EFFECT OF SOWING DATES ON REPRODUCTIVE BEHAVIOR OF WHEAT

MD. MOSARRAF HOSSIN

DEPARTMENT OF AGRICULTURAL BOTANY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA 1207

JUNE, 2014

EFFECT OF SOWING DATES ON REPRODUCTIVE BEHAVIOR OF WHEAT

BY

MD. MOSARRAF HOSSIN

REG. NO. : 06-01932

A Thesis
Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
AGRICULTURAL BOTANY

SEMESTER: JANUARY-JUNE, 2014

APPROVED BY:

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

Prof. Dr. Md. Moinul Haque
Department of Agricultural Botany
SAU, Dhaka
Co-Supervisor

Dr. Md. Ashabul Hoque
Associate Professor
Chairman
Examination Committee

DEDICATED

TO

MY BELOVED PARENTS

DEPARTMENT OF AGRICULTURAL BOTANY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

Memo No: SAU/

CERTIFICATE

This is to certify that the thesis entitled **'Effect of Sowing Dates on Reproductive Behavior of Wheat'** submitted to the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Agricultural Botany,** embodies the results of a piece of bonafide research work carried out by **Md. Mosarraf Hossin,** Registration No. **06-01932** 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 been duly acknowledged.

Date:
Dhaka, Bangladesh

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

Supervisor

ACKNOWLEDGEMENTS

All praises to Almightly and Kindfull trust on to "Omnipotent Creator" for Almighty's never-ending blessing, the author deems it a great pleasure to express his profound thankfulness to his respected parents, who entiled much hardship inspiring for prosecuting his studies, receiving proper education.

The author likes to express his deepest sense of gratitude to his respected supervisor Dr. Kamal Uddin Ahamed, Professor, Department of Agricultural Botany, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his scholastic guidance, support, encouragement and valuable suggestions and constructive criticism throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript writing.

The author also expresses his gratefulness to his respected Co-Supervisor, Dr. Md. Moinul Hoque, Professor, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and in preparation of the thesis.

The author expresses his sincere gratitude towards the sincerity of the Chairman, Dr. Md. Ashabul Hoque, Associate professor, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for his valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of the Department of Agricultural Botany, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.

The author expresses his sincere appreciation to his brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

The Author

EFFECT OF SOWING DATES ON REPRODUCTIVE BEHAVIOR OF WHEAT

ABSTRACT

The study was conducted at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2012 to March 2013 in rabi season to find out the effect of sowing dates on reproductive behavior of wheat. The experiment comprised of two factor; Factor A: Sowing date (4 times) - S_1: Sowing at 17 November, 2012; S_2: Sowing at 30 November, 2012; S_3: Sowing at 15 December, 2012 and S_4: Sowing at 30 December, 2012 and Factor B: Wheat varieties (6 wheat varieties) - V_1: BARI Gom 21; V_2: BARI Gom 23; V_3: BARI Gom 24; V_4: BARI Gom 25; V_5: BARI Gom 26 and V_6: BARI Gom 27. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different yield contributing characters and yield were recorded and significant variation was computed due to the effect of sowing dates, wheat varieties and their interaction effect. For different sowing dates, at 25, 35, 45, 55, 65 DAS and at harvest, the longest plants (30.43, 48.49, 69.37, 79.77, 85.60 and 95.15 cm, respectively) were observed from S_2, while the shortest plants (27.51, 43.62, 63.50, 74.36, 81.06 and 88.51 cm, respectively) from S_4. The maximum number of effective tillers plant^{-1} (4.89) was observed from S_2, whereas the minimum number (4.34) from S_4. The maximum number of filled grain spike^{-1} (45.16) was recorded from S_2, while the minimum number (39.11) from S_4. The highest grain yield ha^{-1} (3.93 ton) was observed from S_2, while the lowest (3.09 ton) was found from S_4. In case of wheat varieties, at 25, 35, 45, 55, 65 DAS and at harvest, the longest plants (30.46, 48.68, 68.71, 79.49, 86.78 and 96.03 cm, respectively) were found from V_3, again the shortest plants (27.76, 43.14, 63.97, 74.43, 80.69 and 88.51 cm, respectively) from V_2. The maximum number of effective tillers plant^{-1} (4.89) was recorded from V_3, while the minimum number (4.37) from V_2. The maximum number of filled grain spike^{-1} (45.51) was obtained from V_3, whereas the minimum number (38.39) from V_2. The highest grain yield ha^{-1} (3.70 ton) was recorded from V_3, again the lowest (3.30 ton) from V_2. Due to the interaction effect of sowing dates and wheat varieties, the longest plants were observed from S_3V_3 and the shortest plants from S_4V_4. The maximum number of effective tillers plant^{-1} (5.60) was recorded from S_2V_3, whereas the minimum number (3.90) from S_4V_4. The maximum number of filled grain spike^{-1} (51.50) was attained from S_3V_3 and the minimum number (30.57) from S_4V_4. The highest grain yield ha^{-1} (4.14 ton) was recorded from S_2V_3, whereas the lowest (2.83 ton) from S_4V_4. From the above results, it can be concluded that 30 November sowing provided best yield for most of the varieties and the varieties BARI Gom 24 and BARI Gom 26 provided better yield than the other varieties.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important food crop and primarily grown across the exceptionally diverse range of environments (WRC, 2009). 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). 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). 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). At present about 706.33 thousand hectares of land in Bangladesh is covered by wheat with the annual production of 1,592 thousand tons (BBS, 2011).

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; 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; 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 find out the effect of sowing dates on growth, development and yield of wheat genotypes;

ii. To observe the growth and yield performance of different wheat genotypes and

iii. To investigate the interaction effect of sowing dates and different wheat genotypes with a picture of reproductive characters of the 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, sowing time and subsequently variety 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 sowing time and variety of wheat done at home and abroad have been reviewed under the following headings:

2.1 Influence of sowing date on growth and yield of wheat

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 (18^{th} November) and late sowing (11^{th} 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 (18^{th} November) and late sowing (11^{th} 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 25^{th} November was studied on yield and yield components of wheat. Average of two years data showed that 5^{th} 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 (1^{st} November, 15^{th} November, 1^{st} December and 15^{th} 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 1^{st} to 15^{th} November followed by biological yield (6824 kg ha^{-1}) and grain yield (2336 kg ha^{-1}) were produced from late sowing (15^{th} 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 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. Reduction in grain yield is mainly attributed by the reduced number of spike plant^{-1}, grains spike^{-1} and thousand grain weight due to restriction of period for development of these parameters.

2.2 Effect of wheat 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}.

Litvinrnko *et al*. (1997) produced winter wheat with high grain quality for bread making in Southern Ukraine. Wheat breeding was started more than 80 years ago.

Over this time, seven wheat varieties were selected where yield potential increased from 2.73 to 6.74 t ha^{-1}.

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 at the Lithuanian Institute of Agriculture's Joniskelis Experimental Station 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 from Portuguese under irrigated Mediterranean systems at two locations of Southeast Portugal. 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) 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 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.

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 sowing dates on reproductive behavior of wheat and related growth performances. 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 2012 to March 2013 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 5.6 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details have been presented in Appendix II.

3.2 Experimental details

3.2.1 Treatment of the experiment

The experiment comprised of two factors

Factors A: Sowing date (4 times)

i) S_1: Sowing at 17 November, 2012

ii) S_2: Sowing at 30 November, 2012

iii) S_3: Sowing at 15 December, 2012

iv) S_4: Sowing at 30 December, 2012

Factor B: Wheat variety (6 wheat variety)

i) V_1: BARI Gom 21

ii) V_2: BARI Gom 23

iii) V_3: BARI Gom 24

iv) V_4: BARI Gom 25

v) V_5: BARI Gom 26

vi) V_6: BARI Gom 27

There were in total 24 (4×6) treatment combinations such as S_1V_1, S_1V_2, S_1V_3, S_1V_4, S_1V_5, S_1V_6, S_2V_1, S_2V_2, S_2V_3, S_2V_4, S_2V_5, S_2V_6, S_3V_1, S_3V_2, S_3V_2, S_3V_3, S_3V_4, S_3V_5, S_3V_6, S_4V_1, S_4V_2, S_4V_3, S_4V_4, S_4V_5 and S_4V_6.

3.2.2 Experimental design and layout

The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experiment area was divided into three equal blocks. Each block contained 24 plots where 24 treatments combination were allotted at random. There were 72 unit plot altogether in the experiment. The size of each plot was 2.0 m × 1.5 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 Seed collection

