding varieties. In Bangladesh although some varieties have been identified for late sowing condition (Islam *et al.*, 1993 and Ahmed *et al.*, 1989).

Climate and weather conditions greatly influence the performance of new wheat cultivars both for yield and quality (Wajid *et al.*, 2004; Sharma *et al.*, 2006; Abdullah *et al.*, 2007). Accurate knowledge of the sowing window of any particular variety at a particular location is critical to achieve a high grain yield (Ortiz-Monasterio *et al.*, 1994). Varieties-sowing date interactions regarding 1000-grain weight and bread quality have been found to be highly significant showing different varietal behavior in different sowing dates (Qamar *et al.*, 2004; Subhan *et al.*, 2004). Information on the precise time of sowing of different wheat variety to optimize the wheat production within the farmers limited resources is inadequate in Bangladesh. So, in the context of the above mentioned situation in respect of wheat cultivation in Bangladesh, the present piece of work was undertaken with the following objectives-

i. To determine the response of high yielding varieties against varying sowing dates for wheat;

ii. To identify effective sowing date for wheat cultivation and

iii. To assess the interaction effect of sowing date on different BARI released wheat varieties.

CHAPTER II

REVIEW OF LITERATURE

One of the major reasons of yield reduction of wheat is that about 60% of the crop is cultivated at late sowing condition after harvesting the transplanted aman rice and unawareness in the selection of suitable variety for different agro-climatic condition. So, variety and subsequently sowing time are the most important factors needed to be considered in wheat cultivation. Some of the important and informative works and research findings related to the variety and sowing time of wheat done at home and abroad have been reviewed under the following headings:

2.1 Effect of variety

Good quality wheat variety for producing maximum yield through highest yield contributing characters that plays an important and major role for wheat production. Some of the pertinent literatures regarding wheat variety/genotypes from country and abroad have been presented below-

Plant height

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 and reported that plant height were significantly affected by variety.

Litvinrnko *et al.* (1997) produced winter wheat with high grain quality for bread making in Southern Ukraine and reported that plant height itself governed by genetically.

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 tallest plant due to variety. He also reported that the variety Waggershauser, Hohenh, Weisser, Kolben gave the tallest plant.

Qasim *et al.* (2008) reported the growth and yield response of three wheat varieties (Suliman-96, Chakwal-97 and Inqalab-91) to various sowing times when they studied an experiment at Karakoram Agricultural Reserch Institute, (Norther Areas) Gilgit, Pakistan and reported that plant height varied for different cultivars of wheat.

A study was undertaken by Khokhar *et al.* (2010) to determine the effects of planting dates on growth and yield of different wheat genotypes in Sindh. Four sowing dates and six wheat genotypes (V-7001, V-7002, V-7004, MPT-6, Abadgar-93, and Anmol-91) were used. Better plant growth was recorded in for wheat genotype, V-7002.

A pot experiment was carried out by Al-Musa *et al.* (2012) at Patuakhali Science and Technology University to study the performance of some BARI wheat varieties under the coastal area of Patuakhali. Four wheat varieties viz. BARI ghom-23, BARI ghom-24, BARI ghom-25 and BARI ghom-26 were planted in the field to evaluate their comparative performance. Among the BARI varieties, BARI ghom-26 produced the taller plant (47.91 cm).

A study was undertaken by Mohsen *et al.* (2013) to determine the effects of sowing dates on growth and yield components of different wheat cultivar in Iran. Five sowing dates and five wheat cultivars (Pishgam, Parsi, Bahar, Sivand and Pishtaz) were used in this experiment. Results showed that the effect of cultivars was significant on all parameters.

Iranian winter wheat cultivars and their response to delay sowing date were investigated as a field experiment by Yajam and Madani (2013). The experiment designed with four winter wheat cultivars namely B.C. Roshan, Alvand, Amirkabir and Shahriar and six sowing date from very early to very late sowing time. The results showed significant differences between cultivars the first in relation to plant height.

A field experiment was conducted by Zia-Ul-Hassan *et al.* (2014) to evaluate the response of high yielding varieties against varying sowing dates under rainfed conditions at Adaptive Research Farm, Bhaun, Chakwal. Treatments were four sowing dates and five varieties, viz. GA 2002, Chakwal 50, Farid 2006, Wafaq 2001 and Sehar 2006). The results showed that varieties remained significant in consideration of plant height.

Tillering pattern

Growth and yield response of three wheat varieties (Suliman-96, Chakwal-97 and Inqalab-91) to various sowing times was studied by Qasim *et al.* (2008) at Karakoram Agricultural Research Institute, (Norther Areas) Gilgit, Pakistan and recorded the maximum tillers were in Inqalab-91 (302.17).

A study was undertaken by Khokhar *et al.* (2010) to determine the effects of planting dates on growth and yield of different wheat genotypes in Sindh. Four sowing dates and six wheat genotypes (V-7001, V-7002, V-7004, MPT-6, Abadgar-93, and Anmol-91) were used. Better tillering, were recorded in for wheat genotype V-7002 in comparison with other genotypes.

A pot experiment was carried out by Al-Musa *et al.* (2012) at Patuakhali Science and Technology University to study the performance of some BARI wheat varieties under the coastal area of Patuakhali. Four wheat varieties viz. BARI ghom-23, BARI ghom-24, BARI ghom-25 and BARI ghom-26 were planted in the field to evaluate their comparative performance. Among the BARI varieties, BARI ghom-26 produced the maximum effective tillers $hill^{-1}$ (18.08).

Yajam and Madani (2013) investigated as a field experiment with Iranian winter wheat cultivars and their response to delay sowing date. The experiment design was split plot completely randomized with three replications where the main plots were four winter wheat cultivars namely B.C. Roshan, Alvand, Amirkabir and Shahriar and Sub plots were six sowing date from very early to very late sowing time. The results showed significant differences between cultivars the first.

Spike, grains and 1000-grain weight

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%.

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^{0}C 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.

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. Spike/m^2, grain/spike and 1000-grain weight were significantly affected by variety.

WRC (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 related characters. Variety Shatabdi produced maximum grain spike^{-1} and 1000 grain weight.

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 reported that the variety Waggershauser, Hohenh, Weisser, Kolben gave the longest spike.

A study was undertaken by Khokhar *et al.* (2010) to determine the effects of planting dates on growth and yield of different wheat genotypes in Sindh. Four sowing dates and six wheat genotypes (V-7001, V-7002, V-7004, MPT-6, Abadgar-93, and Anmol-91) were used. Better number of grain per unit area and grain weight were recorded in for wheat genotype, V-7002.

A pot experiment was carried out by Al-Musa *et al.* (2012) at Patuakhali Science and Technology University to study the performance of some BARI wheat varieties under the coastal area of Patuakhali. Four wheat varieties viz. BARI ghom-23, BARI ghom-24, BARI ghom-25 and BARI ghom-26 were planted in the field to evaluate their comparative performance. Among the BARI varieties, BARI ghom-26 produced the maximum grains spike^{-1} (38.52) and higher weight of 1000-grains (49.38 g).

Iranian winter wheat cultivars and their response to delay sowing date were investigated as a field experiment by Yajam and Madani (2013). The experiment designed with four winter wheat cultivars namely B.C. Roshan, Alvand, Amirkabir and Shahriar and sub plots were six sowing date from very early to very late sowing time. The results showed significant differences between cultivars the first.

A study was undertaken by Mohsen *et al.* (2013) to determine the effects of sowing dates on growth and yield components of different wheat cultivar in Iran. Five sowing dates and five wheat cultivars (Pishgam, Parsi, Bahar, Sivand and Pishtaz) were in sub plots. Results showed that the effect of cultivars was significant on all parameters excluding 1000 grain weight. Maximum number of grain spike^{-1} related to Pishtaz cultivar.

A field experiment was conducted by Zia-Ul-Hassan *et al.* (2014) to evaluate the response of high yielding varieties against varying sowing dates under rainfed conditions at Adaptive Research Farm, Bhaun, Chakwal. Treatments were four sowing dates and five varieties, viz. GA 2002, Chakwal 50, Farid 2006, Wafaq 2001 and Sehar 2006). The results showed that varieties remained significant on spike length, spikelets per spike and grains per spike.

Field experiments were conducted by Suleiman *et al.* (2014) at the Demonstration Farm of College of Agriculture, University of Bahri to assess the performance of different wheat cultivars under different sowing dates. The experiment comprised of four dates of sowing and five wheat cultivars namely, Al Nilein, Debiera, Imam, Sasaraib, and Wad el Neil in subplots. The cultivar Imam and Wad el Neil scored the first rank in number of grains spike^{-1}.

Grain and straw yield

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. 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.

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 were significantly affected by variety.

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.

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 $spike^{-1}$.

Litvinmko *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}.

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}).

WRC (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.

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.

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 as well as yield.

Maiksteniene *et al.* (2006) carried out a field experiment 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.

Growth and yield response of three wheat varieties (Suliman-96, Chakwal-97 and Inqalab-91) to various sowing times was studied by Qasim *et al.* (2008) at Karakoram Agricultural Reserch Institute, (Norther Areas) Gilgit, Pakistan and recorded the Suliman-95 topped in grain yield (4243.75 kg ha^{-1}).

A study was undertaken by Khokhar *et al.* (2010) to determine the effects of planting dates on growth and yield of different wheat genotypes in Sindh. Four sowing dates and six wheat genotypes (V-7001, V-7002, V-7004, MPT-6, Abadgar-93, and Anmol-91) were used. Better tillering, plant growth, growth period, number of grain per unit area and grain weight were recorded in for wheat genotype, V-7002 had significantly higher grain yield of 5578 kg ha^{-1} in comparison with other genotypes, whereas V-7004 had minimum grain yield of 4716 kg ha^{-1} in comparison with other genotypes.

The study was conducted by Anwar *et al.* (2011) to determine the proper time of sowing for promising wheat genotypes and to compare their yield behavior with already approved cultivars. Four already approved varieties of wheat i.e. Inqilab-91, Uqab-2000, Shafaq-2006, Seher-2006 and eight new promising lines i.e. V-

03079, V-04188, V-04189, V-03094, V-03138, V-04022, V-04112 and V-04178 were sown at six sowing dates. Most of the genotypes produced lesser yield at later sowing dates; however this response was different amongst genotypes.

Refay (2011) conducted an investigation aimed to study the influences of genotypes, sowing dates and their interaction on grain yield and yield component characters of bread wheat. Two promising lines viz., KSU-105; KSU-106 and introduce cv. Yecora Rojo, as well as two planting dates were selected. Result revealed that KSU-106 surpassed the other two genotypes by 2.0% and 11.3%.

Al-Musa *et al.* (2012) carried out a study at Patuakhali Science and Technology University to study the performance of some BARI wheat varieties under the coastal area of Patuakhali. Four wheat varieties viz. BARI ghom-23, BARI ghom-24, BARI ghom-25 and BARI ghom-26 were planted in the field to evaluate their comparative performance. Among the BARI varieties, BARI ghom-26 produced the higher grain (3.35 t ha^{-1}) and straw (8.50 g $plant^{-1}$) yield.

A study was undertaken by Mohsen *et al.* (2013) to determine the effects of sowing dates on growth and yield components of different wheat cultivar in Iran. Five sowing dates and five wheat cultivars (Pishgam, Parsi, Bahar, Sivand and Pishtaz) were used. Results showed that Parsi cultivar has the highest seed yield (10.23 t ha^{-1}) and the Pishtaz cultivar has the lowest seed yield (8.59 t ha^{-1}).

Rita Costa *et al.* (2013) conducted a study to determine the effects of sowing date and seeding rate on grain yield and test weight of fifteen bread wheat varieties and five advanced lines and comparing the results obtained in the two studied locations, Beja showed, for the majority of the varieties, 3.0 t ha^{-1} higher average yield than Elvas.

Field experiments were conducted by Suleiman *et al.* (2014) to assess the performance of different wheat cultivars under different sowing dates. The experiment comprised of four dates of sowing and five wheat cultivars namely, Al

Nilein, Debiera, Imam, Sasaraib, and Wad el Neil in subplots. The cultivar Imam and Wad el Neil scored the first rank in grain yield t ha^{-1}.

A field experiment was conducted by Zia-Ul-Hassan *et al.* (2014) to evaluate the response of high yielding varieties against varying sowing dates. Treatments were four sowing dates and five varieties, viz. GA 2002, Chakwal 50, Farid 2006, Wafaq 2001 and Sehar 2006. The results showed yields were reduced by 19.7%, 21.5%, 12.4% and 3.2%, by wheat varieties GA 2002, Farid 2006, Wafaq 2001 and Sehar 2006, respectively, as compared with wheat variety Chakwal 50.

Harvest index

Al-Khatib and Paulesn (1990) evaluated the yield performance of 10 wheat genotypes grown under moderate day/night temperature (22/17^{0}C,) and high day/night temperature (32/7^{0}C). Harvest index of all 10 genotypes was affected little by temperature, but individual genotypes responded very differently.

A pot experiment was carried out by Al-Musa *et al.* (2012) with four wheat varieties viz. BARI ghom-23, BARI ghom-24, BARI ghom-25 and BARI ghom-26 were planted in the field to evaluate their comparative performance. Among the BARI varieties, BARI ghom-26 produced the greater HI (44.03%).

A study was conducted by Mohsen *et al.* (2013) to determine the effects of sowing dates on growth and yield components of different wheat cultivar. Five sowing dates and five wheat cultivars (Pishgam, Parsi, Bahar, Sivand and Pishtaz) were in sub plots. Results showed that the effect of cultivars was significant on all parameters. Maximum HI related to Pishgam and Bahar cultivars.

Iranian winter wheat cultivars and their response to delay sowing date were investigated as a field experiment by Yajam and Madani (2013). The experiment designed with four winter wheat cultivars namely B.C. Roshan, Alvand, Amirkabir and Shahriar and six sowing date and the results showed the maximum harvest index was for Shahriar cultivar.

2.2 Effect of sowing date

For enhancing wheat production, optimum time of sowing is the most important agronomic factor affecting the growth and development of plants. Research works done at home and abroad showed that delay in sowing after the optimum time which coincides with the onset of seasonal rains, consistently reduced yields. The yield and yield parameters of wheat varied from location to location due to the prevailing weather situation during pre-antesis and post-anthesis development. Some of the pertinent literatures regarding effect of sowing time in different location of the world have been presented below-

Plant height

In a trial with cultivar Balaka in Joydepur and Jessore, BARI (1984) reported that the tallest plant (76.83 cm) was obtained at Jessore when sowing was done on 20 November and shortest with 30 December sowing. Similar results have also been observed by Farid *et al.* (1993).

The plant height of barely was significantly influenced by date of sowing. In an experiment carried out by Moula (1999) to study the effect of sowing time on growth and development of barley varieties and reported that the tallest plant was recorded by November 25 sowing (111.8 cm) and the shortest plant was recorded by December 25 sowing (73.8 cm).

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, 01 sown plant. But at 60 DAS highest plant height was recorded in December, 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.

Twelve wheat genotypes bred at this Institute were assessed by Sial *et al.* (2005) for yield and quality parameters at two levels of sowing dates i.e., normal (18th

November) and late sowing (11th December). With delayed planting, the development of plant organs and transfer from source to sink were remarkably affected, which was reflected by overall shortening of plant height.

Growth and yield response of three wheat varieties (Suliman-96, Chakwal-97 and Inqalab-91) to various sowing times was studied by Qasim *et al.* (2008) at Karakoram Agricultural Reserch Institute, (Norther Areas) Gilgit, Pakistan. Three sowing dates viz., November 15, November, 30 and December, 15 were tested. Early planted wheat yielded maximum plant height (79.81 cm).

In order to optimize seed rate and time of sowing of wheat variety Hashim-8, an experiment was conducted by Baloch *et al.* (2010) at the Agricultural Research Institute, Dera Ismail Khan on different sowing dates viz. October-25, November-10, November-25, December-10 and December-25 with different seeding rates. Data indicated that sowing wheat on October-25 and November-10 produced the highest plant height, which subsequently decreased with successive sowing dates.