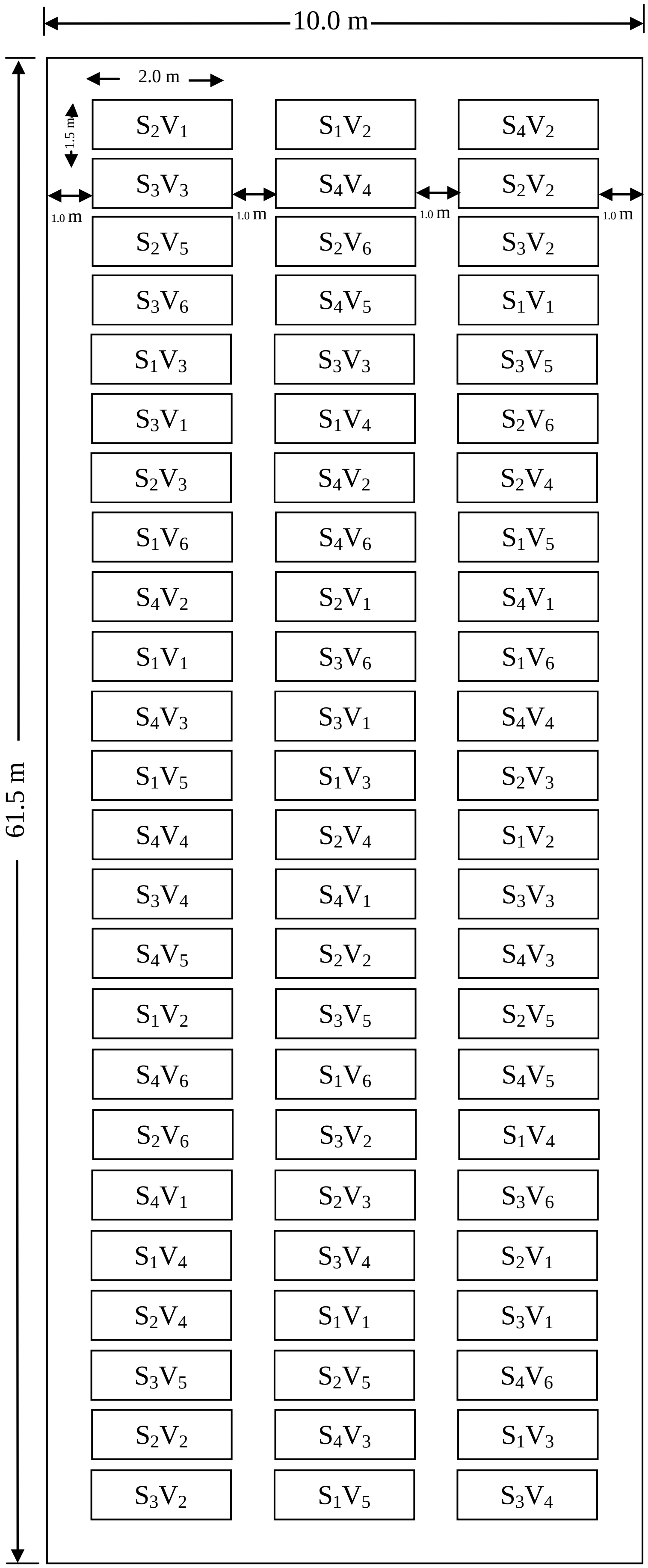
The seeds of different wheat varieties were collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur**.** 'BARI Gom 21' ('Shatabdi') in 2000; 'BARI Gom 23' ('Bijoy') and 'BARI Gom 24' ('Prodip') in 2005; 'BARI Gom 25' and 'BARI Gom 26' released in 2010 and 'BARI Gom 27' were released in 2012 (BARI, 2012).

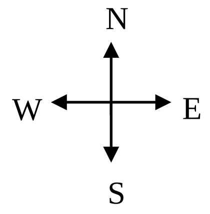
3.3.2 Preparation of the main field

The piece of land selected for the experiment was opened in the 1st week of November 2012 with a power tiller, and was exposed to the sun for a week after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally a desirable tilth of soil was obtained for sowing of seeds. Fertilizers and manures as indicated below in 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 17 November, 30 November, 15 December and 30 December, 2012 as per the sowing dates treatment of the experiment. Seeds were sown continuouly 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.





Plot size: 2.0 m × 1.5 m

Plot spacing: 0.50 m

Between block: 1.00 m

Factors A: Sowing date (4 times)

S_1: Sowing at 17 November, 2012

S_2: Sowing at 30 November, 2012

S_3: Sowing at 15 December, 2012

S_4: Sowing at 30 December, 2012

Factor B: Wheat genotypes (6 wheat genotypes)

V_1: BARI Gom 21

V_2: BARI Gom 23

V_3: BARI Gom 24

V_4: BARI Gom 25

V_5: BARI Gom 26

V_6: BARI Gom 27

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 12 January 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, 2012. 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 Emergence of seedlings

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

3.5.2 Plant height

The height of plant was recorded in centimeter (cm) at 25, 35, 45, 55 and 65 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.

3.5.3 Tillers $plant^{-1}$

The number of tillers $plant^{-1}$ was recorded at the time of 25, 35, 45, 55 and 65 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.

3.5.4 Days to staring of booting

Days to starting of booting was recorded by calculating the number of days from sowing to starting of booting by keen observation of the experimental plots.

3.5.5 Days to starting of ear emergence

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

3.5.6 Days to starting of anthesis

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

3.5.7 Days to starting of maturity

Days to starting of 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.

3.5.8 Leaves plant^{-1}

The total number of leaves plant^{-1} was counted as the number of leaves from 10 randomly selected plants from each plot and average value was recorded.

3.5.9 Length of flag leaf

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

3.5.10 Breadth of flag leaf

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

3.5.11 Leaf area of flag leaf

The area per flag leaf was determined by multiplying the maximum flag leaf length with maximum breadth and express in cm^2. The area was multiplied by 0.75 to have the actual area of the flag leaves.

3.5.12 Effective tillers plant^{-1}

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

3.5.13 Non-effective tillers plant^{-1}

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

3.5.14 Total tillers plant^{-1}

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

3.5.15 Ear length

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

3.5.16 Spikelets spike^{-1}

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

3.5.17 Fertile florets spikelets^{-1}

The number of fertile floret spikelet^{-1} was counted from 10 randomly selected spikelets from each plot and average value was recorded.

3.5.18 Dry matter content

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 70^0C for 72 hours. Then oven-dried samples were transferred into a desiccator and allowed to cool down to room temperature, thereafter dry weight of stem was taken and expressed in gram.

As per the above procedure dry matter content of ear, seeds, husk and roots per plant was recorded after harvest of wheat crop.

3.5.19 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.

3.5.20 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.

3.5.21 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.

3.5.22 1000 seeds weight

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

3.5.23 Grain yield m^{-2}

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

3.5.24 Grain yield ha^{-1}

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

3.5.25 Straw yield m^{-2}

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

3.5.26 Straw yield ha^{-1}

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

3.5.27 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.

3.5.28 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 sowing dates and wheat genotypes 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 sowing dates on growth, reproductive behavior and yield of wheat. Data on different reproductive behaviors, yield contributing characters and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters have been presented in Appendix III-XII. The results have been presented with the help of table and graphs and possible interpretations have been given under the following headings:

4.1 Days to starting of seedling emergence

Statistically significant variation was found in terms of days to starting of seedling emergence due to different sowing dates under the present trial (Table 2). The maximum days (5.94) to starting of seedling emergence was recorded from S_4 (sowing on 30 December) which was statistically identical (5.83) to S_3 (sowing on 15 December), whereas the minimum days (4.78) was found from S_1 (sowing on 17 November which was statistically identical (5.06) to S_2 (sowing on 30 November). Management factor, soil moisture content and weather condition influence days to starting of seedling emergence and all of these factors are governed by time of seed sowing. The same time sowing of wheat at the first available opportunity may not always be the best for emergence; rather cultivars need to be matched to sowing time according to their time of flowering and maturity (Wajid *et al.*, 2002; Kumar and Sharma, 2003).

Different wheat varieties showed statistically non-significant difference on days to starting of seedling emergence (Table 2). The maximum days (5.50) to starting of seedling emergence was observed from V_5 (BARI Gom 26), again the minimum days (5.33) was recorded from V_1 (BARI Gom 21) and V_6 (BARI Gom 27). Seedling emergence itself is a genetical character and climatic conditions greatly influence the emergence performance of wheat cultivars (Wajid *et al.*, 2004; Sharma *et al.*, 2006; Abdullah *et al.*, 2007).

Table 2. Effect of different sowing dates and varieties on days to seedling emergence of wheat

Treatment	Days to seedling emergence		
	Starting of emergence	50% emergence	100% emergence
Sowing dates			
S_1	4.78 b	7.67 c	10.67 c
S_2	5.06 b	7.89 bc	10.94 bc
S_3	5.83 a	8.11 b	11.28 ab
S_4	5.94 a	8.71 a	11.44 a
LSD (0.05)	0.279	0.347	0.453
Significance level	0.01	0.01	0.01
Wheat varieties			
V_1	5.33	7.92	11.08 ab
V_2	5.42	8.17	11.50 a
V_3	5.42	8.08	10.67 b
V_4	5.42	7.92	10.75 b
V_5	5.50	8.25	11.07 ab
V_6	5.33	8.23	11.42 a
LSD (0.05)	--	--	0.554
Significance level	NS	NS	0.05
CV(%)	7.71	6.39	6.08

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Sowing dates and wheat varieties showed significant differences on days to starting of seedling emergence due to interaction effect (Table 3). The maximum days to starting of seedling emergence (6.33) was found from S_4V_5 (sowing on 30 December and BARI Gom 26), while the minimum days (4.33) was recorded from S_1V_1 (sowing on 17 November and BARI Gom 21).

4.2 Days to 50% seedling emergence

Days to 50% seedling emergence showed statistically significant variation due to different sowing dates (Table 2). Data revealed that the maximum days to 50% seedling emergence (8.11) was observed in case of S_4 (sowing on 30 December) which was closely followed (8.11) by S_3 (sowing on 15 December), while the minimum days (7.67) from S_1 (sowing on 17 November) which was statistically identical (7.89) to S_2 (sowing on 30 November).

Statistically non-significant variation was recorded for different wheat varieties for days to 50% seedling emergence (Table 2). The maximum days to 50% seedling emergence (8.25) was recorded from V_5 (BARI Gom 26), whereas the minimum days (7.92) from V_1 (BARI Gom 21) and V_4 (BARI Gom 25).

Interaction effect of sowing dates and wheat varieties showed significant differences on days to 50% seedling emergence (Table 3). The maximum days to 50% seedling emergence (9.00) was recorded from S_4V_3 (sowing on 30 December and BARI Gom 24) and the minimum days (6.67) from the treatment combination S_1V_4 (sowing on 17 November and BARI Gom 25).