A study was undertaken by Mohsen *et al.* (2013) to determine the effects of sowing dates on growth and yield components of different wheat cultivar in Iran. Five sowing dates i.e. October 31, November 15 and 30, December 15 and 30 were in main plots, whereas five wheat cultivars were in sub plots. Results showed that the effect of sowing date was significant on all parameters.

A field experiment was conducted by Zia-Ul-Hassan *et al.* (2014) to evaluate the response of high yielding varieties against varying sowing dates under rainfed conditions at Adaptive Research Farm, Bhaun, Chakwal. Treatments were four sowing dates, viz. D_1 (October 15), D_2 (October 30), D_3 (November 15), D_4 (November 30), and five varieties, viz. GA 2002, Chakwal 50, Farid 2006, Wafaq 2001 and Sehar 2006). The results showed that sowing dates remained significant on plant height.

Field experiments were conducted by Suleiman *et al.* (2014) at the Demonstration Farm of College of Agriculture, University of Bahri to assess the performance of

different wheat cultivars under different sowing dates. The experiment comprised of four dates of sowing, namely 1st November, 15th November, 1st December and 15th December and five wheat cultivars. The sowing dates shown significant effect yield components that decreased with delay in sowing date and the highest values were obtained when cultivars sown on 1st November and 15th November.

Tillering pattern

The associations of yield and effective tiller were also reported by many scientists. In a trial with wheat in Joydebpur and Jessore, BARI (1984) reported that the highest number of effective tillers plant^{-1} was obtained by 20 November sowing similar finding were reported by Sarker *et al.* (1999).

Shrivastava *et al.* (1998) studied relationship between various traits in wheat. They reported that yield had significant positive correlation with effective tillers per plant.

Chowdhury (2002) conducted an experiment with four sowing dates and reported that the highest number of average tillers plant^{-1} were produced by November 15 sown wheat plants and the second highest number were produced by November 30 sown plants which was at par with November 1 sown plants. The lowest number of tillers plant^{-1} were produced by December 15 sown plants.

Twelve wheat genotypes bred at this Institute were assessed by Sial *et al.* (2005) for yield and quality parameters at two levels of sowing dates i.e., normal (18th November) and late sowing (11th December). With delayed planting, the development of plant organs and transfer from source to sink were remarkably affected, which was reflected by overall reduction of yield components.

A field experiment was conducted by Ahmed *et al.* (2006) at Farming System Research and Development (FSRD) site, Chabbishnagar, Godagari, Rajshahi under rainfed condition during rabi seasons to find out the suitable variety and sowing time (30 November, 15 December and 30 December). They concluded

that number of tiller increased significantly with early sowing (30 November) in all varieties in both the years.

In order to optimize seed rate and time of sowing of wheat variety Hashim-8, an experiment was conducted by Baloch *et al.* (2010) at the Agricultural Research Institute, Dera Ismail Khan on different sowing dates viz. October-25, November-10, November-25, December-10 and December-25 with seeding rates of 100, 125, 150, 175 and 200 kg ha^{-1}. Data indicated that sowing wheat on October-25 and November-10 produced the highest number of tillers, which subsequently decreased with successive sowing dates.

A study was undertaken by Mohsen *et al.* (2013) to determine the effects of sowing dates on growth and yield components of different wheat cultivar in Iran. Five sowing dates i.e. October 31, November 15 and 30, December 15 and 30 were in main plots, whereas five wheat cultivars were in sub plots. Results showed that the effect of sowing date was significant on all parameters.

A field experiment was conducted by Aslam *et al.* (2013) at Adaptive Research Farm, Rahim Yar Khan, Pakistan. Effect of four planting dates i.e. 25th October, 5th November, 15th November and 25th November was studied on yield and yield components of wheat. Average of two years data showed that 5th November sowing significantly produced maximum tillers (359 m^{-2}) followed by 15th November sowing. The data further indicated that 25th October sowing produced minimum tillers (232 m^{-2}) due to high temperature, not suitable for growth of wheat plant.

Field experiments were conducted by Suleiman *et al.* (2014) at the Demonstration Farm of College of Agriculture, University of Bahri to assess the performance of different wheat cultivars under different sowing dates. The experiment comprised of four dates of sowing, namely 1st November, 15th November, 1st December and 15th December and five wheat cultivars. The sowing dates shown significant effect

on yield components that decreased with delay in sowing date and the highest values were obtained when cultivars sown on 1st November and 15th November.

Spike, grains and 1000-grain weight

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

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

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

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

Chowdhury (2002) conducted an experiment with four sowing dates and reported that spike length, grains spike^{-1} and 1000-grain weight decreased with delay in sowing date from November 15 and the lowest spike length, grains spike^{-1} and 1000-grain weight were recorded in December 15 sown plants.

Haider (2002) reported that early sown plants (November 15) had the highest spike length, grains spike^{-1} and 100-grain weight and late sown plants (December 5) resulted the lowest values of these parameters of wheat.

Zende *et al.* (2005) conducted an experiment during rabi season in Akola, Maharashtra, India, to evaluate the effects of sowing time (15 November, 1 December and 15 December) on the growth and yield of durum wheat and

concluded that the growth, yield and yield attributes, except for the spike length, showed significant increases when durum wheat crops were sown on 15 November compared with those sown on 1 December and 15 December.

Twelve wheat genotypes bred at this Institute were assessed by Sial *et al.* (2005) for yield and quality parameters at two levels of sowing dates i.e., normal (18th November) and late sowing (11th December). With delayed planting, the development of plant organs and transfer from source to sink were remarkably affected, which was reflected by overall reduction yield components.

To study the effect of planting time on quality characteristics of wheat varieties, Inqilab-91 and AS-2002, an experiment was carried out by Abdullah *et al.* (2007) at Wheat Research Institute, Faisalabad. The crop was sown from 25th October to 10th January with 15 days interval. Characters such as 1000-grain weight declined progressively with delayed sowing. These had shown maximum value in first planting date i.e. 25th October and minimum value in the last planting date i.e. 10th January.

Growth and yield response of three wheat varieties to various sowing times was studied by Qasim *et al.* (2008) at Karakoram Agricultural Reserch Institute, (Norther Areas) Gilgit, Pakistan. Three sowing dates viz., November 15, November, 30 and December, 15 were tested. Early planted wheat yielded maximum grains spike^{-1} (44.14) and 1000-grain weight (39.17 g).

In order to optimize seed rate and time of sowing of wheat variety Hashim-8, an experiment was conducted by Baloch *et al.* (2010) at the Agricultural Research Institute, Dera Ismail Khan on different sowing dates viz. October-25, November-10, November-25, December-10 and December-25 with seeding rates of 100, 125, 150, 175 and 200 kg ha^{-1}. Data indicated that sowing wheat on October-25 and November-10 produced the highest spike length, 1000-grain weight and the grain yield, which subsequently decreased with successive sowing dates.

A study was designed by Said *et al.* (2012) to investigate the effects of various sowing dates and seeding rates on the yield and yield components of wheat. The experiment included four planting dates (1st November, 15th November, 1st December and 15th December) and three seeding rates. Sowing dates affect the yield components of wheat. Significant differences were found among the planting dates for number of grains spike^{-1} and 1000 grain weight. Maximum number of grains spike^{-1} (53.99) and 1000 grain weight (40.2 gm) were produced from 1st to 15th November followed by number of grains spike^{-1} (50.1) and 1000 grain weight (32.1 gm) were produced from late sowing (15th December).

A field experiment was conducted by Aslani and Mehrvar (2012) at Seed and Plant Improvement Institute, Karaj (Iran), on farmer's fields to investigate the effect of two sowing dates; optimum sowing date (1st November) and late sowing date (20th November) on yield and yield components of eight wheat genotypes. The results showed that the optimum sowing produced higher 1000-grain weight and spike per square meter compared to late sowing.

Aslam *et al.* (2013) conducted an experiment at Adaptive Research Farm, Rahim Yar Khan, Pakistan during winter seasons. Effect of four planting dates i.e. 25th October, 5th November, 15th November and 25th November was studied on yield and yield components of wheat. Results revealed that yield and yield parameters were significantly affected by sowing dates. Average of two years data showed that 5th November sowing significantly increase in yield was associated with progressive increase in all growth components.

A study was undertaken by Mohsen *et al.* (2013) to determine the effects of sowing dates on growth and yield components of different wheat cultivar in Iran. Five sowing dates i.e. October 31, November 15 and 30, December 15 and 30 were in main plots, whereas five wheat cultivars were in sub plots. Results showed that the effect of sowing date was significant on all parameters.

Zia-Ul-Hassan *et al.* (2014) conducted a field experiment to evaluate the response of high yielding varieties against varying sowing dates under rainfed conditions at Adaptive Research Farm, Bhaun, Chakwal. The treatments of the experiment were four sowing dates, viz. D_1 (October 15), D_2 (October 30), D_3 (November 15), D_4 (November 30), and five varieties. The results showed that sowing dates remained significant on spike length, spikelets per spike and grains spike^{-1} and early sowing produced the best one.

A study was undertaken by Eslami *et al.* (2014) to determine the effects of sowing dates and seeding density on growth and yield of wheat, variety N-85-5 in Iran. Three sowing dates were i.e. December 21, December 30 and January 29 and results shows that sowing wheat on December 21 produced the highest number of spike, spike weight and 1000-grain weight which subsequently decreased with successive sowing dates.

Field experiments were conducted by Suleiman *et al.* (2014) at the Demonstration Farm of College of Agriculture, University of Bahri to assess the performance of different wheat cultivars under different sowing dates. The experiment comprised of four dates of sowing, namely 1st November, 15th November, 1st December and 15th December and five wheat cultivars. The sowing dates that used in this experiment shown significant effect on yield components that decreased with delay in sowing date and the highest values were obtained when cultivars sown on 1st November and 15th November. This indicated that late sowing shortened the development phases of wheat and adversely affected the grain development and yield contributing characters.

Grain and straw yield

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

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

Comy (1995) concluded from two years study in Ireland on malting barley cv. Blenhiem sown on March, early April and late April that the earliest sown spring barley generally gave the highest yield and the best quality grain .

BARI (1997) reported from the study in Jamalpur during the rabi season that among the five sowing dates viz. November 5, November 20, December5, December 20 and January 5, the grain yield was statistically different among those sowings. The crop sown on December 20 produced the lowest grain yield which was closely followed by that of January 5 sowing. Adrastic reduction in grain yield was observed when the crop was sown on December 5 or later.

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

Haider (2002) conducted experiment with two sowing dates and reported that November 15 sown plants produced significantly higher grain yield in both the years for all the irrigation regimes and varieties of wheat and the lowest yield was recorded in December 5 sown plants.

Twelve wheat genotypes bred at this Institute were assessed by Sial *et al.* (2005) for yield and quality parameters at two levels of sowing dates i.e., normal (18th November) and late sowing (11th December). With delayed planting, the

development of plant organs and transfer from source to sink were remarkably affected, which was reflected by overall reduction of yield.

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

To evaluate the effect of planting time on the quality characteristics of spring wheat varieties, Inqilab-91 and AS-2002, an experiment was carried out by Abdullah *et al.* (2007) at Wheat Research Institute, Faisalabad. The crop was sown from 25th October to 10th January with 15 days interval. Characters such as flour yield declined progressively with delayed sowing. These had shown maximum value in first planting date i.e. 25th October and minimum value in the last planting date i.e. 10th January.

Growth and yield response of three wheat varieties (Suliman-96, Chakwal-97 and Inqalab-91) to various sowing times was studied by Qasim *et al.* (2008) at Karakoram Agricultural Reserch Institute, (Norther Areas) Gilgit, Pakistan. Three sowing dates viz., November 15, November, 30 and December, 15 were tested. Early planted wheat yielded maximum grain yield (4165.7 kg ha^{-1}) and straw yield (6814.2 kg ha^{-1}).

In order to optimize seed rate and time of sowing of wheat variety Hashim-8, an experiment was conducted by Baloch *et al.* (2010) at the Agricultural Research Institute, Dera Ismail Khan on different sowing dates viz. October-25, November-10, November-25, December-10 and December-25 with seeding rates of 100, 125, 150, 175 and 200 kg ha^{-1}. Data indicated that sowing wheat on October-25 and

November-10 produced the highest grain yield, which subsequently decreased with successive sowing dates.

Refay (2011) conducted an investigation aimed to study the influences of genotypes, sowing dates and their interaction on grain yield and yield component characters of bread wheat. Two promising lines and introduce cv. Yecora Rojo, as well as two planting dates (November, 21 and December, 21) were selected. Result revealed that delayed sowing is associated with substantial losses in grain yield estimated by 7.98% as compared with early sowing. The present study support the use of early sowing dates for obtaining maximum yield.

The study was conducted by Anwar *et al.* (2011) to determine the proper time of sowing for promising wheat genotypes and to compare their yield behavior with already approved cultivars. Four already approved varieties of wheat and eight new promising lines were sown at six sowing dates with 10 days interval, i.e. 01 November, 10 November, 20 November, 30 November, 10 December, and 20 December. The grain yield of most of the genotypes was highest on the sowing date 20 November, except genotypes V-03094 and V-04022 which gave highest yield on 10 November and genotypes V-03138 and V-04178 which produced highest yield on sowing date of 01 November.

A study was designed by Said *et al.* (2012) to investigate the effects of various sowing dates and seeding rates on the yield and yield components of wheat. The experiment included four planting dates (1st November, 15th November, 1st December and 15th December) and three seeding rates. Significant differences were found among the planting dates for biological yield and grain yield. Maximum biological yield (11953 kg ha^{-1}) and grain yield (4134 kg ha^{-1}) were produced from 1st to 15th November followed by biological yield (6824 kg ha^{-1}) and grain yield (2336 kg ha^{-1}) were produced from late sowing (15th December).

A field experiment was conducted by Aslani and Mehrvar (2012) at Seed and Plant Improvement Institute, Karaj (Iran), on farmer's fields to investigate the

effect of two sowing dates; optimum sowing date (1st November) and late sowing date (20th November) on yield and yield components of eight wheat genotypes. The results showed that the optimum sowing produced higher grain and biomass yields compared to late sowing.

Iranian winter wheat cultivars and their response to delay sowing date were investigated as a field experiment by Yajam and Madani (2013). The experiment design was split plot completely randomized with three replications where the main plots were four winter wheat cultivars namely B.C. Roshan, Alvand, Amirkabir and Shahriar and Sub plots were six sowing date from very early to very late sowing time or September 23th, October 9th, October 24th, November 10th, November 25th and December 24th. The maximum yield for late sowing date was obtain for Shahriar cultivar with 3.7 t ha^{-1} grain yield. The maximum grain yield by 5.3 t ha^{-1} was obtained at 23th September sowing date by Shahriar cultivar. The results showed that the Roshan B.C (by 0.9 t ha^{-1}) and Alvand (by 1.1 t ha^{-1}) cultivars had lowest yield for delay in sowing time on 24th December. Study revealed that the yield components there were records the maximum value for sowing date on 23th September and the minimum in December 24th sowing date. Later sowing indicated shorter grain, straw and biomass yield as compared to relative earlier sowing dates.

A study was undertaken by Mohsen *et al.* (2013) to determine the effects of sowing dates on growth and yield components of different wheat cultivar in Iran. Five sowing dates i.e. October 31, November 15 and 30, December 15 and 30 were in main plots, whereas five wheat cultivars were in sub plots. Results showed that the highest seed yield of 10.15 t ha^{-1} gave for sowing date at Nevember15, while the lowest seed yield of 6.1 t ha^{-1} gave at December 30 sowing date.

Rita Costa *et al.* (2013) conducted a study to determine the effects of sowing date and seeding rate on grain yield and test weight of fifteen bread wheat varieties and five advanced lines at two locations of Southeast Portugal. Two seeding rates as

26 October and 21 December were compared in two different sowing dates. At Elvas, higher yield was obtained with sowing date 21 December for most of the varieties studied. In opposite, in Beja trials, the highest values for yield were found when varieties were sown 26 October.

A study was undertaken by Eslami *et al.* (2014) to determine the effects of sowing dates and seeding density on growth and yield of wheat, variety N-85-5 in Iran. Three sowing dates were i.e. December 21, December 30 and January 29 and results shows that sowing wheat on December 21 produced the highest biological and grain yield, which subsequently decreased with successive sowing dates.