4.3 Days to 100% seedling emergence

Different sowing dates varied significantly for days to 100% seedling emergence (Table 2). The maximum days to 100% seedling emergence (11.44) was found from S_4 (sowing on 30 December) which was statistically identical (11.28) to S_3 sowing on 15 December). On the other hand, the minimum days (10.67) was observed in case of S_1 (sowing on 17 November) which was statistically identical (10.94) to S_2 (sowing on 30 November).

Table 3. Interaction effect of different sowing dates and varieties on days to seedling emergence of wheat

Treatment	Days to seedling emergence		
	Starting of emergence	50% emergence	100% emergence
S_1V_1	4.33 c	7.67 bc	10.33 cd
S_1V_2	5.00 bc	8.33 a-c	10.67 b-d
S_1V_3	4.67 c	7.67 bc	10.33 cd
S_1V_4	4.67 c	6.67 d	10.00 d
S_1V_5	4.67 c	8.00 a-c	10.67 b-d
S_1V_6	5.00 bc	7.67 bc	12.00 ab
S_2V_1	5.00 bc	8.00 a-c	11.00 b-d
S_2V_2	5.00 bc	7.67 bc	11.00 b-d
S_2V_3	5.00 bc	8.00 a-c	10.67 b-d
S_2V_4	5.00 bc	7.67 bc	11.33 a-d
S_2V_5	5.33 a-c	8.00 a-c	11.33 a-d
S_2V_6	5.00 bc	8.00 a-c	10.33 cd
S_3V_1	5.67 ab	7.33 cd	11.33 a-d
S_3V_2	5.67 ab	8.33 a-c	12.33 a
S_3V_3	6.00 a	7.67 bc	11.00 b-d
S_3V_4	6.00 a	8.33 a-c	10.67 b-d
S_3V_5	6.00 a	8.67 ab	11.00 b-d
S_3V_6	5.67 ab	8.33 a-c	11.33 a-d
S_4V_1	6.00 a	8.67 ab	11.67 a-c
S_4V_2	6.00 a	8.33 a-c	12.00 ab
S_4V_3	6.00 a	9.00 a	10.67 b-d
S_4V_4	6.00 a	8.67 ab	11.00 b-d
S_4V_5	6.33 a	8.33 a-c	11.33 a-d
S_4V_6	5.67 ab	8.90 a	12.00 ab
LSD (0.05)	0.684	0.849	1.109
Significance level	0.05	0.05	0.05
CV(%)	7.71	6.39	6.08

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

S_1: Sowing on 17 November, 2012 V_1: BARI Gom 21 V_2: BARI Gom 23

S_2: Sowing on 30 November, 2012 V_3: BARI Gom 24 V_4: BARI Gom 25

S_3: Sowing on 15 December, 2012 V_5: BARI Gom 26 V_6: BARI Gom 27

S_4: Sowing on 30 December, 2012

Days to 100% seedling emergence varied significantly for different wheat varieties under the present trial (Table 2). The maximum days to 100% seedling emergence (11.50) was obtained from V_2 (BARI Gom 23) which was statistically identical (11.42, 11.08 and 11.07) to V_6 (BARI Gom 27), V_1 (BARI Gom 21) and V_5 (BARI Gom 26), whereas the minimum days (10.67) was found from V_3 (BARI Gom 24) which was statistically similar (10.75) to V_4 (BARI Gom 25).

Statistically significant variation was recorded due to the interaction effect of sowing dates and wheat varieties in terms of days to 100% seedling emergence (Table 3). The maximum days (12.33) was recorded from the treatment combination S_3V_2 (sowing on 15 December and BARI Gom 23), whereas the minimum days to 100% seedling emergence (10.00) was observed from S_1V_5 (sowing on 17 November and BARI Gom 26).

4.4 Plant height

Plant height showed statistically significant differences due to different sowing dates under the present trial at 25, 35, 45, 55, 65 DAS and harvest (Figure 2). Data revealed that at 25, 35, 45, 55, 65 DAS and at harvest, the longest plant (30.43, 48.49, 69.37, 79.77, 85.60 and 95.15 cm, respectively) was observed from S_2 (sowing on 30 November), while the shortest plant (27.51, 43.62, 63.50, 74.36, 81.06 and 88.51 cm, respectively) was found from S_4 (sowing on 30 December). Seeds sowing at November 19 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.

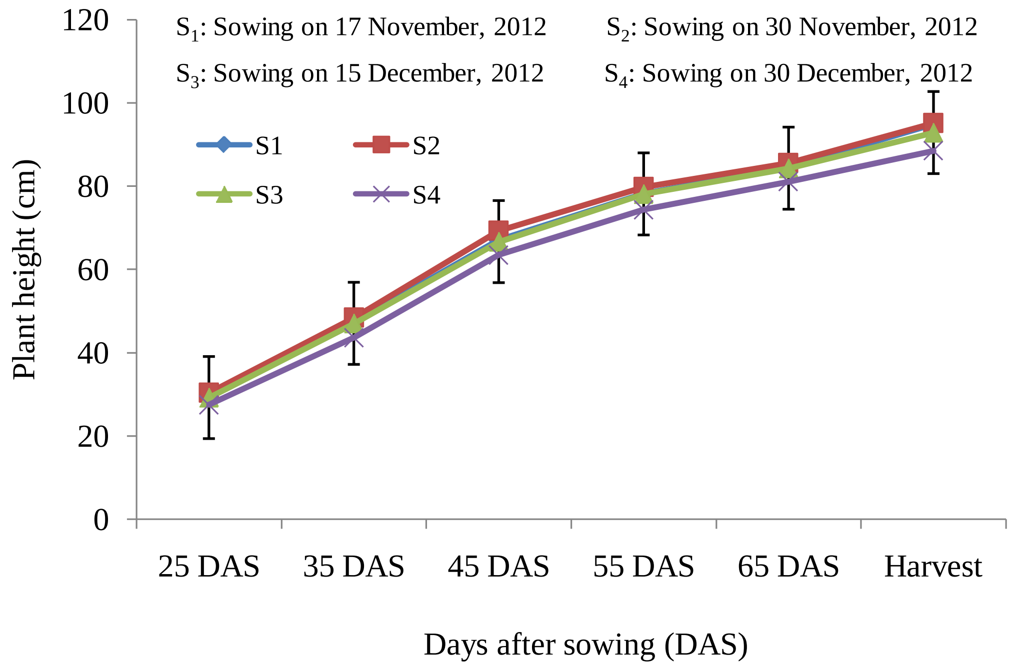


Figure 2. Effect of different sowing dates on plant height of wheat. Vertical bars represent LSD value.

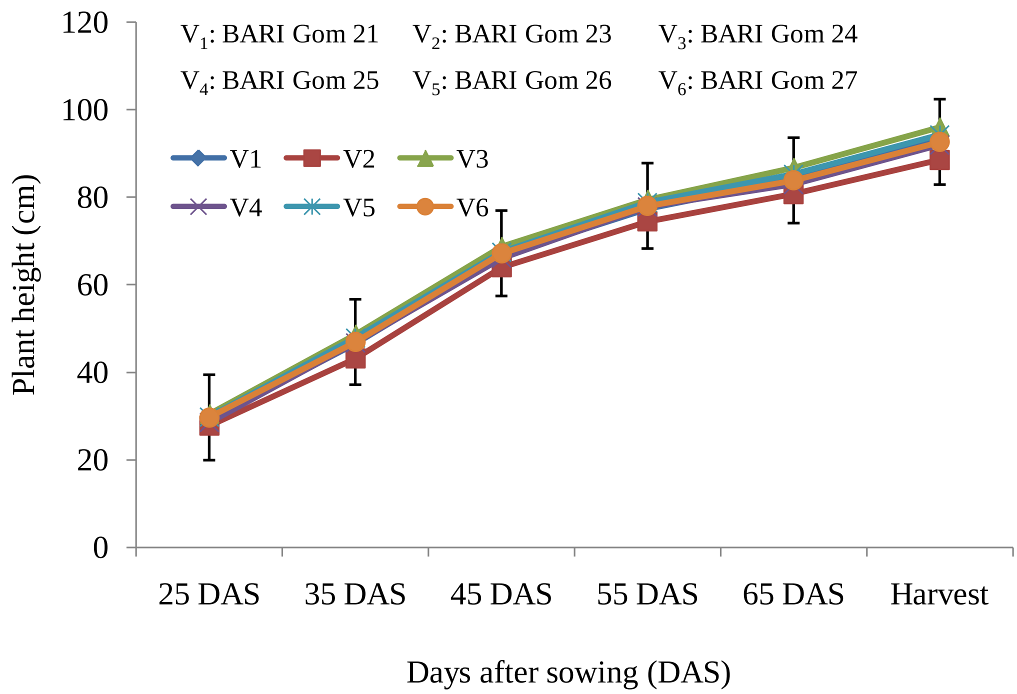


Figure 3. Effect of different wheat varieties on plant height. Vertical bars represent LSD value.

Different wheat varieties showed statistically significant difference on plant height at 25, 35, 45, 55, 65 DAS and harvest (Figure 3). At 25, 35, 45, 55, 65 DAS and harvest, the longest plant (30.46, 48.68, 68.71, 79.49, 86.78 and 96.03 cm, respectively) was found from V_3 (BARI Gom 24), again the shortest plant (27.76, 43.14, 63.97, 74.43, 80.69 and 88.51 cm, respectively) was recorded from V_2 (BARI Gom 23). 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 ghom-26 produced the taller plant (47.91 cm).

Interaction effect of sowing dates and wheat varieties showed significant differences on plant height at 25, 35, 45, 55, 65 DAS and harvest (Table 4). At 25, 35, 45, 55, 65 DAS and harvest, the longest plant (32.46, 52.94, 71.29, 83.24, 91.51 and 99.52 cm, respectively) was observed from S_3V_3 (sowing on 15 December and BARI Gom 24) and the shortest plant (24.62, 38.72, 61.04, 70.22, 75.90 and 83.06 cm, respectively) was obtained from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.5 Number of tillers plant^{-1}

Different sowing dates varied significantly in terms of number of tillers plant^{-1} at 25, 35, 45, 55 and 65 DAS (Table 5). At 25, 35, 45, 55 and 65 DAS, the maximum number of tillers plant^{-1} (3.24, 3.92, 4.20, 4.56 and 4.67, respectively) was observed from S_2 (sowing on 30 November), again the minimum number (2.87, 3.44, 3.98, 4.27 and 4.44, respectively) was found from S_4 (sowing on 30 December) at 25, 35, 45, 55 and 65 DAS. Seeds sowing at November 19 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 data further indicated that the 25th October sowing produced minimum tillers (232 m^{-2}) due to high temperature, not suitable for growth of wheat plant.

Table 4. Interaction effect of different sowing dates and varieties on plant height at different days after sowing and harvest of wheat

Treatment	Plant height (cm) at					
	25 DAS	35 DAS	45 DAS	55 DAS	65 DAS	Harvest
S_1V_1	27.65 b-e	45.19 b-f	65.05 d-j	75.16 d-j	82.09 b-e	92.39 a-e
S_1V_2	28.56 a-e	43.72 c-g	64.02 g-j	74.99 e-j	80.72 b-e	91.34 a-f
S_1V_3	30.44 a-c	49.41 a-c	68.97 a-e	80.41 a-e	87.45 a-c	98.01 ab
S_1V_4	28.22 b-e	45.08 b-f	65.72 c-i	76.48 b-i	81.16 b-e	90.91 a-f
S_1V_5	31.23 ab	49.94 ab	69.16 a-d	80.91 a-c	87.79 a-c	98.07 ab
S_1V_6	31.57 ab	50.69 ab	69.57 a-d	81.42 ab	88.54 ab	98.27 ab
S_2V_1	31.25 ab	49.29 a-c	70.00 a-c	80.35 a-e	86.33 a-c	96.16 a-c
S_2V_2	28.79 a-d	48.20 a-d	68.64 a-f	79.87 a-e	86.39 a-c	94.67 a-c
S_2V_3	30.97 ab	49.65 a-c	70.39 ab	80.65 a-d	87.03 a-c	96.51 a-c
S_2V_4	31.59 ab	50.11 ab	70.48 ab	81.14 ab	87.42 a-c	97.12 ab
S_2V_5	30.39 a-c	48.09 a-d	69.08 a-e	79.25 a-f	84.33 a-d	95.77 a-c
S_2V_6	29.60 a-d	45.61 b-f	67.66 a-g	77.34 b-i	82.09 b-e	90.67 a-f
S_3V_1	27.65 b-e	43.80 c-g	64.98 d-j	75.40 c-j	82.00 b-e	93.13 a-e
S_3V_2	25.81 de	40.88 fg	60.60 j	71.92 ij	76.98 de	84.41 ef
S_3V_3	32.46 a	52.94 a	71.29 a	83.24 a	91.51 a	99.52 a
S_3V_4	29.52 a-d	50.70 ab	67.29 a-h	81.67 ab	86.11 a-c	95.21 a-c
S_3V_5	30.78 ab	49.61 a-c	68.64 a-f	80.44 a-e	86.94 a-c	95.10 a-c
S_3V_6	29.35 a-d	46.69 b-f	66.96 a-h	77.92 a-h	83.53 a-e	91.28 a-f
S_4V_1	29.89 a-d	47.89 a-e	66.61 b-i	78.20 a-g	85.71 a-c	93.38 a-d
S_4V_2	27.88 b-e	41.92 e-g	62.17 ij	72.63 h-j	79.75 c-e	84.96 d-f
S_4V_3	27.96 b-e	42.73 d-g	64.18 f-j	73.68 g-j	81.13 b-e	90.07 b-f
S_4V_4	24.62 e	38.72 g	61.04 j	70.22 j	75.90 e	83.06 f
S_4V_5	26.60 c-e	43.65 c-g	62.95 h-j	74.36 f-j	81.69 b-e	88.00 c-f
S_4V_6	28.12 b-e	44.63 b-f	64.50 e-j	75.34 d-j	81.12 b-e	90.25 b-f
LSD (0.05)	3.412	5.105	3.882	4.642	6.834	7.394
Significance level	0.05	0.01	0.01	0.01	0.05	0.05
CV(%)	7.11	6.66	4.54	5.64	4.96	5.85

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Table 5. Effect of different sowing dates and varieties on number of tillers plant^{-1} at different days after sowing of wheat

Treatment	Number of tillers plant^{-1} at				
	25 DAS	35 DAS	45 DAS	55 DAS	65 DAS
Sowing dates					
S_1	2.99 b	3.66 b	4.20 b	4.56 ab	4.67 ab
S_2	3.24 a	3.92 a	4.48 a	4.74 a	4.82 a
S_3	2.97 bc	3.58 bc	4.14 bc	4.48 b	4.56 bc
S_4	2.87 c	3.44 c	3.98 c	4.27 c	4.44 c
LSD (0.05)	0.104	0.173	0.204	0.189	0.181
Significance level	0.01	0.01	0.01	0.01	0.01
Wheat varieties					
V_1	2.99 b	3.61 bc	4.17 b	4.57 a	4.68 a
V_2	2.81 c	3.42 c	3.87 c	4.24 b	4.37 b
V_3	3.19 a	4.00 a	4.58 a	4.66 a	4.74 a
V_4	3.02 b	3.59 bc	4.14 b	4.46 ab	4.55 ab
V_5	3.09 ab	3.70 b	4.31 b	4.66 a	4.78 a
V_6	3.02 b	3.58 bc	4.13 b	4.50 a	4.62 a
LSD (0.05)	0.127	0.213	0.249	0.231	0.222
Significance level	0.01	0.01	0.01	0.01	0.01
CV(%)	5.17	7.10	7.21	6.22	5.85

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Statistically significant variation was recorded for different wheat varieties in terms of number of tillers plant^{-1} at 25, 35, 45, 55 and 65 DAS (Table 5). At 25, 35, 45, 55 and 65 DAS, the maximum number of tillers plant^{-1} (3.19, 4.00, 4.58, 4.66 and 4.74, respectively) was found from V_3 (BARI Gom 24), while the minimum number (2.81, 3.42, 3.87, 4.24 and 4.37, respectively) was obtained from V_2 (BARI Gom 23). Although management practices influenced the number of tillers at different days after sowing but genotypes itself contributed to the number of tillers plant^{-1}.

Number of tillers plant^{-1} showed significant differences due to interaction effect of sowing dates and wheat varieties at 25, 35, 45, 55 and 65 DAS (Table 6). At 25, 35, 45, 55 and 65 DAS, the maximum number of tillers plant^{-1} (3.40, 4.27, 4.83, 4.93 and 4.97, respectively) was recorded from S_2V_4 (sowing on 30 November and BARI Gom 25), whereas the minimum number (2.60, 3.23, 3.63, 3.97 and 4.13, respectively) was obtained from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.6 Days to starting of booting

Statistically significant variation was recorded in terms of days to starting of booting due to different sowing dates (Table 7). The maximum days to starting of booting (47.11) was found from S_1 (sowing on 17 November) which was statistically identical (45.89) to S_2 (sowing on 30 November). On the other hand, the minimum days (44.17) was recorded from S_4 (sowing on 30 December) which was closely followed (45.56) by S_3 (sowing on 15 December).

Different wheat varieties showed statistically non-significant difference on days to starting of booting (Table 7). The maximum days to starting of booting (46.92) was found from V_2 (BARI Gom 23) which was statistically similar (46.58, 45.92 and 45.67) to V_1 (BARI Gom 21), V_6 (BARI Gom 27) and V_5 (BARI Gom 26), again the minimum days (44.15) was recorded from V_4 (BARI Gom 25) which was statistically similar (44.83) to V_3 (BARI Gom 24).

Table 6. Interaction effect of different sowing dates and varieties on number of tillers plant^{-1} at different days after sowing of wheat

Treatment	Number of tillers plant^{-1} at				
	25 DAS	35 DAS	45 DAS	55 DAS	65 DAS
S_1V_1	2.87 c-f	3.43 e-h	3.90 e-h	4.50 a-g	4.60 a-d
S_1V_2	2.80 d-f	3.37 f-h	3.77 gh	4.13 e-g	4.33 b-d
S_1V_3	3.13 a-c	4.00 a-d	4.60 a-c	4.67 a-e	4.77 ab
S_1V_4	2.97 c-e	3.57 c-h	4.00 d-h	4.40 a-g	4.50 a-d
S_1V_5	3.07 b-d	3.77 b-g	4.43 a-e	4.80 a-c	4.90 a
S_1V_6	3.13 a-c	3.83 a-f	4.50 a-d	4.87 a	4.93 a
S_2V_1	3.30 ab	4.00 a-d	4.57 a-d	4.87 a	4.90 a
S_2V_2	3.13 a-c	3.80 a-g	4.43 a-e	4.70 a-d	4.77 ab
S_2V_3	3.33 ab	4.07 a-c	4.80 ab	4.83 ab	4.93 a
S_2V_4	3.40 a	4.27 a	4.83 a	4.93 a	4.97 a
S_2V_5	3.27 ab	3.93 a-e	4.50 a-d	4.83 ab	4.93 a
S_2V_6	3.07 b-d	3.43 e-h	3.87 e-h	4.27 c-g	4.37 b-d
S_3V_1	2.73 ef	3.30 gh	3.83 f-h	4.20 d-g	4.30 b-d
S_3V_2	2.73 ef	3.30 gh	3.53 h	4.03 fg	4.17 cd
S_3V_3	3.33 ab	4.13 ab	4.70 ab	4.87 a	4.90 a
S_3V_4	3.03 b-d	3.50 d-h	4.23 b-g	4.53 a-f	4.57 a-d
S_3V_5	3.10 b-d	3.70 b-h	4.30 a-g	4.70 a-d	4.80 ab
S_3V_6	2.97 c-f	3.57 c-h	4.10 c-h	4.57 a-f	4.67 a-c
S_4V_1	3.07 b-d	3.70 b-h	4.37 a-f	4.70 a-d	4.90 a
S_4V_2	2.70 ef	3.30 gh	3.73 gh	4.10 fg	4.23 cd
S_4V_3	2.90 c-f	3.60 c-h	4.10 c-h	4.27 c-g	4.33 b-d
S_4V_4	2.60 f	3.23 h	3.63 h	3.97 g	4.13 d
S_4V_5	2.93 c-e	3.40 f-h	4.00 d-h	4.30 b-g	4.50 a-d
S_4V_6	2.90 c-e	3.47 e-h	4.03 c-h	4.30 b-g	4.50 a-d
LSD (0.05)	0.255	0.425	0.499	0.462	0.444
Significance level	0.01	0.05	0.01	0.01	0.01
CV(%)	5.17	7.10	7.21	6.22	5.85