Field experiments were conducted by Suleiman *et al.* (2014) at the Demonstration Farm of College of Agriculture, University of Bahri to assess the performance of different wheat cultivars under different sowing dates. The experiment comprised of four dates of sowing, namely 1st November, 15th November, 1st December and 15th December and five wheat cultivars. The sowing dates shown significant effect on yield that decreased with delay in sowing date and the highest values were obtained when cultivars sown on 1st November and 15th November. This indicated that late sowing shortened the development phases of wheat and adversely affected the grain development and thus the grain yield.

A field experiment was conducted by Zia-Ul-Hassan *et al.* (2014) to evaluate the response of high yielding varieties against varying sowing dates under rainfed conditions at Adaptive Research Farm, Bhaun, Chakwal. Treatments were four sowing dates, viz. D_1 (October 15), D_2 (October 30), D_3 (November 15), D_4 (November 30), and five varieties. The results showed that yields were reduced by 17.4%, 17.2% and 26.2% from the crop planted on November 15, November 30 and October 15, respectively, as compared with crop planted on October 30.

Harvest index

Sharma (1993) conducted an experiment with eight spring wheat (*Triticum aestivum)* cultivars and 2 advanced breeding lines in Nepal and showed that due

to delayed sowing harvest index was reduced and maximum harvest index of 41.1% occurred with the November 25 sowing.

Samuel *et al.* (2000) reported that late sowing condition (6 January 1997) reduce the harvest index (36.1%) from (41.5%) of normal sowing condition (29 November 1996) in wheat.

Ehdaie *et al.* (2001) reported that early sowing decreased harvest index. They reported that greater N supply increased shoot biomass by 29%, grain yield by 16% and protein by 5% but decrease harvest index by 10%.

A study was designed by Said *et al.* (2012) to investigate the effects of various sowing dates and seeding rates on the yield and yield components of wheat (*Triticum aestivem* L.). The experiment included four planting dates (1st November, 15th November, 1st December and 15th December) and three seeding rates. Sowing dates had no effect on harvest index.

A study was conducted by Mohsen *et al.* (2013) to determine the effects of sowing dates on growth and yield components of different wheat cultivar. Five sowing dates i.e. October 31, November 15 and 30, December 15 and 30 were used in the experiment. Results showed that the effect of sowing date was significant on all parameters excluding harvest index.

From the above review of literature it is evident that variety and sowing time has a significant influence on yield and yield components of wheat. The literature suggests that early or delay sowing other than optimum time reduces the grain yield of wheat which is directly related with the temperature of the growing period of the crop. From the above review of literature it is evident that variety itself influenced the yield and yield components of wheat. The literature revealed that accurate knowledge of the sowing window of any particular variety at a particular location is critical to achieve a high grain yield of wheat.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out the effect of variety and sowing dates on the growth and yield of wheat. The details of the materials and methods i.e. location of experimental site, soil and climate condition of the experimental plot, materials used, design of the experiment, data collection and procedure of data analysis those were used or followed in this experiment have been presented below under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from November 2013 to March 2014 in rabi season.

3.1.2 Site description

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

3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February and the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of 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, Dhaka and details has been presented in Appendix I.

3.1.4 Soil characteristics of the experimental plot

The soil belongs 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 6.2 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

3.2.1 Treatment of the experiment

The experiment comprised of two factors

Factor A: Wheat variety (4)

i) BARI Gom 21 (V_1)

ii) BARI Gom 23 (V_2)

iii) BARI Gom 25 (V_3)

v) BARI Gom 26 (V_4)

Factors B: Sowing date (4)

i) Sowing at 10 November, 2013 (S_1)

ii) Sowing at 20 November, 2013 (S_2)

iii) Sowing at 30 November, 2013 (S_3)

iv) Sowing at 10 December, 2013 (S_4)

There were in total 16 (4×4) treatment combinations such as V_1S_1, V_1S_2, V_1S_3, V_1S_4, V_2S_1, V_2S_2, V_2S_3, V_2S_4, V_3S_1, V_3S_2, V_3S_2, V_3S_3, V_3S_4, V_4S_1, V_4S_2, V_4S_3 and V_4S_4.

3.2.2 Experimental design and layout

The experiment was laid out in a split plot design with three replications. The experiment area was divided into three equal blocks. Each block contained 16 plots where 16 treatments combination were allotted at random. There were 48 unit plot altogether in the experiment. The size of each plot was 4.0 m × 2.5 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively. The layout of the experiment is shown in Figure 1.

3.3 Growing of crops

3.3.1 Collection of seeds

The seeds of different wheat varieties were collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur. 'BARI Gom 21' ('Shatabdi') was released in 2000 and 'BARI Gom 23' ('Bijoy'), 'BARI Gom 25' and 'BARI Gom 26' was released in 2010 (BARI, 2012).

3.3.2 Preparation of the main field

The piece of land selected for the experiment was opened in the 2nd November 2013 with a power tiller, and exposed to the sun for a week after that the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally a desirable tilth of soil was obtained for sowing of seeds. Fertilizers and manures as mentioned in the section 3.3.4 were mixed with the soil of plot.

3.3.3 Seeds sowing

Furrows were made for sowing the wheat seeds when the land was in proper joe condition and seeds were sown at 10 November, 20 November, 30 November and 10 December, 2013 as per the sowing dates treatment of the experiment. Seeds were sown continuously maintaining 20 cm line to line distance and plant to plant 5 cm. After sowing, seeds were covered with soil and slightly pressed by hand.

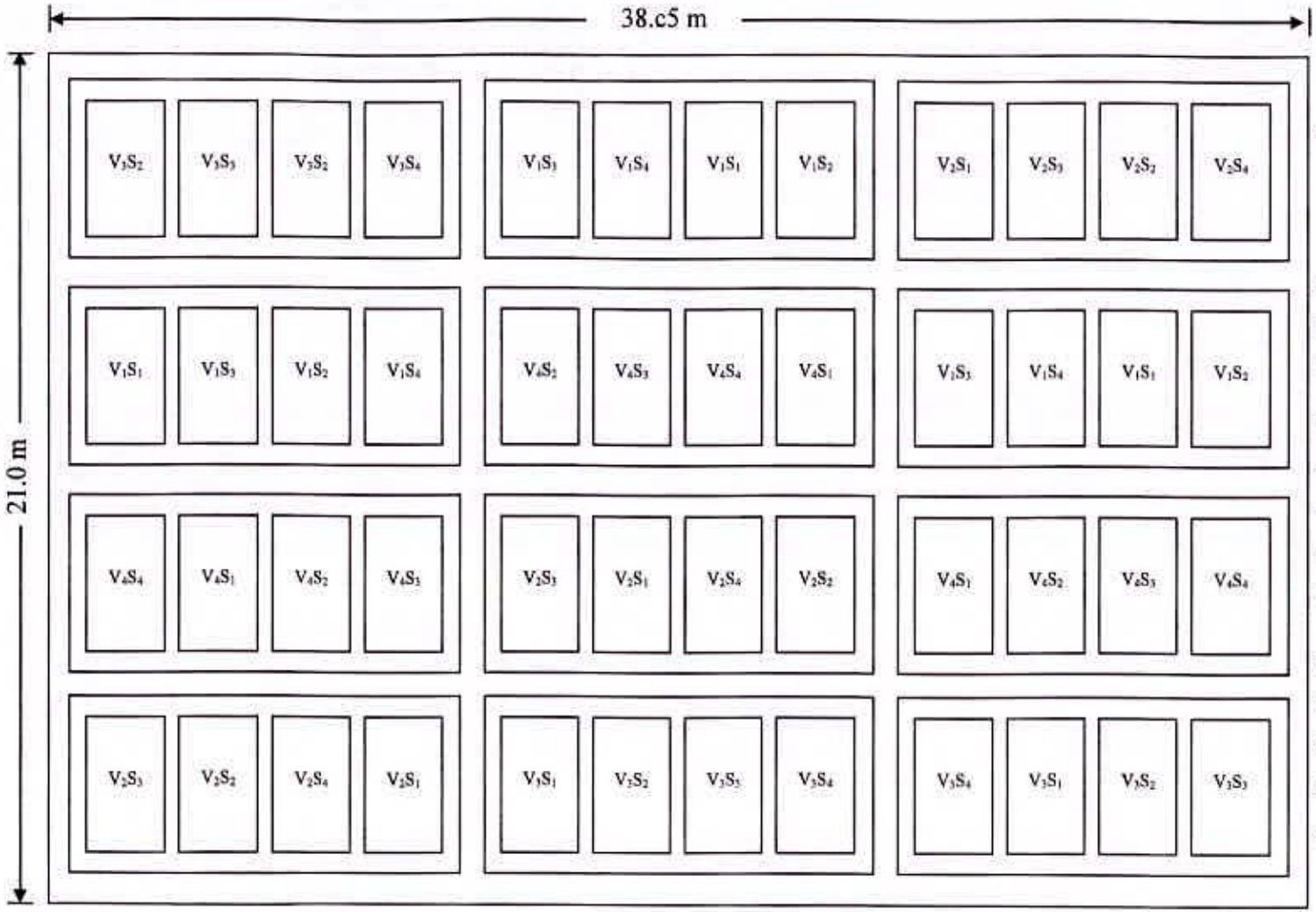


Figure 1. Layout of the experimental plot

3.3.4 Application of fertilizers and manure

The fertilizers N, P, K and S in the form of Urea, TSP, MP and Gypsum, respectively were applied. Cowdung was applied @ 10 t ha^{-1} 15 days before seeds sowing in the field. The entire amount of TSP, MP and Gypsum and 2/3rd of urea were applied during the final preparation of land. Rest of urea was top dressed after first irrigation (BARI, 2011). The dose and method of application of fertilizers are presented below in Table 1.

Table 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: BARI, 2011, Krishi Projukti Hatboi, Joydebpur, Gazipur

3.3.5 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.

3.3.5.1 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.

3.3.5.2 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. The rotary weeder was used starting from 30 DAS, four times, an interval of 15 days. One manual weeding was taken up once at peak tillering stage to remove weeds around the clumps.

3.3.5.3 Plant protection

The crop was attacked by different kinds of insects during the growing period. Triel-20 ml was applied on 05 January, 2014 and sumithion-40 ml/20 litre of water was applied on 30 January as plant protection measure. During the entire growing period the crop was observed carefully to take protection measures.

3.4 Harvesting, threshing and cleaning

The crop was harvested manually depending upon the maturity starting from the third week of March, 2014. 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 dried, cleaned and weighed for individual plot. The weight was adjusted to a moisture content of 12%. Yields of wheat grain and straw m^{-2} were recorded and converted to t ha^{-1}.

3.5 Data collection

3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at 30, 45, 60 and 75 DAS (Days After Sowing) and at harvest 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.

3.5.2 Tillers plant^{-1}

The number of tillers plant^{-1} was recorded at the time of 30, 45, 60 and 75 DAS. Data were recorded by counting tillers from each plant and as the average of 10 plants selected at random from the inner rows of each plot.

3.5.3 Dry matter content plant^{-1}

Data from ten sample plants of each plot were collected after harvest 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^{0}C for 72 hours. Then oven-dried samples were

transferred into a desiccator and allowed to cool down to room temperature, thereafter dry weight of plant was taken and expressed in gram. As per the above procedure dry matter content plant^{-1} was recorded at 30, 45, 60 and 75 DAS.

3.5.4 Days to spike initiation

Days to starting of spike emergence was recorded by calculating the number of days from sowing to starting of spike emergence by keen observation of the experimental plots during the experimental period.

3.5.5 Days to maturity

Days to maturity was recorded by calculating the number of days from sowing to starting of maturity as spikes become brown color by keen observation of the experimental plot.

3.5.6 Number of spikes plant^{-1}

The total number of spikes plant^{-1} was recorded by calculating spikes plant^{-1}. Data on number of spikes plant^{-1} were counted from 10 selected plant at harvest and average value was recorded.

3.5.7 Number of spikelets plant^{-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.

3.5.8 Ear length

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

3.5.9 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.

3.5.10 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.

3.5.11 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.

3.5.12 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.

3.5.13 Grain yield

Grains obtained from 1.0 m^2 of each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area was used to record grain yield m^{-2} and this was converted into t ha^{-1}.

3.5.14 Straw yield

Straw obtained from 1.0 m^2 of 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 into t ha^{-1}.

3.5.15 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.

3.5.16 Harvest index

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

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

3.6 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the wheat variety and sowing dates and their interaction. 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

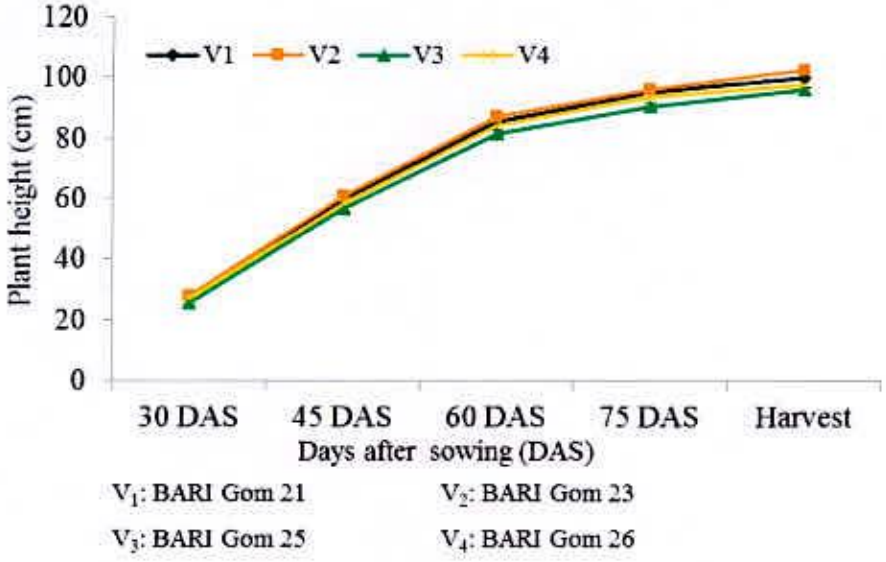
RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of variety and sowing dates on the growth and yield performance of wheat. Data on different yield contributing characters and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters have been presented in Appendix III-VIII. The results have been presented with the help of table and graphs and possible interpretations have been given under the following headings:

4.1 Plant height

Different wheat varieties showed statistically significant difference on plant height at 30, 45, 60, 75 DAS and harvest (Fig. 2). At 30, 45, 60, 75 DAS and harvest, the longest plant (27.86, 60.91, 87.32, 95.98 and 102.38 cm, respectively) was found from V_2 (BARI Gom 23) which was statistically similar (27.40, 59.94, 85.40, 95.06 and 100.07 cm, respectively) to V_1 (BARI Gom 21) and followed (27.13, 58.45, 84.16, 93.51 and 97.81 cm, respectively) by V_4 (BARI Gom 26), while the shortest plant (25.68, 56.75, 81.58, 90.46 and 95.90 cm, respectively) was recorded from V_3 (BARI Gom 25). Different genotypes produced different plant height on the basis of their varietal characters. Qasim *et al.* (2008) reported that plant height varied for different cultivars of wheat. Al-Musa *et al.* (2012) reported that among the BARI varieties, BARI gom-26 produced the taller plant (47.91 cm).

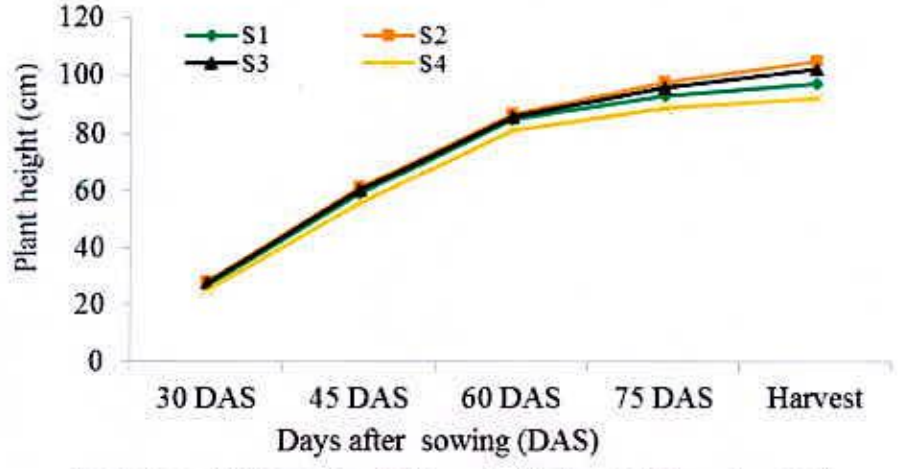
Plant height showed statistically significant differences due to different sowing dates under the present trial at 30, 45, 60, 75 DAS and harvest (Fig. 3). Data revealed that at 30, 45, 60, 75 DAS and harvest, the tallest plant (28.18, 61.21, 86.62, 97.79 and 104.71 cm, respectively) was observed from S_2 (sowing on 20 November) which was statistically similar (27.85, 60.26, 85.80, 95.71 and 102.19 cm, respectively) to S_3 (sowing on 30 November) and closely followed (26.73, 58.97, 84.91, 92.95 and 97.09 cm, respectively) by S_1 (sowing on 10 November),



V_1: BARI Gom 21 V_2: BARI Gom 23

V_3: BARI Gom 25 V_4: BARI Gom 26

Fig. 2. Effect of different varieties on plant height of wheat (SE = 0.398, 0.518, 0.890, 0.667 and 0.839 for 30, 45, 60, 75 DAS and at harvest)



S_1: Sowing at 10 November, 2013 S_2: Sowing at 20November, 2013

S_3: Sowing at 30 November, 2013 S_4: Sowing at 10 December, 2013

Fig. 3. Effect of different sowing dates on plant height of wheat (SE = 0.676, 0.560, 1.063, 0.843 and 1.354 for 30, 45, 60, 75 DAS and at harvest)

Whereas the shortest plant (25.32, 55.62, 81.14, 88.56 and 92.17 cm, respectively) was found from S_4 (sowing on 10 December). Seeds sowing at 20 November ensured the tallest plant than early and delay sowing of seeds. BARI (1984) reported that the tallest plant height was found when sowing was done on 20 November and shortest with 30 December sowing. Sial *et al.* (2005) reported that in case of delayed planting, the development of plant organs and transfers from source to sink were remarkably affected, which was influenced and also reflected by overall shortening of plant height. Zia-Ul-Hassan *et al.* (2014) earlier reported that sowing dates remained significant in terms of plant height of modern cultivated wheat.

Interaction effect of wheat varieties and sowing dates showed significant differences on plant height at 30, 45, 60, 75 DAS and harvest (Table 2). At 30, 45, 60, 75 DAS and harvest, the longest plant (29.97, 63.89, 89.42, 98.78 and 108.32 cm, respectively) was observed from V_2S_2 (BARI Gom 23 and sowing on 20 November) and the shortest plant (22.36, 54.14, 80.92, 84.15 and 88.17 cm, respectively) was obtained from the treatment combination V_3S_4 (BARI Gom 25 sowing and 10 December).

4.2 Number of tillers plant^{-1}

Number of tillers plant^{-1} at 30, 45, 60 and 75 DAS varied significantly due to different wheat varieties under the present trial (Fig. 4). Data revealed that at 30, 45, 60 and 75 DAS, the maximum number of tillers plant^{-1} (2.95, 3.80, 5.54 and 5.98, respectively) was recorded from V_2 which was statistically similar (2.89, 3.75, 5.37 and 5.74, respectively) to V_1 and followed (2.72, 3.59, 5.20 and 5.55, respectively) by V_4, whereas the minimum number of tillers plant^{-1} (2.65, 3.40, 5.08 and 5.39, respectively) was observed from V_3. Although management practices influenced the number of tillers at different days after sowing but genotypes itself contributed to the number of tillers plant^{-1}.

Table 2. Interaction effect of varieties and sowing dates on plant height of wheat at different days after sowing (DAS) and harvest

Treatments	Plant height (cm) at				
	30 DAS	45 DAS	60 DAS	75 DAS	Harvest
V_1S_1	27.27 a-c	60.34 a-d	84.70 ab	93.60 ab	98.43 b-f
V_1S_2	28.53 ab	63.47 a	89.28 a	98.07 a	106.77 ab
V_1S_3	26.78 a-d	60.40 a-d	86.66 ab	95.57 a	100.10 a-e
V_1S_4	27.01 a-c	55.55 ef	80.96 b	93.02 a-c	94.98 d-g
V_2S_1	28.27 ab	61.92 a-c	89.77 a	98.37 a	103.67 a-d
V_2S_2	29.97 a	63.89 a	89.42 a	98.78 a	108.32 a
V_2S_3	29.89 a	62.80 ab	89.34 a	97.68 a	107.72 a
V_2S_4	23.31 cd	55.04 ef	80.77 b	89.10 b-d	89.82 fg
V_3S_1	24.70 b-d	55.57 ef	81.27 b	85.70 d	91.42 e-g
V_3S_2	26.67 a-d	57.77 d-f	81.92 b	97.40 a	99.52 a-e
V_3S_3	29.03 ab	59.54 b-d	82.19 b	94.58 a	104.47 a-c
V_3S_4	22.36 d	54.14 f	80.92 b	84.15 d	88.17 g
V_4S_1	26.70 a-d	58.04 de	83.92 ab	94.11 ab	94.82 d-g
V_4S_2	27.56 a-c	59.73 b-d	85.85 ab	96.90 a	104.25 a-c
V_4S_3	25.68 a-d	58.29 c-e	85.00 ab	95.03 a	96.48 c-g
V_4S_4	28.58 ab	57.75 d-f	81.89 b	87.99 cd	95.70 c-g
SE(±)	1.352	1.119	2.126	1.686	2.707
Level of significance	0.05	0.05	0.01	0.05	0.05
CV(%)	8.67	5.28	4.35	5.12	4.73

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

V_1: BARI Gom 21

V_2: BARI Gom 23

V_3: BARI Gom 25

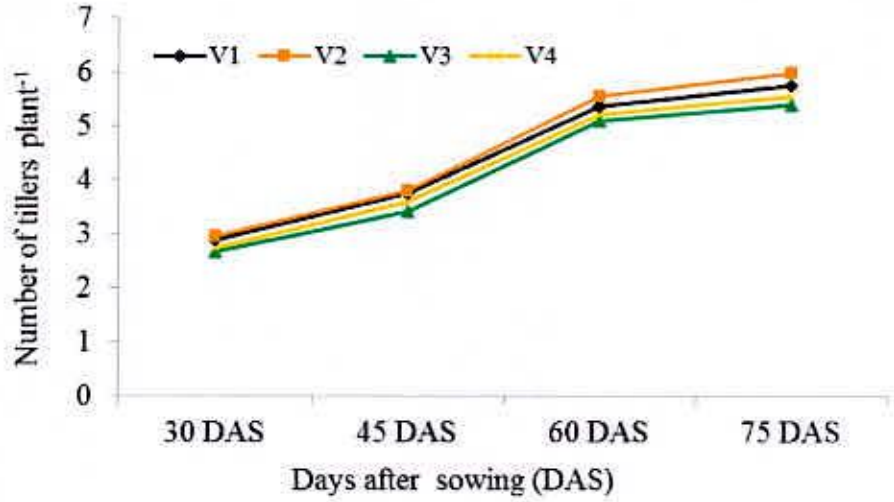
V_4: BARI Gom 26

S_1: Sowing at 10 November, 2013

S_2: Sowing at 20 November, 2013

S_3: Sowing at 30 November, 2013

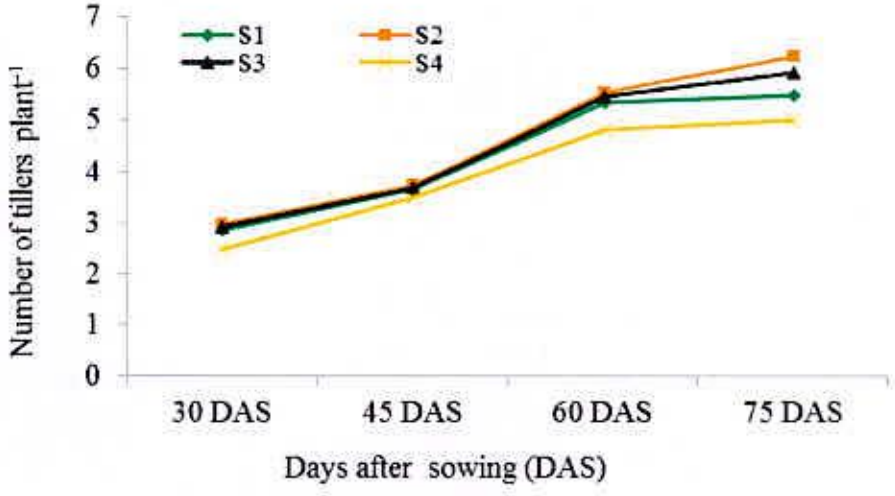
S_4: Sowing at 10 December, 2013



V_1: BARI Gom 21 V_2: BARI Gom 23

V_3: BARI Gom 25 V_4: BARI Gom 26

Fig. 4. Effect of different varieties on number of tillers plant^{-1} of wheat (SE=0.027, 0.024, 0.044 and 0.115 for 30, 45, 60, 75 DAS)



S_1: Sowing at 10 November, 2013 S_2: Sowing at 20 November, 2013

S_3: Sowing at 30 November, 2013 S_4: Sowing at 10 December, 2013

Fig. 5. Effect of different sowing dates on number of tillers plant^{-1} of wheat (SE = 0.029, 0.018, 0.042 and 0.100)

Different sowing dates showed statistically significant differences in terms of number of tillers plant^{-1} at 30, 45, 60 and 75 DAS (Fig. 5). The maximum number of tillers plant^{-1} (2.97, 3.72, 5.54 and 6.24 respectively) was found from S_2 which was statistically similar (2.92, 3.69, 5.47 and 5.93 respectively) to S_3 and closely followed (2.86, 3.65, 5.34 and 5.48 respectively) by S_1, while the minimum (2.47, 3.48, 4.83 and 5.02 respectively) was recorded from S_4 at 30, 45, 60 and 75 DAS. Seeds sowing at 20 November ensured the maximum tiller than early and delay sowing. BARI (1984) reported that 20 November sowing produced the highest number of tillers plant^{-1}. Aslam *et al.* (2013) reported that that the 5th November sowing significantly produced maximum tillers (359 m^{-2}) followed by the 15th November sowing, the 25th October sowing produced minimum tillers (232 m^{-2}) due to high temperature, not suitable for growth of wheat plant.

Statistically significant variation was recorded due to the interaction effect of wheat varieties and sowing dates on number of tillers plant^{-1} at 30, 45, 60 and 75 DAS (Table 3). At 30, 45, 60 and 75 DAS, the maximum number of tillers hill^{-1} (3.20, 3.93, 5.83 and 6.53 respectively) was found from V_2S_2, whereas the minimum number of tillers plant $^{-1}$ (2.33, 3.33, 4.77 and 4.80 respectively) was recorded from the treatment combination V_3S_4.

4.3 Dry matter content plant^{-1}

Statistically significant difference was observed due to different wheat varieties in terms of dry matter content plant^{-1} at 30, 45, 60 and 75 DAS (Fig. 6). At 30, 45, 60 and 75 DAS, the highest dry matter content plant^{-1} (0.77, 2.03, 3.56 and 5.54 g, respectively) was observed from V_2 which was statistically similar (0.73, 1.94, 3.37 and 5.30 g, respectively) to V_1 and followed (0.68, 1.75, 3.11 and 5.25 g, respectively) by V_4, again the lowest dry matter content plant^{-1} (0.64, 1.60, 2.99 and 5.05, g respectively) was found from V_3.

Table 3. Inter4action effect of varieties and sowing dates on number of tillers plant^{-1} of wheat at different days after sowing (DAS) and harvest

Treatments	Number of tillers plant^{-1}			
	30 DAS	45 DAS	60 DAS	75 DAS
V_1S_1	2.93 b-d	3.80 b	5.50 cd	5.67 c-f
V_1S_2	3.03 ab	3.83 ab	5.57 bc	6.43 ab
V_1S_3	2.97 bc	3.80 b	5.47 c-e	5.80 b-e
V_1S_4	2.63 fg	3.57 cd	4.93 g	5.07 fg
V_2S_1	3.07 ab	3.80 b	5.63 a-c	6.03 a-d
V_2S_2	3.20 a	3.93 a	5.83 a	6.53 a
V_2S_3	3.10 ab	3.90 ab	5.80 ab	6.27 a-c
V_2S_4	2.43 h	3.57 cd	4.90 g	5.10 fg
V_3S_1	2.67 ef	3.40 ef	5.00 fg	4.87 g
V_3S_2	2.80 c-f	3.43 ef	5.37 c-e	5.70 c-f
V_3S_3	2.80 c-f	3.43 ef	5.20 ef	6.20 a-c
V_3S_4	2.33 h	3.33 f	4.77 g	4.80 g
V_4S_1	2.77 d-f	3.60 c	5.23 d-f	5.33 e-g
V_4S_2	2.83 c-e	3.67 c	5.40 c-e	6.30 a-c
V_4S_3	2.80 c-f	3.63 c	5.43 c-e	5.43 d-g
V_4S_4	2.47 gh	3.47 de	4.73 g	5.13 fg
SE(±)	0.058	0.037	0.084	0.2000
Level of significance	0.05	0.05	0.05	0.05
CV(%)	4.49	5.74	4.74	6.12

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

V_1: BARI Gom 21

V_2: BARI Gom 23

V_3: BARI Gom 25

V_4: BARI Gom 26

S_1: Sowing at 10 November, 2013

S_2: Sowing at 20 November, 2013

S_3: Sowing at 30 November, 2013

S_4: Sowing at 10 December, 2013

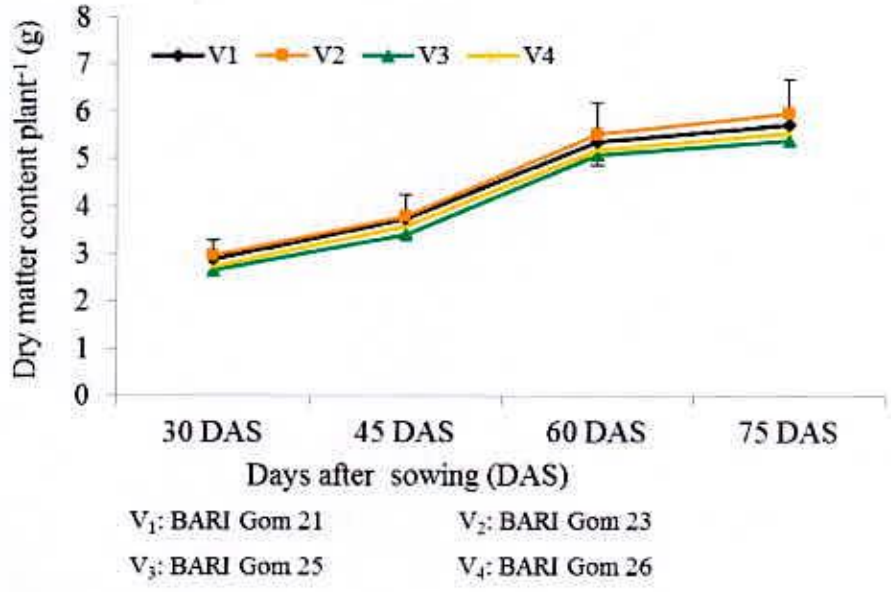


Fig. 6. Effect of different varieties on dry matter content plant^{-1} of wheat (SE=0.016, 0.030, 0.055 and 0.049 for 30, 45, 60 and 75 DAS)

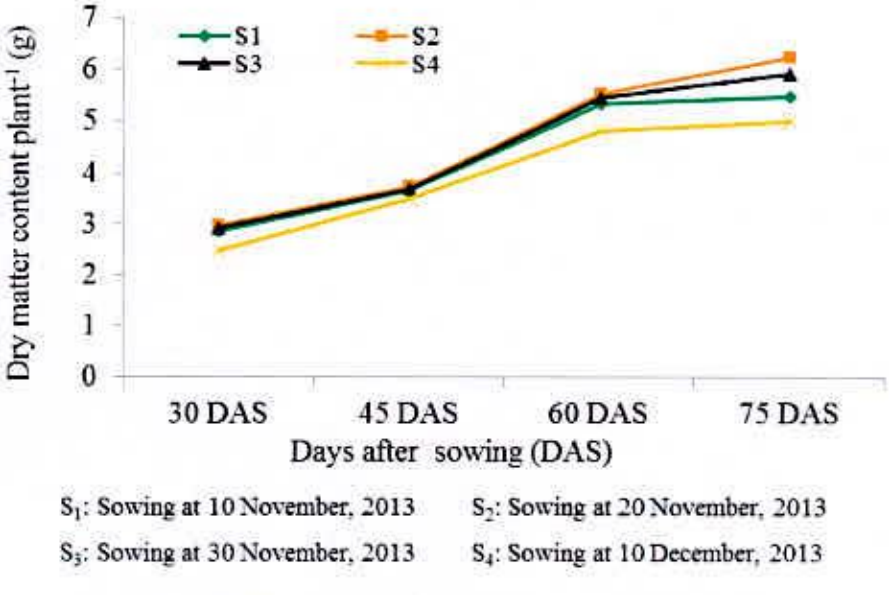


Fig. 7. Effect of different sowing dates on dry matter content plant^{-1} of wheat (SE=0.018, 0.049, 0.066 and 0.132 for 30, 45, 60 and 75 DAS)

Dry matter content plant^{-1} showed statistically significant differences due to different sowing dates under the present trial at 30, 45, 60 and 75 DAS (Fig. 7). Data revealed that at 30, 45, 60 and 75 DAS, the highest dry matter content plant^{-1} (0.76, 1.95, 3.47and 5.68 respectively) was attained from S_2 which was statistically similar (0.74, 1.94, 3.38 and 5.59 respectively) to S_3 and closely followed (0.68, 1.79, 3.25 and 5.03 respectively) by S_1, whereas the lowest (0.63, 1.65, 2.92 and 4.84 respectively) was found from S_4.