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

S_1: Sowing on 17 November, 2012 V_1: BARI Gom 21 V_2: BARI Gom 23
S_2: Sowing on 30 November, 2012 V_3: BARI Gom 24 V_4: BARI Gom 25
S_3: Sowing on 15 December, 2012 V_5: BARI Gom 26 V_6: BARI Gom 27
S_4: Sowing on 30 December, 2012

Table 7. Effect of different sowing dates and varieties on days required for starting of booting, ear emergence, anthesis and maturity of wheat

Treatment	Days required for			
	Starting of booting	Starting of ear emergence	Starting of anthesis	Starting of maturity
Sowing dates				
S_1	47.11 a	59.17 a	77.94 a	89.22 a
S_2	45.89 ab	58.67 a	75.33 a	89.94 a
S_3	45.56 b	55.78 b	72.00 b	84.72 b
S_4	44.17 c	55.00 b	69.28 b	84.94 b
LSD (0.05)	1.243	1.646	2.724	3.067
Significance level	0.01	0.01	0.01	0.01
Wheat varieties				
V_1	46.58 a	57.58 ab	73.08 ab	88.33 ab
V_2	46.92 a	56.58 bc	72.75 ab	85.50 bc
V_3	44.83 bc	55.17 c	71.00 b	83.25 c
V_4	44.17c	59.17 a	75.67 a	90.75 a
V_5	45.67 a-c	57.75 ab	75.83 a	88.42 ab
V_6	45.92 ab	56.67 bc	73.50 ab	87.00 a-c
LSD (0.05)	1.522	2.016	3.336	3.756
Significance level	0.01	0.01	0.05	0.01
CV(%)	4.06	6.29	5.51	5.24

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Sowing dates and wheat varieties showed significant differences on days to starting of booting due to interaction effect (Table 8). The maximum days to starting of booting (49.00) was found from S_2V_2 (sowing on 30 November and BARI Gom 23), while the minimum days (42.67) was observed from the treatment combination S_3V_4 (sowing on 15 December and BARI Gom 25).

4.7 Days to starting of ear emergence

Days to starting of ear emergence showed statistically significant differences due to different sowing dates (Table 7). Data revealed that the maximum days to starting of ear emergence (59.17) was recorded from S_1 (sowing on 17 November) which was statistically identical (58.67) to S_2 (sowing on 30 November), while the minimum days (55.00) was found from S_4 (sowing on 30 December) which was statistically identical (55.78) to S_3 (sowing on 15 December).

Different wheat varieties showed statistically non-significant difference on days to starting of ear emergence under the present trial (Table 7). The maximum days to starting of ear emergence (59.17) was recorded from V_4 (BARI Gom 25) which was statistically similar (57.75 and 57.58) to V_5 (BARI Gom 26) and V_1 (BARI Gom 21). On the other hand, the minimum days (55.17) was found from V_3 (BARI Gom 24) which was statistically identical (56.67 and 56.58) to V_6 (BARI Gom 27) and V_2 (BARI Gom 23). Although management practices influenced the days to starting of ear emergence but genotypes itself contributed the days to starting of ear emergence.

Interaction effect of sowing dates and wheat varieties showed statistically significant differences on days to starting of ear emergence (Table 8). The maximum days to starting of ear emergence (62.00) was recorded from S_1V_6 (sowing on 17 November and BARI Gom 27) and the minimum days (50.00) was found from the treatment combination S_3V_3 (sowing on 15 December and BARI Gom 24).

Table 8. Interaction effect of different sowing dates and varieties on days required for starting of booting, ear emergence, anthesis and maturity of wheat

Treatment	Days required for			
	Starting of booting	Starting of ear emergence	Starting of anthesis	Starting of maturity
S_1V_1	48.00 a-d	56.67 b-h	71.67 d-h	85.67 a-f
S_1V_2	46.00 a-g	57.33 a-h	78.33 b-d	86.67 a-f
S_1V_3	47.67 a-e	57.00 b-h	72.67 c-g	84.67 b-f
S_1V_4	45.67 a-g	60.67 a-c	74.67 c-f	91.67 a-e
S_1V_5	46.67 a-f	61.33 ab	83.33 ab	92.67 a-d
S_1V_6	48.67 ab	62.00 a	87.00 a	94.00 a
S_2V_1	48.00 a-d	60.33 a-d	76.67 b-e	93.33 ab
S_2V_2	49.00 a	58.00 a-g	73.00 c-g	86.67 a-f
S_2V_3	43.67 fg	60.00 a-e	75.33 c-f	93.00 a-c
S_2V_4	44.67 d-g	60.67 a-c	80.33 a-c	94.33 a
S_2V_5	45.67 a-g	57.67 a-g	78.00 b-d	89.00 a-f
S_2V_6	44.33 e-g	55.33 e-h	68.67 e-h	83.33 ef
S_3V_1	46.33 a-g	57.67 a-g	73.67 c-f	88.33 a-f
S_3V_2	48.33 a-c	54.00 g-i	68.00 f-h	81.33 f
S_3V_3	44.33 e-g	50.00 i	65.67 gh	84.00 c-f
S_3V_4	42.67 g	59.33 a-f	76.33 b-e	91.33 a-e
S_3V_5	45.00 c-g	57.00 b-h	74.33 c-f	88.33 a-f
S_3V_6	46.67 a-f	56.67 b-h	74.00 c-f	87.67 a-f
S_4V_1	44.00 fg	55.67 d-h	70.33 d-h	86.00 a-f
S_4V_2	44.33 e-g	57.00 b-h	71.67 d-h	87.33 a-f
S_4V_3	43.67 fg	53.67 g-i	70.33 d-h	71.33 g
S_4V_4	43.67 fg	56.00 c-h	71.33 d-h	85.67 a-f
S_4V_5	45.33 b-g	55.00 f-h	67.67 f-h	83.67 d-f
S_4V_6	44.00 fg	52.67 hi	64.33 h	83.00 ef
LSD (0.05)	3.045	4.032	6.673	7.512
Significance level	0.05	0.01	0.01	0.01
CV(%)	4.06	6.29	5.51	5.24

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

4.8 Days to starting of anthesis

Statistically significant variation was recorded in terms of days to starting of anthesis due to different sowing dates under the present trial (Table 7). The maximum days to starting of anthesis (77.94) was found from S_1 (sowing on 17 November) which was statistically identical (75.33) to S_2 (sowing on 30 November), whereas the minimum days (69.28) was observed from S_4 (sowing on 30 December) which was statistically similar (72.00) to S_3 (sowing on 15 December).

Days to starting of anthesis showed statistically significant difference due to different wheat varieties (Table 7). The maximum days to starting of anthesis (75.83) was found from V_5 (BARI Gom 26) which was statistically similar (75.67) to V_4 (BARI Gom 25), again the minimum days (71.00) was recorded from V_3 (BARI Gom 24). Although management practices influence the days to starting of anthesis but genotypes itself influenced days to starting of anthesis of wheat.

Sowing dates and wheat varieties varied significantly in terms of days to starting of anthesis due to interaction effect (Table 8). The maximum days to starting of anthesis (87.00) was obtained from S_1V_6 (sowing on 17 November and BARI Gom 27), while the minimum days (64.33) from the treatment combination S_4V_6 (sowing on 30 December and BARI Gom 27).

4.9 Days to starting of maturity

Different sowing dates showed statistically significant differences in terms of days to starting of maturity under the present trial (Table 7). The maximum days to starting of maturity (89.94) was attained from S_2 (sowing on 30 November) which was statistically similar (89.22) to S_1 (sowing on 17 November). On the other hand, the minimum days (84.72) was observed from S_3 (sowing on 15 December) which was statistically similar (84.94) to S_4 (sowing on 30 December).

Different wheat varieties showed statistically significant difference on days to starting of maturity (Table 7). The maximum days to starting of maturity (90.75) was obtained from V_4 (BARI Gom 25) which was statistically similar (88.42 and 88.33) to V_5 (BARI Gom 26) and V_1 (BARI Gom 21), whereas the minimum days (83.25) was recorded from V_3 (BARI Gom 24) which was statistically identical (85.50) to V_2 (BARI Gom 23).

Statistically significant variation was recorded due to the interaction effect of sowing dates and wheat varieties in terms of days to starting of maturity (Table 8). The maximum days to starting of maturity (94.33) was observed from S_2V_4 (sowing on 30 November and BARI Gom 25), again the minimum days (71.33) was recorded from the treatment combination of S_4V_3 (sowing on 30 December and BARI Gom 24).

4.10 Leaves plant^{-1}

Statistically significant difference was observed in terms of number of leaves plant^{-1} due to different sowing dates under the present trial (Figure 4). Data revealed that the maximum number of leaves plant^{-1} (5.84) was observed from S_2 (sowing on 30 November) which was statistically identical (5.77 and 5.64) to S_1 (sowing on 17 November) and S_3 (sowing on 15 December), while the minimum number (5.41) was recorded from S_4 (sowing on 30 December). Zia-Ul-Hassan *et al.* (2014) earlier reported that sowing dates remained significant in terms of number of leaves per plant of modern cultivated wheat and early sowing produced maximum number of leaves per plant.

Number of leaves plant^{-1} showed statistically significant difference due to different wheat varieties (Figure 5). The maximum number of leaves plant^{-1} (5.97) was recorded from V_3 (BARI Gom 24) which was statistically similar (5.73) to V_5 (BARI Gom 26). On the other hand, the minimum number (5.48) was found from V_2 (BARI Gom 23) which was statistically similar (5.57, 5.60 and 5.65) to V_6 (BARI Gom 27), V_4 (BARI Gom 25) and V_1 (BARI Gom 21).

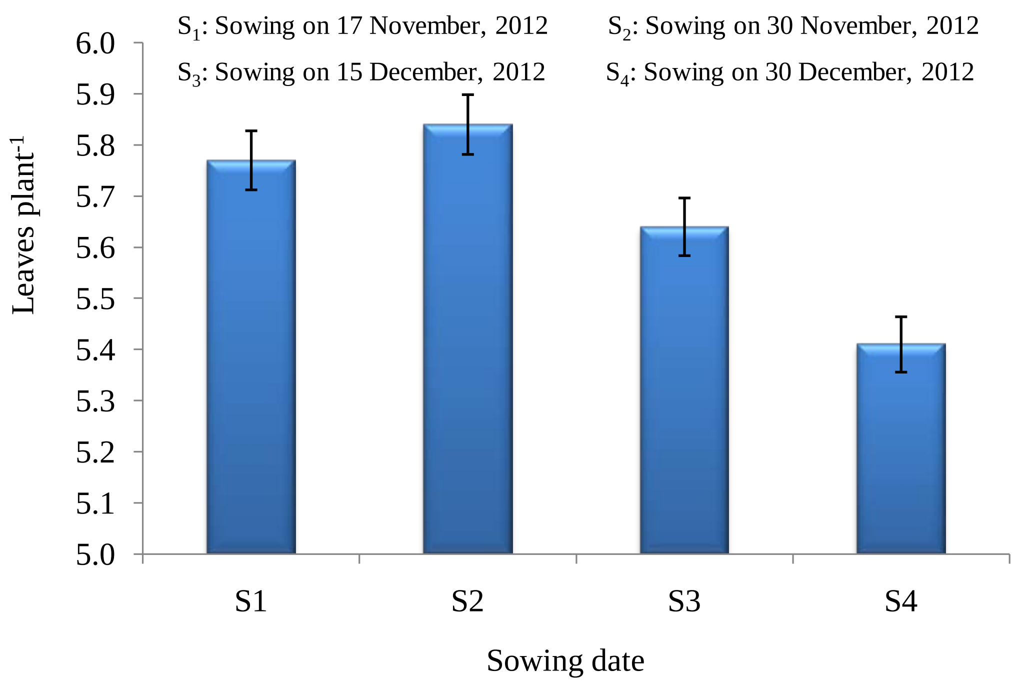


Figure 4. Effect of sowing dates on number of leaves plant^{-1}. Vertical bars represent LSD value.

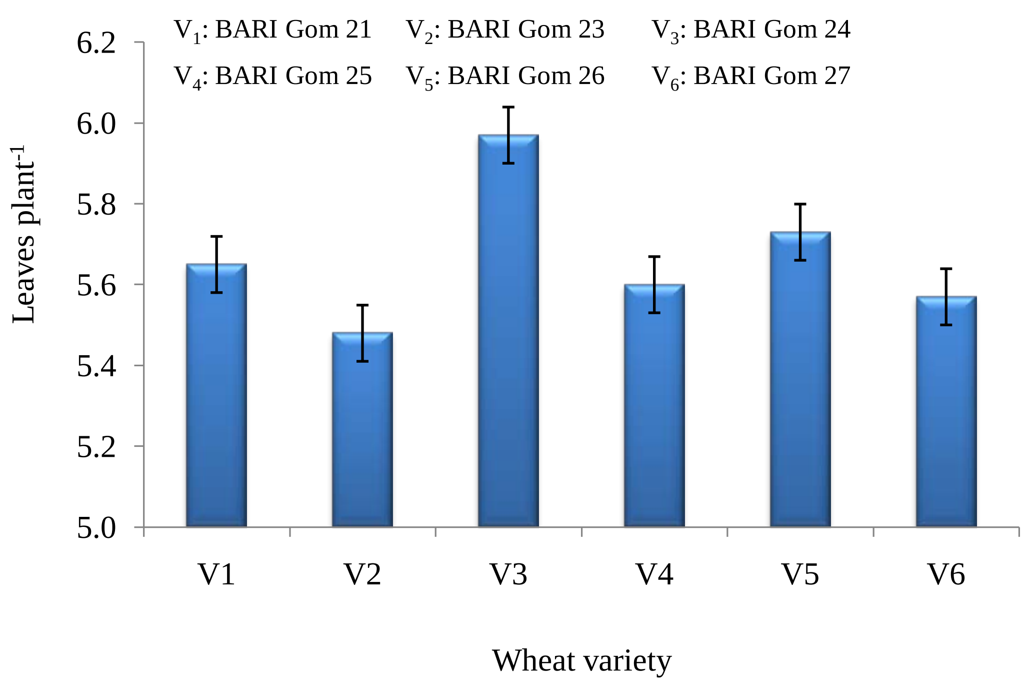


Figure 5. Effect of different wheat varieties on number of leaves plant^{-1}. Vertical bars represent LSD value.

Interaction effect of sowing dates and wheat varieties showed significant differences on number of leaves plant^{-1} (Figure 6). The maximum number of leaves plant^{-1} (6.27) was observed from S_2V_3 (sowing on 30 November and BARI Gom 24), while the minimum number (5.00) was recorded from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.11 Length of flag leaf

Length of flag leaf varied significantly in terms of different sowing dates under the present trial (Table 9). The highest length of flag leaf (21.02 cm) was obtained from S_2 (sowing on 30 November) which was statistically similar (20.18 cm and 19.69 cm) to S_3 (sowing on 15 December) and S_1 (sowing on 17 November), whereas the lowest length of flag leaf (18.66 cm) was observed from S_4 (sowing on 30 December).

Different wheat varieties showed statistically significant difference on length of flag leaf (Table 9). The highest length of flag leaf (22.52 cm) was found from V_3 (BARI Gom 24) which was closely followed (20.18 cm) by V_4 (BARI Gom 25), again the lowest length (18.19 cm) was observed from V_2 (BARI Gom 23).

Sowing dates and wheat varieties showed significant differences on length of flag leaf due to interaction effect (Table 10). The highest length of flag leaf (26.71 cm) was found from S_2V_3 (sowing on 30 November and BARI Gom 24) and the lowest length of flag leaf (15.91 cm) was recorded from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.12 Breadth of flag leaf

Statistically significant variation was recorded in terms of breadth of flag leaf due to different sowing dates (Table 9). The highest breadth of flag leaf (1.38 cm) was recorded from S_2 (sowing on 30 November) which was statistically identical (1.34 cm) to S_3 (sowing on 15 December), while the lowest breadth of flag leaf (1.17 cm) was obtained from S_4 (sowing on 30 December) which was closely followed (1.25 cm) by S_1 (sowing on 17 November).

Table 9. Effect of different sowing dates and varieties on length, breadth and area of flag leaf of wheat

Treatment	Length of flag leaf (cm)	Breadth of flag leaf (cm)	Area of flag leaf (cm^2)
Sowing dates			
S_1	19.69 ab	1.25 b	24.77 b
S_2	21.02 a	1.38 a	29.12 a
S_3	20.18 a	1.34 a	27.61 a
S_4	18.66 b	1.17 c	21.92 c
LSD (0.05)	1.416	0.070	2.798
Significance level	0.01	0.01	0.01
Wheat varieties			
V_1	19.96 bc	1.23 c	24.71 bcd
V_2	18.19 c	1.20 c	22.07 d
V_3	22.52 a	1.39 a	31.54 a
V_4	20.18 b	1.28 bc	26.26 bc
V_5	19.93 bc	1.36 ab	27.29 b
V_6	18.53 bc	1.25 c	23.26 cd
LSD (0.05)	1.734	0.086	3.426
Significance level	0.01	0.01	0.01
CV(%)	10.61	8.14	16.13

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Table 10. Interaction effect of different sowing dates and varieties on length, breadth and area of flag leaf of wheat

Treatment	Length of flag leaf (cm)	Breadth of flag leaf (cm)	Area of flag leaf (cm^2)
S_1V_1	18.94 c-f	1.08 gh	20.39 e
S_1V_2	17.72 d-f	1.05 h	18.51 e
S_1V_3	21.89 b-d	1.38 a-d	30.25 bc
S_1V_4	20.66 b-e	1.20 c-h	24.94 b-e
S_1V_5	20.06 b-f	1.46 ab	29.21 b-d
S_1V_6	18.85 c-f	1.35 a-e	25.34 b-e
S_2V_1	21.10 b-e	1.39 a-c	29.36 b-d
S_2V_2	21.41 b-d	1.46 ab	31.39 b
S_2V_3	26.71 a	1.50 a	39.99 a
S_2V_4	19.89 b-f	1.45 ab	28.90 b-d
S_2V_5	21.24 b-e	1.42 ab	30.18 b-d
S_2V_6	19.07 c-f	1.15 e-h	21.99 de
S_3V_1	19.16 c-f	1.19 d-h	22.83 c-e
S_3V_2	18.06 c-f	1.14 f-h	18.44 e
S_3V_3	23.39 ab	1.39 a-d	32.88 b
S_3V_4	22.10 bc	1.47 ab	32.74 b
S_3V_5	20.15 b-e	1.43 ab	28.98 b-d
S_3V_6	17.05 ef	1.33 a-f	22.91 c-e
S_4V_1	20.65 b-e	1.27 b-g	26.27 b-e
S_4V_2	17.73 d-f	1.14 f-h	20.18 e
S_4V_3	18.10 c-f	1.28 b-g	23.05 c-e
S_4V_4	15.91 f	1.02 h	18.19 e
S_4V_5	18.26 c-f	1.14 f-h	20.80 e
S_4V_6	19.16 c-f	1.19 c-h	22.79 c-e
LSD (0.05)	3.469	0.172	6.853
Significance level	0.01	0.01	0.01
CV(%)	10.61	8.14	16.13