Interaction effect of wheat varieties and sowing dates showed significant differences on dry matter content plant^{-1} at 30, 45, 60 and 75 DAS (Table 4). At 30, 45, 60 and 75 DAS, the highest dry matter content plant^{-1} (0.91, 2.35, 4.01 and 6.04 respectively) was found from V_2S_2, while the lowest dry matter content plant^{-1} (0.60, 1.51, 2.82 and 5.35 respectively) was obtained from the treatment combination V_3S_4 at the same sampling dates

4.4 Days to spike initiation

Different wheat varieties showed statistically significant difference on days to spike initiation (Table 5). The highest days to spike initiation (66.08) was found from V_3 which was statistically similar to V_4 (64.50) and V_1 (63.75), whereas the lowest days to spike initiation (61.67) was recorded from V_2. Although management practices influenced the days to starting of ear emergence but genotypes itself contributed the days to starting of ear emergence.

Statistically significant differences were observed in terms of days to spike initiation due to different sowing dates (Table 5). The highest days to spike initiation (65.92) was observed from S_1 which was statistically similar to S_4 (65.67) and S_3 (63.25), while the lowest days to spike initiation (61.17) was found from S_4.

Table 4. Interaction effect of varieties and sowing dates on dry matter content plant^{-1} of wheat at different days after sowing (DAS)

Treatments	Dry matter content plant^{-1} (g) at			
	30 DAS	45 DAS	60 DAS	75 DAS
V_1S_1	0.70 c-f	1.91 b-e	3.41 cd	4.88 de
V_1S_2	0.80 a-c	2.09 a-c	3.60 bc	6.28 ab
V_1S_3	0.76 b-d	2.00 b-d	3.35 c-e	5.35 cd
V_1S_4	0.65 d-f	1.76 d-g	3.13 d-g	4.70 de
V_2S_1	0.74 b-d	2.01 b-d	3.59 bc	5.52 b-d
V_2S_2	0.91 a	2.35 a	4.01 a	6.04 a-c
V_2S_3	0.83 ab	2.20 ab	3.90 ab	6.40 a
V_2S_4	0.58 f	1.58 fg	2.72 g	4.19 e
V_3S_1	0.62 ef	1.56 fg	2.94 e-g	4.63 de
V_3S_2	0.62 ef	1.50 g	2.90 fg	5.10 d
V_3S_3	0.73 b-f	1.84 c-f	3.29 c-f	5.12 d
V_3S_4	0.60 f	1.51 g	2.82 g	5.35 cd
V_4S_1	0.65 d-f	1.67 e-g	3.06 d-g	5.10 d
V_4S_2	0.72 b-e	1.86 c-f	3.38 cd	5.28 cd
V_4S_3	0.66 d-f	1.71 d-g	2.99 d-g	5.51 b-c
V_4S_4	0.67d-f	1.76 d-g	3.01 d-g	5.11 d
SE(±)	0.037	0.098	0.132	0.265
Level of significance	0.01	0.01	0.01	0.01
CV(%)	8.82	9.30	7.03	8.66

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

V_1: BARI Gom 21

V_2: BARI Gom 23

V_3: BARI Gom 25

V_4: BARI Gom 26

S_1: Sowing at 10 November, 2013

S_2: Sowing at 20 November, 2013

S_3: Sowing at 30 November, 2013

S_4: Sowing at 10 December, 2013

Table 5. Effect of varieties and sowing dates on days to spike initiation, days to maturity, number of spikes plant^{-1} and number of spikelets spike^{-1} of wheat

Treatments	Days to spike initiation	Days to maturity	Number of spikes plant^{-1}	Number of spikelets spike^{-1}
Varieties				
V_1	63.75 ab	107.92 bc	4.71 ab	20.59 ab
V_2	61.67 b	105.58 c	4.86 a	21.24 a
V_3	66.08 a	111.25 a	4.30 c	19.49 c
V_4	64.50 a	109.17 ab	4.58 b	20.33 b
SE(±)	0.719	0.810	0.071	0.195
Level of significance	0.05	0.01	0.01	0.01
CV(%)	5.13	4.12	6.59	4.46
Sowing dates				
S_1	65.92 a	109.92 a	4.63 b	20.44 a
S_2	61.17 b	106.08 b	4.98 a	21.10 a
S_3	63.25 ab	108.08 a	4.83 ab	20.75 a
S_4	65.67 a	109.83 a	4.00 c	19.36 b
SE(±)	0.948	0.665	0.088	0.263
Level of significance	0.01	0.01	0.01	0.01
CV(%)	5.13	4.12	6.59	4.46

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

V_1: BARI Gom 21

V_2: BARI Gom 23

V_3: BARI Gom 25

V_4: BARI Gom 26

S_1: Sowing at 10 November, 2013

S_2: Sowing at 20 November, 2013

S_3: Sowing at 30 November, 2013

S_4: Sowing at 10 December, 2013

Interaction effect of wheat varieties and sowing dates showed significant differences on days to spike initiation (Table 6). The highest days to spike initiation (69.33) was observed from V_3S_4, while the lowest days to spike initiation (59.67) was obtained from the treatment combination V_2S_2.

4.5 Days to maturity

Days to maturity showed statistically significant difference in terms of different wheat varieties (Table 5). The highest days to maturity (111.25) was recorded from V_3 which was statistically similar to V_4 (109.17) and followed by V_1 (107.92), while the lowest days to maturity was found from V_2 (105.58).

Different sowing dates varied significantly in terms of days to maturity (Table 5). The highest days to maturity was found from S_1 (109.92) which was statistically similar to S_4 (109.83) and S_3 (108.08), whereas the lowest days to maturity was recorded from S_2 (106.08).

Days to maturity showed significant differences due to the interaction effect of wheat varieties and sowing dates (Table 6). The highest days to maturity (113.00) was found from V_3S_4 and the lowest days to maturity (103.33) was recorded from the treatment combination V_2S_2.

4.6 Number of spikes plant^{-1}

Different wheat varieties showed statistically significant difference on number of spikes plant^{-1} (Table 5). The highest number of spikes plant^{-1} was observed from V_2 (4.86) which was statistically similar to V_1 (4.71) and followed by V_4 (4.58), while the lowest number of spikes plant^{-1} was found from V_3 (4.30).

Number of spikes plant^{-1} showed statistically significant differences due to different sowing dates (Table 5). The highest number of spikes plant^{-1} was recorded from S_2 (4.98) which was statistically similar to S_3 (4.83) and closely followed by S_1 (4.63), while the lowest number of spikes plant^{-1} was found from S_4 (4.00).

Table 6. Interaction effect of varieties and sowing dates on days to spike initiation, days to maturity, number of spikes plant^{-1} and number of spikelets spike^{-1} of wheat

Treatments	Days to spike initiation	Days to maturity	Number of spikes plant^{-1}	Number of spikelets spike^{-1}
V_1S_1	67.67 a-c	110.33 a-d	4.87 a-c	20.43 b-d
V_1S_2	61.67 c-e	104.00 fg	5.03 a-c	21.53 ab
V_1S_3	61.67 c-e	107.00 c-g	4.83 a-c	21.00 a-c
V_1S_4	64.00 a-e	110.33 a-d	4.10 d-f	19.40 cd
V_2S_1	60.33 e	108.33 b-f	5.10 ab	21.60 ab
V_2S_2	59.67 e	103.33 g	5.23 a	22.23 a
V_2S_3	66.00 a-e	105.67 e-g	5.13 ab	21.60 ab
V_2S_4	60.67 e	105.00 e-g	3.97 ef	19.53 cd
V_3S_1	67.33 a-d	109.00 a-e	4.00 ef	19.57 cd
V_3S_2	62.33 b-e	111.00 a-c	4.80 a-c	19.77 cd
V_3S_3	65.33 a-e	112.00 ab	4.50 c-e	19.83 b-d
V_3S_4	69.33 a	113.00 a	3.90 f	18.80 d
V_4S_1	68.33 ab	112.00 ab	4.57 b-d	20.17 b-d
V_4S_2	61.00 de	106.00 d-g	4.87 a-c	20.87 a-c
V_4S_3	60.00 e	107.67 b-g	4.87 a-c	20.57 a-d
V_4S_4	68.67 ab	111.00 a-c	4.03 d-f	19.70 cd
SE(±)	1.895	1.331	0.175	0.526
Level of significance	0.05	0.05	0.05	0.05
CV(%)	5.13	4.12	6.59	4.46

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

V_1: BARI Gom 21

V_2: BARI Gom 23

V_3: BARI Gom 25

V_4: BARI Gom 26

S_1: Sowing at 10 November, 2013

S_2: Sowing at 20 November, 2013

S_3: Sowing at 30 November, 2013

S_4: Sowing at 10 December, 2013

Interaction effect of wheat varieties and sowing dates showed significant differences on number of spikes hill^{-1} (Table 6). The highest number of spikes hill^{-1} (5.23) was observed from V_2S_2 and the lowest number of spikes hill^{-1} (3.90) was found from the treatment combination V_3S_4.

4.7 Number of spikelets spike^{-1}

Statistically significant variation was recorded in terms of different wheat varieties in terms of number of spikelets spike^{-1} (Table 5). The highest number of spikelets spike^{-1} was recorded from V_2 (21.24) which was statistically similar to V_1 (20.59) and followed by V_4 (20.33), whereas the lowest number of spikelets spike^{-1} was recorded from V_3 (19.49).

Different sowing dates showed statistically significant differences in number of spikelets spike^{-1} (Table 5). The highest number of spikelets spike^{-1} was observed from S_2 (21.10) which was statistically similar to S_3 (20.75) and S_1 (20.44), while the lowest number of spikelets spike^{-1} was found from S_4 (19.36). Suleiman *et al.* (2014) reported that sowing dates have significant effect yield components that decreased with delay in sowing date and the highest values were obtained when cultivars sown on 1st November and 15th November.

Number of spikelets spike^{-1} varied significantly due to the interaction effect of wheat varieties and sowing dates under the present trial (Table 6). Data revealed that the highest number of spikelets spike^{-1} was observed from V_2S_2 (22.23), whereas the lowest number of spikelets spike^{-1} was obtained from the treatment combination V_3S_4 (18.80).

4.8 Ear length

Different wheat varieties showed statistically significant difference on ear length (Table 7). The highest ear length was recorded from V_2 (18.04 cm) which was statistically similar to V_1 (17.49 cm) and followed by V_4 (16.90 cm), while the lowest ear length from V_3 (16.07 cm). Although management practices influence the ear length of wheat but genotypes itself produced different length of ear.

Table 7. Effect of varieties and sowing dates on ear length, filled, unfilled and total grains spike^{-1} of wheat

Treatments	Ear length (cm)	Filled grains spike^{-1}	Unfilled grains spike^{-1}	Total grains spike^{-1}
Varieties				
V_1	17.49 ab	32.77 ab	3.17 b	35.93 a
V_2	18.04 a	33.77 a	3.08 b	36.84 a
V_3	16.07 c	31.11 c	3.52 a	34.63 b
V_4	16.90 b	32.49 b	3.43 a	35.93 a
SE(±)	0.236	0.332	0.041	0.346
Level of significance	0.01	0.01	0.01	0.05
CV(%)	5.12	4.01	5.75	3.92
Sowing dates				
S_1	17.13 b	32.38 b	3.48 b	35.87 a
S_2	18.31 a	34.28 a	2.83 c	37.11 a
S_3	17.82 ab	33.91 a	2.94 c	36.85 a
S_4	15.24 c	29.56 c	3.94 a	33.50 b
SE(±)	0.253	0.376	0.055	0.406
Level of significance	0.01	0.01	0.01	0.01
CV(%)	5.12	4.01	5.75	3.92

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

V_1: BARI Gom 21
V_2: BARI Gom 23
V_3: BARI Gom 25
V_4: BARI Gom 26

S_1: Sowing at 10 November, 2013
S_2: Sowing at 20 November, 2013
S_3: Sowing at 30 November, 2013
S_4: Sowing at 10 December, 2013

Ear length showed statistically significant differences due to different sowing dates (Table 7). The highest ear length (18.31 cm) was found from S_2 which was statistically similar (17.82 cm) to S_3 and closely followed (17.13 cm) by S_1, again the lowest ear length (15.24 cm) was recorded from S_4. Chowdhury (2002) conducted an experiment with four sowing dates and reported that ear length decreased with delay in sowing date from November 15 and the lowest ear length were recorded in December 15 sown plants.

Interaction effect of wheat varieties and sowing dates showed significant differences on ear length (Table 8). The highest ear length was observed from V_2S_2 (19.64 cm), whereas the lowest ear length was obtained from the treatment combination V_3S_4 (14.70 cm).

4.9 Filled grains spike^{-1}

Filled grains spike^{-1} varied significantly due to different wheat varieties under the present trial (Table 7). The highest filled grains spike^{-1} was observed from V_2 (33.77) which was statistically similar to V_1 (32.77) and followed by V_4 (32.49), again the lowest filled grains spike^{-1} was recorded from V_3 (31.11).

Statistically significant variation was recorded in terms of filled grains spike^{-1} due to different sowing dates (Table 7). The highest filled grains spike^{-1} (34.28) was recorded from S_2 which was statistically similar (33.91) to S_3 and closely followed (32.38) by S_1, while the lowest filled grains spike^{-1} (29.56) was observed from S_4. Suleiman *et al.* (2014) reported that sowing dates have significant effect yield components that decreased with delay in sowing date and the highest values were obtained when cultivars sown on 1st November and 15th November.

Wheat varieties and sowing dates showed significant differences due to their interaction effect in terms of filled grains spike^{-1} (Table 8). The highest filled grains spike^{-1} (35.73) was found from V_2S_2 and the lowest filled grains spike^{-1} (28.13) was attained from the treatment combination V_3S_4.

Table 8. Interaction effect of varieties and sowing dates on ear length, filled, unfilled and total grains spike^{-1} of wheat

Treatments	Ear length (cm)	Filled grains spike^{-1}	Unfilled grains spike^{-1}	Total grains spike^{-1}
V_1S_1	17.77 b-d	32.30 cd	3.37 c-f	35.67 b-e
V_1S_2	19.25 ab	35.13 ab	2.63 j	37.77 a-c
V_1S_3	17.78 b-d	33.97 a-c	2.73 ij	36.70 a-d
V_1S_4	15.16 fg	29.67 ef	3.93 b	33.60 e-g
V_2S_1	18.55 a-c	34.37 a-c	3.30 d-g	37.67 a-c
V_2S_2	19.64 a	35.73 a	2.77 ij	38.50 a
V_2S_3	19.09 ab	35.43 a	2.80 ij	38.23 ab
V_2S_4	14.87 g	29.53 ef	3.43 c-e	32.97 fg
V_3S_1	15.43 e-g	31.00 de	3.57 cd	34.57 d-g
V_3S_2	16.71 d-f	32.40 cd	2.93 h-j	35.33 c-f
V_3S_3	17.42 cd	32.90 b-d	3.17 e-h	36.07 a-e
V_3S_4	14.70 g	28.13 f	4.40 a	32.53 g
V_4S_1	16.77 d-f	31.87 c-e	3.70 bc	35.57 b-f
V_4S_2	17.63 b-d	33.87 a-c	2.97 g-j	36.83 a-d
V_4S_3	16.99 c-e	33.33 a-d	3.07 f-i	36.40 a-d
V_4S_4	16.23 d-g	30.90 de	4.00 b	34.90 d-g
SE(±)	0.506	0.752	0.110	0.811
Level of significance	0.05	0.05	0.05	0.05
CV(%)	5.12	4.01	5.75	3.92

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

V_1: BARI Gom 21

V_2: BARI Gom 23

V_3: BARI Gom 25

V_4: BARI Gom 26

S_1: Sowing at 10 November, 2013

S_2: Sowing at 20 November, 2013

S_3: Sowing at 30 November, 2013

S_4: Sowing at 10 December, 2013

4.10 Unfilled grains spike^{-1}

Different wheat varieties showed statistically significant difference on unfilled grains spike^{-1} (Table 7). The highest unfilled grains spike^{-1} was found from V_3 (3.52) which was statistically similar to V_4 (3.43), whereas the lowest unfilled grains spike^{-1} was recorded from V_2 (3.08) which was statistically similar to V_1(3.17).

Unfilled grains spike^{-1} showed statistically significant differences due to different sowing dates (Table 7). The highest unfilled grains spike^{-1} was observed from S_4 (3.94) which was statistically similar to S_1 (3.48), while the lowest unfilled grains spike^{-1} was found from S_2 (2.83) which was statistically similar to S_3 (2.94).

Interaction effect of wheat varieties and sowing dates showed significant differences on unfilled grains spike^{-1} (Table 8). The highest unfilled grains spike^{-1} was observed from V_3S_4 (4.40) and the lowest unfilled grains spike^{-1} was obtained from the treatment combination V_2S_2 (2.77).

4.11 Total grains spike^{-1}

Total grains spike^{-1} varied significantly due to different wheat varieties under the present trial (Table 7). Data revealed that the highest total grains spike^{-1} was observed from V_2 (36.86) which was statistically similar to V_4 and V_1 (35.93 and 35.93, respectively), whereas the lowest total grains spike^{-1} was found from V_3 (34.63). WRC (2003) reported that the varieties Shatabdi produced maximum grain spike^{-1}.

Total grains spike^{-1} showed statistically significant differences due to different sowing dates (Table 7). The highest total grains spike^{-1} was recorded from S_2 (37.11) which was statistically similar to S_3 (36.85) and S_1 (35.87), again the lowest total grains spike^{-1} was observed from S_4 (33.50). Chowdhury (2002) conducted an experiment with four sowing dates and reported that grains spike^{-1} decreased with delay in sowing date from November 15 and the lowest grains spike^{-1} were recorded in December 15 sown plants. Zia-Ul-Hassan *et al.* (2014)

reported that that sowing dates remained significant on grains spike^{-1} and early sowing produced the best one.

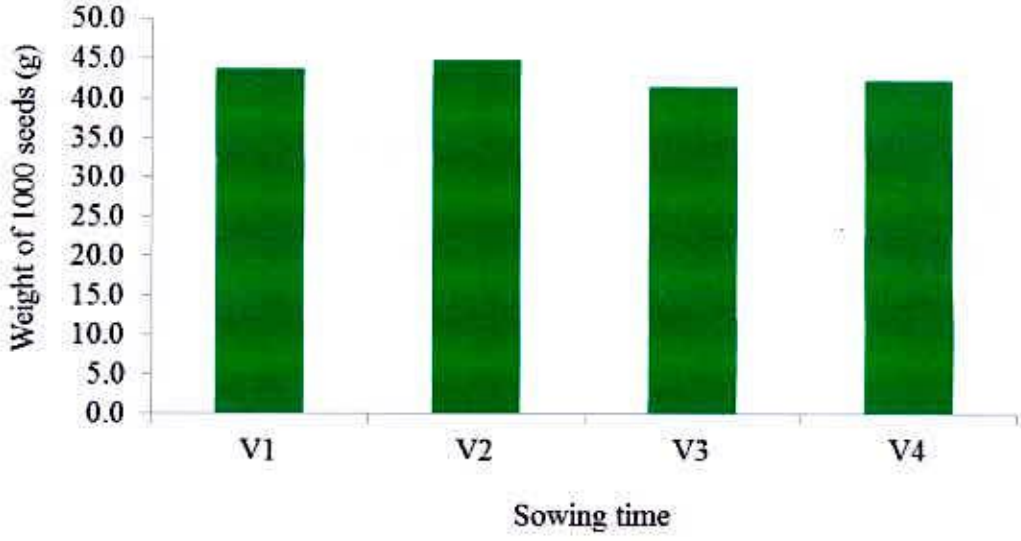
Statistically significant variation was recorded due to the interaction effect of wheat varieties and sowing dates in terms of total grains spike^{-1} (Table 8). The highest total grains spike^{-1} was found from V_2S_2 (38.50), while the lowest total grains spike^{-1} was recorded from the treatment combination V_3S_4 (32.53).

4.12 Weight of 1000-seeds

Different wheat varieties showed statistically significant difference on weight of 1000-seeds (Figure 8). The highest weight of 1000-seeds (44.73 g) was recorded from V_2 which was statistically similar (43.60 g) to V_1, whereas the lowest weight of 1000-seeds (41.28 g) was found from V_3 which was statistically similar (42.17 g) to V_4.

Weight of 1000-seeds showed statistically significant differences due to different sowing dates (Figure 9). The highest weight of 1000-seeds (44.08 g) was found from S_2 which was statistically similar (43.28 g and 42.86 g) to S_3 and (42.86) S_1, while the lowest weight of 1000-seeds (41.56 g) was observed from S_4. Chowdhury (2002) reported that 1000-grain weight decreased with delay in sowing from November 15 and the lowest 1000-grain weight were recorded in December 15 sown plants. Abdullah *et al.* (2007) found that 1000-grain weight declined progressively with delayed sowing and the maximum value in first planting date i.e. 25th October and minimum value in the last planting date i.e. 10th January.

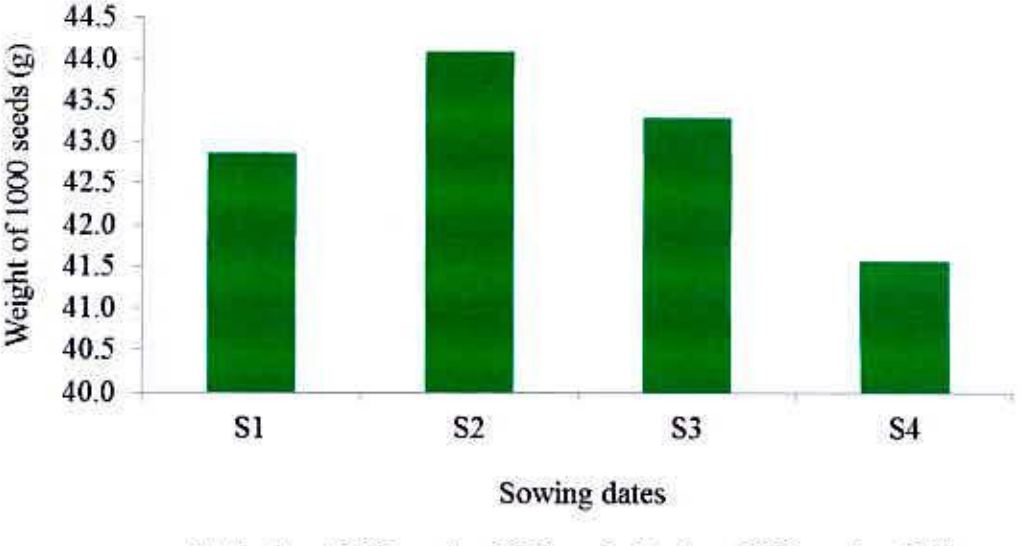
Interaction effect of wheat varieties and sowing dates showed significant differences on weight of 1000-seeds (Figure 10). The highest weight of 1000-seeds (47.24 g) was found from V_2S_2, while the lowest weight of 1000-seeds (40.33 g) was obtained from the treatment combination V_3S_4.



V_1: BARI Gom 21 V_2: BARI Gom 23

V_3: BARI Gom 25 V_4: BARI Gom 26

Fig.8. Effect of different varieties on weight of 1000 seeds of wheat (SE = 0.678)



S_1: Sowing at 10 November, 2013 S_2: Sowing at 20 November, 2013

S_3: Sowing at 30 November, 2013 S_4: Sowing at 10 December, 2013

Fig. 9. Effect of different sowing dates on weight of 1000 seeds of wheat (SE = 0.479)

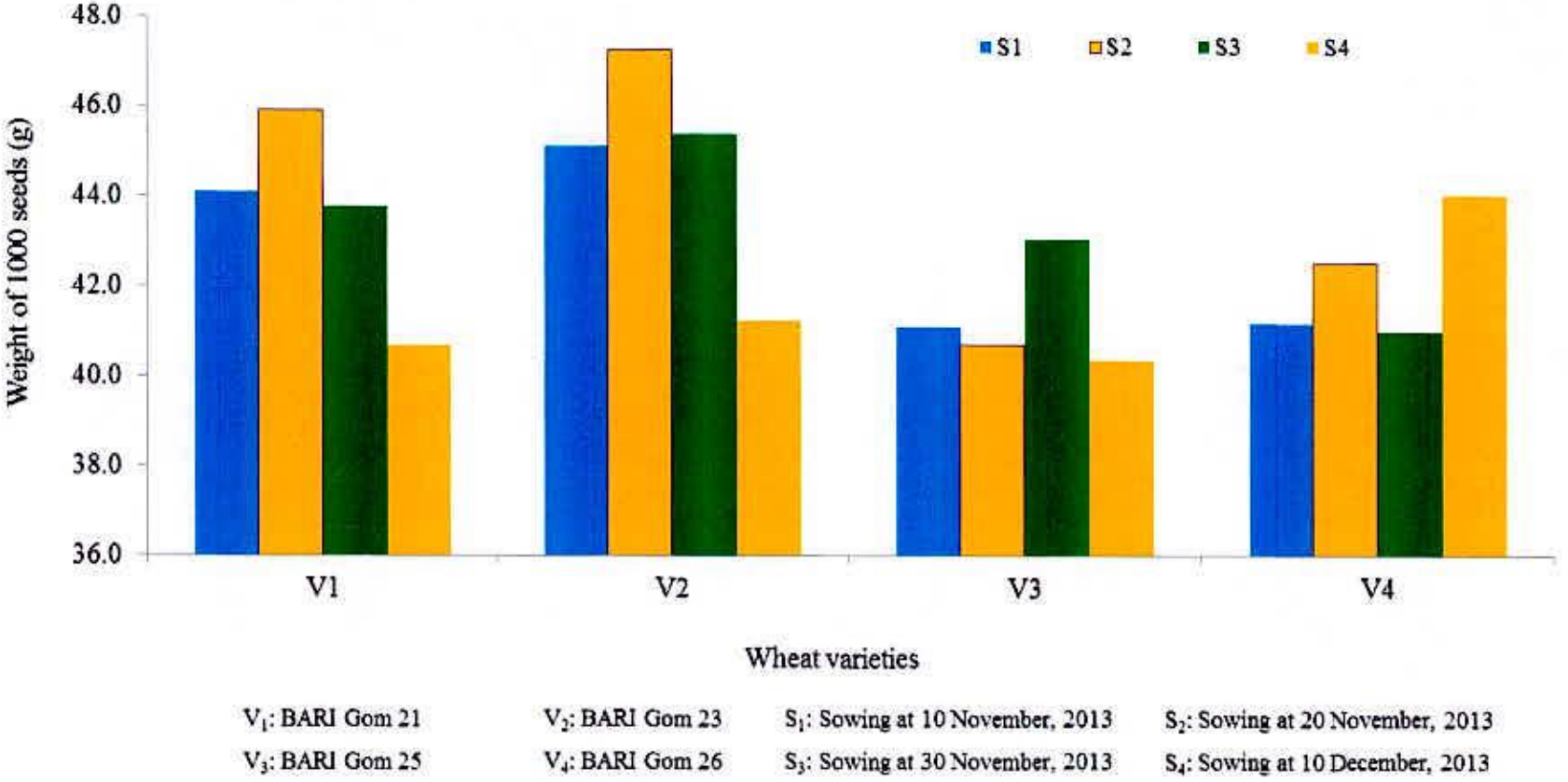


Fig. 10. Interaction effect of different varieties and sowing dates on weight of 1000 seeds of wheat (SE = 0.957)

4.13 Grain yield

Statistically significant variation was observed for different wheat varieties in terms of grain yield (Table 9). The highest grain yield was found from V_2 (3.72 t ha^{-1}) which was statistically similar to V_1 (3.67 t ha^{-1}) and followed by V_4 (3.53 t ha^{-1}) , whereas the lowest grain yield was found from V_3 (3.26 t ha^{-1}). BARI (1993) revealed that mean yield of wheat varieties Kanchan, Akbar, Agrani and Sonalika were 3.59, 3.29, 3.12 and 2.81 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 $spike^{-1}$.

Different sowing dates showed statistically significant differences on grain yield (Table 9). The highest grain yield (3.77 t ha^{-1}) was recorded from S_2 which was statistically similar (3.68 t ha^{-1}) to S_3 and closely followed (3.61 t ha^{-1}) by S_1, again the lowest grain yield (3.12 t ha^{-1}) was observed from S_4. Late planted wheat plants face a period of high temperature stress during reproductive stages causing reduced kernel number $spike^{-1}$ (Bhatta *et al.*, 1994 and Islam *et al.*, 1993) as well as the reduction of seed yield. Numerous publications have been reported an increased wheat yield with early sowing and a reduction in yield when seeds sowing delayed after the optimum time (Bassu *et al.*, 2009 and Bannayan *et al.*, 2013).

Interaction effect of wheat varieties and sowing dates showed significant differences on grain yield (Table 10). The highest grain yield (3.94 t ha^{-1}) was observed from V_2S_2, while the lowest grain yield (3.04 t ha^{-1}) was obtained from the treatment combination V_3S_4.

4.14 Straw yield

Different wheat varieties showed statistically significant difference on straw yield (Table 9). The highest straw yield (5.32 t ha^{-1}) was found from V_2 which was statistically similar (5.16 t ha^{-1}) to V_1 and followed (5.02 t ha^{-1}) by V_4, again the lowest straw yield (4.73 t ha^{-1}) was recorded from V_3.