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

S_1: Sowing on 17 November, 2012

S_2: Sowing on 30 November, 2012

S_3: Sowing on 15 December, 2012

S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23

V_3: BARI Gom 24 V_4: BARI Gom 25

V_5: BARI Gom 26 V_6: BARI Gom 27

Breadth of flag leaf showed statistically significant difference due to different wheat varieties (Table 9). The highest breadth of flag leaf (1.39 cm) was found from V_3 (BARI Gom 24) which was statistically similar (1.36 cm) to V_5 (BARI Gom 26), while the lowest breadth of flag leaf (1.20 cm) was observed from V_2 (BARI Gom 23) which was statistically similar (1.23 cm and 1.25 cm) to V_1 (BARI Gom 21) and V_6 (BARI Gom 27).

Interaction effect of sowing dates and wheat varieties showed significant differences in terms of breadth of flag leaf (Table 10). The highest breadth of flag leaf (1.50 cm) was found from S_2V_3 (sowing on 30 November and BARI Gom 24), whereas the lowest breadth of flag leaf (1.02 cm) was recorded from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.13 Area of flag leaf

Area of flag leaf showed statistically significant variation of due to different sowing dates (Table 9). The highest area of flag leaf (29.12 cm^2) was recorded from S_2 (sowing on 30 November) which was statistically identical (27.61 cm^2) to S_3 (sowing on 15 December) and closely followed (24.77 cm^2) by S_1 (sowing on 17 November), again the lowest area of flag leaf (21.92 cm^2) was observed from S_4 (sowing on 30 December).

Significant variation was recorded due to different wheat varieties for area of flag leaf (Table 9). The highest area of flag leaf (31.54 cm^2) was found from V_3 (BARI Gom 24) which was closely followed (27.29 cm^2 and 26.26 cm^2) by V_5 (BARI Gom 26) and V_4 (BARI Gom 25), while the lowest area (22.07 cm^2) from V_2 (BARI Gom 23) which was closely followed (23.26 cm^2) by V_6 (BARI Gom 27).

Sowing dates and wheat varieties showed significant differences on area of flag leaf due to interaction effect (Table 10). The highest area of flag leaf (39.99 cm^2) was found from S_2V_3 (sowing on 30 November and BARI Gom 24) and the lowest area of flag leaf (18.19 cm^2) was recorded from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.14 Effective tillers plant^{-1}

Different sowing dates showed statistically significant differences in terms of effective tillers plant^{-1} due to (Table 11). The maximum number of effective tillers plant^{-1} (4.89) was observed from S_2 (sowing on 30 November) which was statistically identical (4.71 and 4.64) to S_3 (sowing on 15 December) and S_1 (sowing on 17 November), whereas the minimum number (4.34) was found from S_4 (sowing on 30 December). Chowdhury (2002) reported that the highest number of effective tillers plant^{-1} were produced by November 15 sown and the second highest by November, 30 sown plants which was similarly with November, 01 sown plants. Suleiman *et al*. (2014) reported that effective tillers plant^{-1} decreased with delay in sowing date and the highest values were obtained when cultivars sown on 1st November and 15th November.

Effective tillers plant^{-1} showed statistically significant difference due to different wheat varieties under the present trial (Table 11). Data revealed that the maximum number of effective tillers plant^{-1} (4.89) was recorded from V_3 (BARI Gom 24) which was statistically similar (4.87 and 4.77) to V_4 (BARI Gom 25) and V_5 (BARI Gom 26), while the minimum number (4.37) from V_2 (BARI Gom 23).

Interaction effect of sowing dates and wheat varieties showed significant differences on effective tillers plant^{-1} due to (Table 12). The maximum number of effective tillers plant^{-1} (5.60) was recorded from S_2V_3 (sowing on 30 November and BARI Gom 24), whereas the minimum number (3.90) from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.15 Non-effective tillers plant^{-1}

Different sowing dates showed statistically significant variation in terms of non-effective tillers hill^{-1} (Table 11). The maximum number of non-effective tillers plant^{-1} (0.89) was recorded from S_1 (sowing on 17 November) which was closely followed (0.76 and 0.74) by S_4 (sowing on 30 December) and S_3 (sowing on 15 December) and they were statistically similar, whereas the minimum number (0.66) was found from S_2 (sowing on 30 November).

Table 11. Effect of different sowing dates and varieties on number of effective, non-effective and total tillers plant^{-1} of wheat

Treatment	Number of tillers plant^{-1}		
	Effective	Non-effective	Total
Sowing dates			
S_1	4.64 a	0.89 a	5.54 a
S_2	4.89 a	0.66 c	5.55 a
S_3	4.71 a	0.74 b	5.46 a
S_4	4.34 b	0.76 b	5.10 b
LSD (0.05)	0.251	0.052	0.245
Significance level	0.01	0.01	0.01
Wheat varieties			
V_1	4.45 bc	0.79 a	5.24 bc
V_2	4.37 c	0.80 a	5.17 c
V_3	4.89 a	0.70 b	5.59 a
V_4	4.87 a	0.76 ab	5.63 a
V_5	4.77 ab	0.74 ab	5.51 ab
V_6	4.53 bc	0.79 a	5.33 a-c
LSD (0.05)	0.308	0.064	0.300
Significance level	0.01	0.05	0.01
CV(%)	8.05	10.44	6.74

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Table 12. Interaction effect of different sowing dates and varieties on number of effective, non-effective and total tillers plant^{-1} of wheat

Treatment	Number of tillers plant^{-1}		
	Effective	Non-effective	Total
S_1V_1	4.33 e-g	0.97 a	5.30 b-f
S_1V_2	4.47 d-g	0.83 a-d	5.30 b-f
S_1V_3	4.60 c-g	0.87 a-c	5.47 a-f
S_1V_4	5.03 a-e	0.87 a-c	5.90 a-c
S_1V_5	4.77 b-f	0.90 ab	5.67 a-d
S_1V_6	5.23 a-c	0.87 a-c	6.10 a
S_2V_1	4.90 a-f	0.67 e-h	5.57 a-e
S_2V_2	5.17 a-d	0.63 f-h	5.80 a-c
S_2V_3	5.60 a	0.53 h	6.13 a
S_2V_4	4.80 b-f	0.67 e-h	5.47 a-f
S_2V_5	5.37 ab	0.63 f-h	6.00 ab
S_2V_6	4.20 fg	0.77 b-f	4.97 d-f
S_3V_1	4.37 e-g	0.87 a-c	5.23 c-f
S_3V_2	4.20 fg	0.87 a-c	5.07 d-f
S_3V_3	4.90 a-f	0.60 gh	5.50 a-f
S_3V_4	5.17 a-d	0.67 e-h	5.83 a-c
S_3V_5	4.77 b-f	0.70 d-g	5.47 a-f
S_3V_6	4.17 fg	0.84 a-d	5.00 d-f
S_4V_1	4.20 fg	0.67 e-h	4.87 ef
S_4V_2	4.23 fg	0.80 b-e	5.03 d-f
S_4V_3	4.47 a-g	0.80 b-e	5.27 c-f
S_4V_4	3.90 g	0.90 ab	4.80 f
S_4V_5	4.17 fg	0.73 c-g	4.90 ef
S_4V_6	4.53 c-g	0.70 d-g	5.23 c-f
LSD (0.05)	0.615	0.127	0.599
Significance level	0.01	0.01	0.01
CV(%)	8.05	10.44	6.74

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Non-effective tillers plant^{-1} showed statistically significant due to different wheat varieties under the present trial (Table 11). The maximum number of non-effective tillers plant^{-1} (0.80) was recorded from V_2 (BARI Gom 23) which was statistically similar (0.79) to V_1 (BARI Gom 21) and V_6 (BARI Gom 27), while the minimum number (0.70) was found from V_3 (BARI Gom 24).

Statistically significant variation was recorded due to the interaction effect of sowing dates and wheat varieties in terms of non-effective tillers plant^{-1} (Table 12). Data revealed that the maximum number of non-effective tillers plant^{-1} (0.97) was recorded from S_1V_1 (sowing on 17 November and BARI Gom 21), again the minimum number (0.53) was observed from the treatment combination S_2V_3 (sowing on 30 November and BARI Gom 24).

4.16 Total tillers plant^{-1}

Statistically significant variation was recorded in terms of total tillers plant^{-1} due to different sowing dates under the present trial (Table 11). The maximum number of total tillers plant^{-1} (5.55) was found from S_2 (sowing on 30 November) which was statistically identical (5.54 and 5.46) to S_1 (sowing on 17 November) and S_3 (sowing on 15 December), whereas the minimum number (5.10) was observed from S_4 (sowing on 30 December). Suleiman *et al.* (2014) reported that sowing dates have significant effects on yield components of wheat which decreased with delay in sowing date and the highest values were obtained when cultivars sown on the 1st November and the 15th November.