Table 9. Effect of varieties and sowing dates on yield and harvest index of wheat

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Varieties				
V_1	3.67 a	5.16 ab	8.82 a	41.62
V_2	3.72 a	5.32 a	9.05 a	41.29
V_3	3.26 c	4.73 c	7.99 c	40.97
V_4	3.53 b	5.02 b	8.54 b	41.37
SE(±)	0.040	0.050	0.081	NS
Level of significance	0.01	0.01	0.01	0.01
CV(%)	4.03	5.31	4.18	3.02
Sowing dates				
S_1	3.61 b	5.06 b	8.67 c	41.65 b
S_2	3.77 a	5.61 a	9.39 a	40.20 c
S_3	3.68 ab	5.39 a	9.07 b	40.52 c
S_4	3.12 c	4.16 c	7.28 d	42.89 a
SE(±)	0.041	0.077	0.104	0.360
Level of significance	0.01	0.01	0.01	0.01
CV(%)	4.03	5.31	4.18	3.02

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 significance

V_1: BARI Gom 21

V_2: BARI Gom 23

V_3: BARI Gom 25

V_4: BARI Gom 26

S_1: Sowing at 10 November, 2013

S_2: Sowing at 20 November, 2013

S_3: Sowing at 30 November, 2013

S_4: Sowing at 10 December, 2013

Table 10. Interaction effect of varieties and sowing dates on yield and harvest index of wheat

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1S_1	3.81 a-c	5.34 b-d	9.15 a-c	41.60 a-d
V_1S_2	3.87 ab	5.60 a-c	9.46 ab	40.87 b-e
V_1S_3	3.84 a-c	5.26 b-d	9.10 b-d	42.22 a-d
V_1S_4	3.16 de	4.42 e	7.58 e	41.79 a-d
V_2S_1	3.88 ab	5.57 a-c	9.45 ab	41.07 b-e
V_2S_2	3.94 a	5.88 a	9.82 a	40.16 c-e
V_2S_3	3.91 ab	5.70 ab	9.61 ab	40.67 c-e
V_2S_4	3.17 de	4.15 ef	7.32 e	43.28 ab
V_3S_1	3.09 de	4.32 ef	7.41 e	41.65 a-d
V_3S_2	3.59 c	5.57 a-c	9.16 a-c	39.19 e
V_3S_3	3.31 d	5.14 cd	8.46 d	39.12 e
V_3S_4	3.04 e	3.88 f	6.91 e	43.92 a
V_4S_1	3.67 bc	5.01 d	8.67 cd	42.28 a-d
V_4S_2	3.69 a-c	5.41 a-d	9.10 b-d	40.56 c-e
V_4S_3	3.65 bc	5.46 a-d	9.11 b-d	40.06 de
V_4S_4	3.10 de	4.19 ef	7.29 e	42.58 a-c
SE(±)	0.082	0.155	0.207	0.720
Level of significance	0.05	0.05	0.05	0.05
CV(%)	4.03	5.31	4.18	3.02

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 significance

V_1: BARI Gom 21
V_2: BARI Gom 23
V_3: BARI Gom 25
V_4: BARI Gom 26

S_1: Sowing at 10 November, 2013
S_2: Sowing at 20 November, 2013
S_3: Sowing at 30 November, 2013
S_4: Sowing at 10 December, 2013

Straw yield showed statistically significant differences due to different sowing dates (Table 9). The highest straw yield (5.61 t ha^{-1}) was observed from S_2 which was statistically similar (5.39 t ha^{-1}) to S_3 and closely followed (5.06 t ha^{-1}) by S_1, while the lowest straw yield (4.16 t ha^{-1}) was found from S_4.

Interaction effect of wheat varieties and sowing dates showed significant differences on straw yield (Table 10). The highest straw yield (5.88 t ha^{-1}) was observed from V_2S_2, whereas the lowest straw yield (3.88 t ha^{-1}) was obtained from the treatment combination V_3S_4.

4.15 Biological yield

Biological yield showed statistically significant difference due to different wheat varieties (Table 9). Data revealed that the highest biological yield (9.05 t ha^{-1}) was observed from V_2 which was statistically similar (8.82 t ha^{-1}) to V_1 and followed (8.54 t ha^{-1}) by V_4, while the lowest biological yield (7.99 t ha^{-1}) was obtained from V_3.

Different sowing dates showed statistically significant differences in terms of biological yield (Table 9). The highest biological yield (9.39 t ha^{-1}) was found from S_2 which was closely followed (9.07 t ha^{-1}) by S_3, again the lowest biological yield (7.28 t ha^{-1}) was recorded from S_4 which was closely followed (8.67 t ha^{-1}) by S_1. Said *et al.* (2012) reported significant differences among the planting dates for biological yield and maximum biological yield (11953 kg ha^{-1}) were produced from 1st to 15th November.

Interaction effect of wheat varieties and sowing dates showed significant differences on biological yield (Table 10). The highest biological yield (9.82 t ha^{-1}) was found from V_2S_2 and the lowest biological yield (6.91 t ha^{-1}) was obtained from the treatment combination V_3S_4.

4.16 Harvest index

Different wheat varieties showed statistically non-significant difference on harvest index (Table 9). The highest harvest index (41.62) was found from V_1 and the lowest harvest index (40.97) was recorded from V_3.

Harvest index showed statistically significant differences due to different sowing dates (Table 9). The highest harvest index (42.89) was observed from S_4 which was closely followed (41.65) by S_1, whereas the lowest harvest index (40.20) was found from S_2 which was statistically similar (40.52) to S_3. Samuel *et al.* (2000) reported that late sowing condition (6 January 1997) reduce the harvest index (36.1%) from (41.5%) normal sowing condition (29 November 1996) in wheat.

Interaction effect of wheat varieties and sowing dates showed significant differences on harvest index (Table 10). The highest harvest index (43.92) was observed from V_3S_4, while the lowest harvest index (39.12) was obtained from the treatment combination V_3S_3.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2013 to March 2014 to find out the effect of variety and sowing dates on the growth and yield of wheat. The experiment comprised of two factors; Factor A: Wheat variety (4); V_1: BARI Gom 21,V_2: BARI Gom 2, V_3: BARI Gom 25, V_4: BARI Gom 26 and Factors B: Sowing date (4)-S_1: Sowing at 10 November, 2013, S_2: Sowing at 20 November, 2013, S_3: Sowing at 30 November, 2013, S_4: Sowing at 10 December, 2013 The experiment was laid out in a split plot design with three replications.

In case of wheat varieties, at 30, 45, 60, 75 DAS and harvest, the longest plant (27.86, 60.91, 87.32, 95.98 and 102.38 cm, respectively) was found from V_2, while the shortest plant (25.68, 56.75, 81.58, 90.46 and 95.90 cm, respectively) was recorded from V_3. Data revealed that at 30, 45, 60 and 75 DAS, the maximum number of tillers plant^{-1} (2.95, 3.80, 5.54 and 5.98 respectively) was recorded from V_2, whereas the minimum number of tillers plant^{-1} (2.65, 3.40, 5.08 and 5.39 respectively) was observed from V_3. At 30, 45, 60 and 75 DAS, the highest dry matter content plant^{-1} (0.77, 2.03, 3.56 and 5.54 g, respectively) was observed from V_2 the lowest dry matter content plant^{-1} (0.64, 1.60, 2.99 and 5.05, g respectively) was found from V_3. The highest days to spike initiation (66.08) was found from V_3, the lowest days to spike initiation (61.67) was recorded from V_2. The highest days to maturity (111.25) was recorded from V_3, while the lowest days to maturity (105.58) was found from V_2. The highest number of spikes plant^{-1} (4.86) was observed from V_2, while the lowest number of spikes plant^{-1} (4.30) was found from V_3. The highest number of spikelets spike^{-1} (21.24) was recorded from V_2, the lowest number of spikelets spike^{-1} (19.49) was recorded from V_3. The highest ear length (18.04 cm) was recorded from V_2, the lowest ear

length (16.07 cm) was observed from V_3. The highest filled grains spike^{-1} (33.77) was observed from V_2, the lowest filled grains spike^{-1} (31.11) was recorded from V_3. The highest unfilled grains spike^{-1} (3.52) was found from V_3, the lowest unfilled grains spike^{-1} (3.08) was recorded from V_2. Data revealed that the highest total grains spike^{-1} (36.86) was observed from V_2, the lowest total grains spike^{-1} (34.63) was found from V_3. The highest weight of 1000-seeds (44.73 g) was recorded from V_2, the lowest weight of 1000- seeds (41.28 g) was found from V_3. The highest grain yield (3.72 t ha^{-1}) was found from V_2, the lowest grain yield (3.26 t ha^{-1}) was found from V_3. The highest straw yield (5.32 t ha^{-1}) was found from V_2, the lowest straw yield (4.73 t ha^{-1}) was recorded from V_3. Data revealed that the highest biological yield (9.05 t ha^{-1}) was observed from V_2, the lowest biological yield (7.99 t ha^{-1}) was obtained from V_3. The highest harvest index (41.62) was found from V_1 and the lowest harvest index (40.97) was recorded from V_3.

For different sowing dates, at 30, 45, 60, 75 DAS and harvest, the longest plant (28.18, 61.21, 86.62, 97.79 and 104.71 cm, respectively) was observed from S_2, whereas the shortest plant (25.32, 55.62, 81.14, 88.56 and 92.17 cm, respectively) was found from S_4. The maximum number of tillers plant^{-1} (2.97, 3.72, 5.54 and 6.24 respectively) was found from S_2, while the minimum number (2.47, 3.48, 4.83 and 5.02 respectively) was recorded from S_4 at 30, 45, 60 and 75 DAS. Data revealed that at 30, 45, 60 and 75 DAS, the highest dry matter content plant^{-1} (0.76, 1.95, 3.47and 5.68 respectively) was attained from S_2 whereas the lowest (0.63, 1.65, 2.92 and 4.84 respectively) was found from S_4. The highest days to spike initiation (65.92) was observed from S_1, while the lowest days to spike initiation (61.17) was found from S_4. The highest days to maturity (109.92) was found from S_1, the lowest days to maturity (106.08) was recorded from S_2. The highest number of spikes plant^{-1} (4.98) was recorded from S_2, the lowest number of spikes plant^{-1} (4.00) was found from S_4. The highest number of spikelets spike^{-1} (21.10) was observed from S_2, the lowest number of spikelets spike^{-1} (19.36) was found from S_4. The highest ear length (18.31 cm) was found from S_2, the lowest

ear length (15.24 cm) was recorded from S_4. The highest filled grains spike^{-1} (34.28) was recorded from S_2, the lowest filled grains spike^{-1} (29.56) was observed from S_4. The highest unfilled grains spike^{-1} (3.94) was observed from S_4 the lowest unfilled grains spike^{-1} (2.83) was found from S_2. The highest total grains spike^{-1} (37.11) was recorded from S_2, again the lowest total grains spike^{-1} (33.50) was observed from S_4. The highest weight of 1000- seeds (44.08 g) was found from S_2 the lowest weight of 1000- seeds (41.56 g) was observed from S_4. The highest grain yield (3.77 t ha^{-1}) was recorded from S_2, the lowest grain yield (3.12 t ha^{-1}) was observed from S_4. The highest straw yield (5.61 t ha^{-1}) was observed from S_2, the lowest straw yield (4.16 t ha^{-1}) was found from S_4. The highest biological yield (9.39 t ha^{-1}) was found from S_2, the lowest biological yield (7.28 t ha^{-1}) was recorded from S_4. The highest harvest index (42.89) was observed from S_4, the lowest harvest index (40.20) was found from S_2.

Due to the interaction effect of wheat varieties and sowing dates, at 30, 45, 60, 75 DAS and harvest, the longest plant (29.97, 63.89, 89.42, 98.78 and 108.32 cm, respectively) was observed from V_2S_2 and the shortest plant (22.36, 54.14, 80.92, 84.15 and 88.17 cm, respectively) was obtained from the treatment combination V_3S_4. At 30, 45, 60 and 75 DAS, the maximum number of tillers plant^{-1} (3.20, 3.93, 5.83 and 6.53 respectively) was found from V_2S_2, whereas the minimum number of tillers plant^{-1} (2.33, 3.33, 4.77 and 4.80 respectively) was recorded from the treatment combination V_3S_4. At 30, 45, 60 and 75 DAS, the highest dry matter content plant^{-1} (0.91, 2.35, 4.01 and 6.04 respectively) was found from V_2S_2, while the lowest dry matter content plant^{-1} (0.60, 1.51, 2.82 and 5.35 respectively) was obtained from the treatment combination V_3S_4. The highest days to spike initiation (69.33) was observed from V_3S_4, while the lowest days to spike initiation (59.67) was obtained from the treatment combination V_2S_2. The highest days to maturity (113.00) was found from V_3S_4 and the lowest days to maturity (103.33) was recorded from the treatment combination V_2S_2. The highest number of spikes plant^{-1} (5.23) was observed from V_2S_2 and the lowest number of spikes plant^{-1} (3.90) was found from the treatment combination of V_3S_4. Data revealed

that the highest number of spikelets spike^{-1} (22.23) was observed from V_2S_2, whereas the lowest number of spikelets spike^{-1} (18.80) was obtained from the treatment combination of V_3S_4. The highest ear length (19.64 cm) was observed from V_2S_2, whereas the lowest ear length (14.70 cm) was obtained from the treatment combination of V_3S_4. The highest filled grains spike^{-1} (35.73) was found from V_2S_2 and the lowest filled grains spike^{-1} (28.13) was attained from the treatment combination of V_3S_4. The highest unfilled grains spike^{-1} (4.40) was observed from V_3S_4 and the lowest unfilled grains spike^{-1} (2.77) was obtained from the treatment combination of V_2S_2. The highest total grains spike^{-1} (38.50) was found from V_2S_2, while the lowest total grains spike^{-1} (32.53) was recorded from the treatment combination of V_3S_4. The highest weight of 1000- seeds (47.24 g) was found from V_2S_2, while the lowest weight of 1000-grains (40.33 g) was obtained from the treatment combination of V_3S_4. The highest grain yield (3.94 t ha^{-1}) was observed from V_2S_2, while the lowest grain yield (3.04 t ha^{-1}) was obtained from the treatment combination of V_3S_4. The highest straw yield (5.88 t ha^{-1}) was observed from V_2S_2, whereas the lowest straw yield (3.88 t ha^{-1}) was obtained from the treatment combination of V_3S_4. The highest biological yield (9.82 t ha^{-1}) was found from V_2S_2 and the lowest biological yield (6.91 t ha^{-1}) was obtained from the treatment combination of V_3S_4. The highest harvest index (43.92) was observed from V_3S_4, while the lowest harvest index (39.12) was obtained from the treatment combination of V_3S_3.

From the findings it may be concluded that:

- Among the variety BARI Gom 23 was superior than other variety that used in this experiment
- Sowing on 20 November was the best among the sowing date that used under the trial.
- Among the interactions BARI Gom 23 sown on 20 November was found promising in the present study.

REFERENCES

Abdullah, M., Rehman, A., Ahmad N. and Rasul, I. (2007). Planting time effect on grain and quality characteristics of wheat. *Pak. J. Agri. Sci.*, **44**: 200-202.

Ahmad, S., Ahmes. N., Ahmed, R. and Hamid, M. (1989). Effect of high temperature stress on wheat reproductive growth. *J. Agric. Res.*, **27**: 307-313.

Ahmed, S., Islam, M.S., Salam, A. and Hossain, M.F. (2006). Effect of sowing time on the yield attributes of barley in High Barind Tract. *Bangladesh J. Agril. Res.* **31**(2): 231-239.

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

Al-Musa, M.A.A., Ullah, M.A., Moniruzzaman, M., Islam, M.S. and Mukherjee, A. (2012). Effect of BARI Wheat Varieties on Seed Germination, Growth and Yield under Patuakhali District. *J. Environ. Sci. & Natural Resources*, **5**(2): 209-212.

Andarzian, B., Bakhshandeh, A.M., Bannayan, M., Eman, Y., Fathia, G., Alami Saeed, K. (2008). Wheat Pot: a simple model for spring wheat yield potential using monthly weather data. *Biosyst. Eng.*, **99**: 487–495.

Anonymous. (2008). Statistical year book of Bangladesh-2006. Bangladesh Bureau of Statistics, Planning Division, Ministry of Planning, Government of the People's Republic of Bangladesh. www.bbs.gov.bd (4 November 2012).

Anwar, J., Ahmad, A., Khaliq, T., Mubeen, M., Hammad, H.M. (2011). Optimization of sowing time for promising wheat genotypes in semiarid environment of Faisalabad. *Crop Environ.*, **2**: 24-27.

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.

Aslam, M., Sanghi, A.H., Javed, S. and Khalid, L. (2013). Effect of sowing time on yield and yield components of wheat sown in standing cotton. *J. Agric. Res.*, **51**(2): 133-140.

Aslani, F. and Mehrvar, M.R. (2012). Responses of Wheat Genotypes as Affected by Different Sowing Dates. *Asian J. Agric. Sci.*, **4**(1): 72-74.

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

Baloch, M.S., Shah, I.T.H., Nadim, M.A., Khan, M.I. and Khakwani, A.A. (2010). Effect of seeding density and planting time on growth and yield attributes of wheat. *J. Anim. Plant Sci.*, **20**(4): 239-240.

Bannayan, M., Eyshi Rezaei, E., Hoogenboom, G. (2013). Determining optimum sowing dates for rainfed wheat using the precipitation uncertainty model and adjusted crop evapotranspiration. *Agric. Water Manage.*, **126**: 56–63.

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

BARI (Bangladesh Agricultural Research Institute). (2010). Wheat production in Bangladesh: a success story. ttp://www.bari.gov. bd/index. php? Option =

com simplest forum & view = post list & topic = true & forum Id=1& parented = 288 (4 November 2012).

BARI (Bangladesh Agricultural Research Institute). (2011). Krishi Projukti Hat Boi. BARI. Joydevpur, Gazipur. p. 18.

BARI (Bangladesh Agricultural Research Institute). (2012). Wheat varieties released by Bangladesh Agricultural Research Institute. http://www.bari.gov.bd/index. php? option = com advanced search& view = advanced research & Id=861, 862, 863 (4 November 2012).

BARI. (1993). Annual Report (1991-92). Bangladesh Agril. Res. Inst. Joydebpur, Gazipur. pp. 19-33.

BARI. (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. (2003). Annual Report (2002-2003). Bangladesh Agril. Res. Inst. Joydebpur, Gazipur. p. 17-23.

Bassu, S., Asseng, A., Motzo, R. and Giunta, F. (2009). Optimizing sowing date of durum wheat in a variable Mediterranean environment. *Field Crops Res.* **111**: 109-118.

BBS (Bangladesh Bureau of Statistics). (2012). Monthly Statistical Bulletin, Bangladesh. Statistics Division. Ministry of Planning. Government of the Peoples Republic of Bangladesh. Dhaka. p. 81.

Bhatta, M.R., Hernandez, J.E. and Lales, J.S. (1994). Possibilities of selecting wheats with fast grain filling rate for warmer areas. p. 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, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

Comy, M.J. (1995). A note on the effect of sowing date and fertilizer on the yield, grain nitrogen and screening content of spring-sown malting baeley. *Irish J. Agril. Food Res.*, **34**(1): 69-73.

Dubin, Y.P. and Ginkel, P.M. (1991). Wheat cultivation in the warmer climates exists in the South-East Asia including Bangladesh. *Indian J. Agril. Sci.*, **58**(1): 131-135.

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

Ehdaie, B., Skakiba, M.R. and Waines, J.G. (2001). Sowing date and nitrogen input influence nitrogen use efficiency in spring bread and durum wheat genotypes. *J. Plant Nutri.*, **24**(6): 899-919.

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

Eslami, H., Navae, H.N., Alazmani, A.R. and Shojaei, A.N. (2014). Effect of sowing dates and seeding density on yield of wheat (*Triticumm aestivum* L.). *Intl. Res. J. Appl. Basic Sci.*, **8**(7): 836-838.

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

FAO. (1997). Production Year Book. Food and Agriculture Organization of the United Nations Rome, Italy. **49**: 201-212.

FAO. (2000). Production Year Book. Food and Agriculture Organization of the United Nations Rome, Italy. **54**: 176-186.

Farid , S.M., Hosain, A. and Salahuddin, A.B.M. (1993). Sowing date effects on the yield of three cultivars of barley. *Bangladesh J. Agril. Sci.*, **20**(1): 41-45.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research (2nd 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.

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

Iqbal M., Khan M.A., Anwar. M.Z. (2002). Zero-tillage technology and farm profits: a case study of wheat growers in the rice zone of Punjab. *Pakistan Dev. Rev.*, **41**: 665-682.

Islam, N., Ahmed, S.M., Razzaque, M.A., Sufian, A. 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.

Khokhar, Z., Hussain, I., Khokhar, B. and Sohail, M. (2010). Effect of planting date on yield of wheat genotypes in Sindh. *Pakistan J. Agric. Res.*, **23**(3-4): 103-107.

Kumar, R. and Sharma, S.N. (2003). Effect of levels of nitrogen on wheat as influenced by date of sowing. *Annals Agril. Res.*, **24**: 104-110.

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. [Wheat, Barley and Triticale Abst. 2007].

Mohsen, L., Farnia, A. and Shaban, M. (2013). Effect of different sowing dates on yield components of wheat (*Triticum aestivum* L.) cultivars in Lorestan provience, Iran. *Adv. Agri. Biol.*, **1**(4): 89-93.

Moula, M.G. (1999). Effect of date of planning and irrigation on the growth and yield of barley. M. Sc. (Ag). Thesis, Dept. Agron. Bangladesh Agril. Univ, Mymensingh.

Ortiz-Monasterio, J.I., Dhillon, S.S. and Fischer, R.A. (1994). Date of sowing effects on grain yield and yield components of irrigated spring wheat cultivars and relationships with radiation and temperature in Ludhiana, India. *Field Crops Res.*, **37**: 169–184.

Qamar, M., Shafiullah and Makeen, S. (2004). Genetic variability among wheat cultivars and effect of planting date on grain and straw yield under double cropping zone of Northern areas of Pakistan. *Sarhad J. Agri.*, **20**: 99-102.

Qasim, M., Qamer, M., Faridullah and Alam, M. (2008). Sowing dates effect on yield and yield components of different wheat varieties. *J. Agric. Res.*, **46**(2): 135-140.

Radmehr, M., Ayeneh, G.A. and Mamghani, R., (2003). Responses of late, medium and early maturity bread wheat genotypes to different sowing date.

I. Effect of sowing date on phonological, morphological, and grain yield of four breed wheat genotypes. *Iran. J. Seed. Sapling*, **21**(2): 175–189

Razzaque, A., Das, N. and Roy, S. (1992). Wheat is the most important cereal crop that contributes to the national economy. *Indian J. Agron.* **26**(1): 35-39.

Refay, Y.A. (2011). Yield and yield component parameters of bread wheat genotypes as affected by sowing dates. *Middle-East J. Sci. Res.*, **7**(4): 484-489.

Rita Costa, Pinheiro, N., Almeida, A.S., Gomes, C., Coutinho, J., Coco, J.O., Costa, A. and Macas, B. (2013). Effect of sowing date and seeding rate on bread wheat yield and test weight under Mediterranean conditions. *Emir. J. Food Agric.*, **25**(12): 951-961.

Ryu, Y.H., Lee, C.G. and Ha, 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.

Said, A., Gul, H., Saeed, B., Haleema, B., Badshah, N.L. and Parveen, L. (2012). Response of wheat to different planting dates and seeding rates for yield and yield components. *ARPN J. Agril. Biol. Sci.*, **7**(2): 138-140.

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.

Samuel, S.R., Deshmukh, P.S., Sairam, R.K. and Krshwaha, S.R. (2000). Influence of benzyl adenine application on yield and yield components in wheat genotypes under normal and late planning condition. *Indian J. Agril. Sci.*, **23**(1): 81-86.

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

Sekhon, N.G., Singh, K.K., Dhir, I.S. and Chark, K.S. (1991). Effect of sowing time and growth regulators on wheat productivity. New trends in plant physiology. Proceeding, national symposium on growth and differentiation in plants. 193-199.

Sharma, D.L., D'Antuono, M., Amjad, M., Shackley, B.J., Zaicou-Kunesch, C.M. and Anderson, W.K. (2006). Differences among wheat cultivars in their optimum sowing times in Western Australian environments. Proceedings of 13th Agronomy Conference 10-14 September 2006, Perth, Western Australia.

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

Shrivastava, R.B., Singh, V.P. and Singh, D. (1998). Component characters of grain yield and harvest index in wheat. *Indian J. Agric. Res.*, **2**(2): 65-74.

Shukla, R., Singh, G. and Bhalla, Y. (1992). Differential response of wheat genotype to moisture stress for good germination and early seedling growth. *Indian J. Agril. Res.*, **28**(2): 99-104.

Sial, M.A., Arain, M.A., Mazhar, S.K., Naqvi, M.H., Dahot, U. and Nizamani, N.A. (2005). Yield and quality parameters of wheat genotypes as affected by sowing dates and high temperature stress. *Pakistan J. Bot.*, **37**(3): 575-584.

Singh, S. and Pal, M. (2003). Growth, yield and phonological response of wheat cultivars to delayed sowing. *Indian J. Phys.*, **8**: 277-286.

Singh, T. and Dhaliwal, G.S. (2000). Performance of wheat varieties under late sowing conditions in southwestern region of Punjab. *J. Res., Agril. Univ.*, **37**: 181-183.

Subhan, F., Khan, M. and Jamro, G.H. (2004). Effect of different planting date, seeding rate and weed control method on grain yield and yields components in wheat. *Sarhad J. Agri.*, **20**: 51-55.

Suleiman, A.A., Nganya, J.F. and Ashraf, M.A. (2014). Effect of cultivar and sowing date on growth and yield of wheat (*Triticum aestivum* L.) in Khartoum, Sudan. *J. Forest Prod. Indust.*, **3**(4): 198-203.

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

Timsina, J., Godwin, D., Humphreys, E., Singh, Y., Singh, B., Kukal, S.S. and Smith, D. (2008). Evaluation of options for increasing yield and water productivity of wheat in Punjab, India using The DSSAT–CSM-CERES-wheat model. *Agric. Water Manage.*, **95**: 1099–1110.

Turner, N.C. (2004). Agronomic options for improving rainfall use efficiency of crops in dryland farming systems. *J. Expt. Bot*. **55**: 2413-2425.

Wajid, A. Abid Hussain, Maqsood, M., Ahmad A. and Awais, M. (2002). influence of sowing date and irrigation levels on growth and grain yield of wheat. *Pakistan J. Agri. Sci.*, **39**: 22-24.

Wajid, A., Hussain, A., Ahmad, A., Goheer, A.R., Ibrahim, M. and Mussaddique, M. (2004). Effect of sowing date and plant population on biomass, grain yield and yield components of wheat. *Intl. J. Agril. Bio.*, **6**: 1003-1005.

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

WRC (Wheat Research Center). (2009). Annual Report, 2008–09. Wheat Research Center, Nashipur, Dinajpur, Bangladesh, p. 181.

Yajam, S. and Madani, H. (2013). Delay sowing date and its effect on Iranian winter wheat cultivars yield and yield components. *Annals of Biol. Res.*, **4**(6): 270-275.

Zende, N.B., Sethi, H.N., Karunakar, A.P. and Jiotode, D.J. (2005). Effect of sowing time and fertility levels on growth and yield of durum wheat genotypes. *Res. Crops*. **6**(2): 190-191.

Zhao, I.Q., Lu, M. and Li, G. (1985). Influence of sowing dates on the growth and development of barley cv. *Zhepi. Zhejiang Agril. Sci.*, **5**: 217-221.

Zia-Ul-Hassan, M., Wahla, A.J., Waqar, M.Q. and Anjum Ali, A. (2014). Influence of sowing date on the growth and grain yield performance of wheat varieties under rainfed condition. *Sci. Tech. & Dev.*, **33**(1): 22-25.

APPENDICES

Appendix I. Monthly record of air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from November 2013 to March 2014

Month	*Air temperature (°C)		*Relative humidity (%)	*Total rainfall (mm)
	Maximum	Minimum		
November, 2013	25.8	16.0	78	00
December, 2013	22.4	13.5	74	00
January, 2014	25.2	12.8	69	00
February, 2014	27.3	16.9	66	39
March, 2014	31.7	19.2	57	23

* 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	6.2
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 plant height as influenced by different wheat varieties and sowing dates

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAS	45 DAS	60 DAS	75 DAS	Harvest
Replication	2	0.131	0.066	5.141	1.517	4.142
Varieties (A)	3	10.527*	39.523**	69.568**	70.411**	94.459**
Error	6	1.902	3.223	9.495	5.338	8.450
Sowing date (B)	3	20.072*	71.573**	70.431**	190.709**	372.660*
Interaction (A×B)	9	13.318*	9.243*	33.423*	20.289*	48.988
Error	24	5.487	3.756	13.562	8.531	21.986

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

Appendix IV. Analysis of variance of the data on number of tillers plant^{-1} as influenced by different wheat varieties and sowing dates

Source of variation	Degrees of freedom	Mean square			
		Number of tillers plant^{-1}			
		30 DAS	45 DAS	60 DAS	75 DAS
Replication	2	0.004	0.003	0.010	0.076
Varieties (A)	3	0.241**	0.389**	0.479**	0.780**
Error	6	0.009	0.007	0.023	0.159
Sowing date (B)	3	0.624**	0.132**	1.234**	3.385**
Interaction (A×B)	9	0.022*	0.008*	0.036*	0.299*
Error	24	0.010	0.004	0.021	0.120

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

Appendix V. Analysis of variance of the data on dry matter content plant^{-1} as influenced by different wheat varieties and sowing dates

Source of variation	Degrees of freedom	Mean square			
		Dry matter content plant^{-1} (g) at			
		30 DAS	45 DAS	60 DAS	75 DAS
Replication	2	0.0001	0.005	0.008	0.003
Varieties (A)	3	0.036**	0.450**	0.790**	0.480**
Error	6	0.003	0.011	0.036	0.029
Sowing date (B)	3	0.049**	0.237**	0.703**	2.049**
Interaction (A×B)	9	0.013**	0.086**	0.221**	0.882**
Error	24	0.004	0.029	0.052	0.210

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

Appendix VI. Analysis of variance of the data on days to spike initiation, days to maturity, number of spikes plant^{-1} and number of spikelets spike^{-1} as influenced by different wheat varieties and sowing dates

Source of variation	Degrees of freedom	Mean square			
		Days to spike initiation	Days to maturity	Number of spikes plant^{-1}	Number of spikelets spike^{-1}
Replication	2	0.063	7.646	0.004	0.355
Varieties (A)	3	40.389*	67.410**	0.672**	6.298**
Error	6	6.201	7.868	0.060	0.455
Sowing date (B)	3	60.167**	39.188**	2.248**	6.795**
Interaction (A×B)	9	26.926*	11.354*	0.414*	2.657*
Error	24	10.778	5.313	0.092	0.829

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

Appendix VII. Analysis of variance of the data on ear length, filled, unfilled and total grains spike^{-1} as influenced by different wheat varieties and sowing dates

Source of variation	Degrees of freedom	Mean square			
		Ear length (cm)	Filled grains spike^{-1}	Unfilled grains spike^{-1}	Total grains spike^{-1}
Replication	2	0.021	0.406	0.004	0.482
Varieties (A)	3	8.541**	14.432**	0.533**	9.981*
Error	6	0.670	1.323	0.020	1.438
Sowing date (B)	3	21.761**	55.305**	3.195**	32.426**
Interaction (A×B)	9	2.148*	1.918*	0.081*	4.204*
Error	24	0.769	1.698	0.036	1.974

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

Appendix VIII. Analysis of variance of the data on weight of 1000-grains yield and harvest index as influenced by different wheat varieties and sowing dates

Source of variation	Degrees of freedom	Mean square				
		Weight of 1000-grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	4.386	0.017	0.011	0.001	2.286
Varieties (A)	3	27.997*	0.525**	0.762**	2.532**	0.865
Error	6	5.520	0.019	0.029	0.079	0.414
Sowing date (B)	3	13.303**	1.031**	4.914**	10.396**	17.965**
Interaction (A×B)	9	10.136**	0.055**	0.188*	0.371*	3.024*
Error	24	2.749	0.020	0.072	0.129	1.553

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