Different wheat varieties showed statistically significant difference on total tillers plant^{-1} (Table 11). The maximum number of total tillers plant^{-1} (5.63) was observed from V_4 (BARI Gom 25) which was statistically similar (5.59, 5.51 and 5.33) to V_3 (BARI Gom 24), V_5 (BARI Gom 26) and V_6 (BARI Gom 27), again the minimum number (5.17) was recorded from V_2 (BARI Gom 23) which was statistically identical (5.24) to V_1 (BARI Gom 21).

Number of total tillers plant^{-1} varied significantly due to the effects of sowing dates and wheat varieties (Table 12). The maximum number of total tillers plant^{-1} (6.13) was observed from S_2V_3 (sowing on 30 November and BARI Gom 24), while the minimum number (4.80) was recorded from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.17 Ear length

Ear length showed statistically significant variation due to different sowing dates (Table 13). The longest ear (15.43 cm) was observed from S_2 (sowing on 30 November) which was statistically identical (14.90 cm and 14.85 cm) to S_3 (sowing on 15 December) and S_1 (sowing on 17 November), while the shortest ear (14.33 cm) was found from S_4 (sowing on 30 December). 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.

Different wheat varieties showed statistically significant variation in terms of ear length under the present trial (Table 13). The longest ear (16.49 cm) was recorded from V_3 (BARI Gom 24) which was closely followed (14.85 cm, 14.84 cm, 14.80 cm and 14.68 cm) by V_4 (BARI Gom 25), V_1 (BARI Gom 21), V_5 (BARI Gom 26) and V_6 (BARI Gom 27) and they were statistically similar, whereas the shortest ear (13.61 cm) was found from V_2 (BARI Gom 23). Although management practices influence the ear length of wheat but genotypes itself produced different length of ear.

Statistically significant variation was recorded due to the interaction effect of sowing dates and wheat varieties in terms of ear length (Table 14). The longest ear (17.22 cm) was observed from S_2V_3 (sowing on 30 November and BARI Gom 25), again the shortest ear (12.47 cm) was found from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

Table 13. Effect of different sowing dates and varieties on ear length, spikelets spike^{-1} and fertile floret spikelet^{-1} of wheat

Treatment	Ear length (cm)	Spikelets Spike^{-1}	Fertile floret Spikelet^{-1}
Sowing dates			
S_1	14.85 ab	19.57 b	2.58 b
S_2	15.43 a	22.81 a	2.93 a
S_3	14.90 ab	19.29 b	2.60 b
S_4	14.33 b	17.19 c	2.28 c
LSD (0.05)	0.588	0.822	0.149
Significance level	0.01	0.01	0.01
Wheat varieties			
V_1	14.84 b	19.66 b	2.48 bc
V_2	13.61 c	18.77 b	2.41 c
V_3	16.49 a	20.83 a	2.92 a
V_4	14.85 b	19.38 b	2.56 bc
V_5	14.80 b	19.84 ab	2.67 b
V_6	14.68 b	19.80 ab	2.56 bc
LSD (0.05)	0.720	1.006	0.182
Significance level	0.01	0.01	0.01
CV(%)	5.89	6.21	8.49

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Table 14. Interaction effect of different sowing dates and varieties on ear length, spikelets spike^{-1} and fertile floret spikelet^{-1} of wheat

Treatment	Ear length (cm)	Spikelets Spike^{-1}	Fertile floret Spikelet^{-1}
S_1V_1	14.61 b-f	18.27 h-k	2.37 g-j
S_1V_2	13.61 f-h	16.97 j-l	2.43 f-i
S_1V_3	16.19 ab	21.30 b-d	2.83 b-f
S_1V_4	14.62 b-f	18.83 e-j	2.57 c-h
S_1V_5	15.19 b-f	21.07 b-e	2.63 c-h
S_1V_6	14.91 b-f	20.97 b-f	2.63 c-h
S_2V_1	15.41 b-e	23.13 ab	2.90 b-e
S_2V_2	14.56 b-f	23.00 ab	2.93 b-d
S_2V_3	17.22 a	23.90 a	3.47 a
S_2V_4	15.52 b-d	23.80 a	2.97 bc
S_2V_5	15.46 b-f	22.37 a-c	2.97 bc
S_2V_6	14.38 c-g	20.63 c-g	2.60 c-h
S_3V_1	13.55 f-h	18.70 f-j	2.13 ij
S_3V_2	13.79 e-h	16.93 j-l	2.13 ij
S_3V_3	17.21 a	21.37 b-d	3.23 ab
S_3V_4	15.47 b-e	19.50 d-i	2.70 c-g
S_3V_5	15.74 a-c	19.67 d-h	2.80 c-f
S_3V_6	14.98 b-f	19.60 d-i	2.50 e-i
S_4V_1	15.79 a-c	18.53 g-k	2.53 d-i
S_4V_2	13.82 d-h	17.27 i-l	2.27 h-j
S_4V_3	15.33 b-e	17.67 h-l	2.13 ij
S_4V_4	12.47 h	15.40 l	2.00 j
S_4V_5	12.81 gh	16.27 kl	2.27 h-j
S_4V_6	14.44 c-g	18.00 h-k	2.50 e-i
LSD (0.05)	1.440	2.013	0.364
Significance level	0.01	0.01	0.01
CV(%)	5.89	6.21	8.49

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

S_1: Sowing on 17 November, 2012 — V_1: BARI Gom 21 — V_2: BARI Gom 23

S_2: Sowing on 30 November, 2012 — V_3: BARI Gom 24 — V_4: BARI Gom 25

S_3: Sowing on 15 December, 2012 — V_5: BARI Gom 26 — V_6: BARI Gom 27

S_4: Sowing on 30 December, 2012

4.18 Spikelets spike^{-1}

Statistically significant variation was recorded in terms of spikelets spike^{-1} due to different sowing dates under the present trial (Table 13). The maximum number of spikelets spike^{-1} (22.81) was recorded from S_2 (sowing on 30 November) which was closely followed (19.57 and 19.29) to S_1 (sowing on 17 November) and S_3 (sowing on 15 December) and they were statistically identical, while the minimum number of spikelets spike^{-1} (17.19) was obtained from S_4 (sowing on 30 December). 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.

Different wheat varieties showed statistically significant difference on spikelets spike^{-1} (Table 13). Data revealed that the maximum number of spikelets spike^{-1} (20.83) was found from V_3 (BARI Gom 24). On the other hand, the minimum number of spikelets spike^{-1} (18.77) was recorded from V_2 (BARI Gom 23) which was statistically similar (19.38 and 19.66) to V_4 (BARI Gom 25) and V_1 (BARI Gom 21) and they were statistically similar.

Sowing dates and wheat varieties showed significant differences in terms of spikelets spike^{-1} due to interaction effect (Table 14). The maximum number of spikelets spike^{-1} (23.90) was observed from S_2V_3 (sowing on 30 November and BARI Gom 24) and the minimum number of spikelets spike^{-1} (15.40) was recorded from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.19 Fertile florets spikelet^{-1}

Different sowing dates showed statistically significant differences in terms of fertile florets spikelets^{-1} (Table 13). Data revealed that the maximum number of fertile florets spikelets^{-1} (2.93) was obtained from S_2 (sowing on 30 November) which was closely followed (2.60 and 2.58) to S_3 (sowing on 15 December) and S_1 (sowing on 15 November) and they were statistically similar, whereas the minimum number of fertile florets spikelets^{-1} (2.28) was observed from S_4

(sowing on 30 December). Zia-Ul-Hassan *et al*. (2014) reported from earlier experiment that sowing dates remained significant on spikelets per spike and early sowing produced the best one.

Statistically significant variation was recorded due to different wheat varieties in terms of fertile florets spikelets^{-1} under the present trial (Table 13). The maximum number of fertile florets spikelets^{-1} (2.92) was attained from V_3 (BARI Gom 24), again the minimum number of fertile florets spikelets^{-1} (2.41) was found from V_2 (BARI Gom 23).

Interaction effect of sowing dates and wheat varieties showed significant differences on fertile florets spikelets^{-1} (Table 14). The maximum number of fertile florets spikelets^{-1} (3.47) was found from S_2V_3 (sowing on 30 November and BARI Gom 24), while the minimum number of fertile florets spikelets^{-1} (2.00) was observed from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.20 Dry matter content of stem plant^{-1}

Statistically significant variation was observed in terms of dry matter content of stem plant^{-1} due to different sowing dates under the present trial (Table 15). The highest dry matter content of stem plant^{-1} (15.35 g) was attained from S_2 (sowing on 30 November) which was statistically identical (15.23 g and 14.95 g) to S_1 (sowing on 17 November) and S_3 (sowing on 15 December), while the lowest dry matter content of stem plant^{-1} (14.16 g) was recorded from S_4 (sowing on 30 December).

Different wheat varieties showed statistically significant difference on dry matter content of stem plant^{-1} (Table 15). The highest dry matter content of stem plant^{-1} (15.69 g) was attained from V_3 (BARI Gom 24). On the other hand, the lowest dry matter content of stem plant^{-1} (14.28 g) was found from V_2 (BARI Gom 23) which was statistically similar (14.78 g) to V_1 (BARI Gom 21).

Table 15. Effect of different sowing dates and varieties on dry matter content at maturity of stem, ear, seed, husk and root plant^{-1} of wheat

Treatment	Dry matter content plant^{-1} (g)				
	Stem	Ear	Seed	Husk	Root
Sowing dates					
S_1	15.23 a	2.45 b	5.55 a	3.24 b	2.25 b
S_2	15.35 a	2.67 a	5.74 a	3.54 a	2.43 a
S_3	14.95 a	2.43 b	5.43 a	3.28 b	2.26 b
S_4	14.16 b	2.17 c	4.96 b	3.10 c	2.07 c
LSD (0.05)	0.661	0.118	0.408	0.082	0.082
Significance level	0.01	0.01	0.01	0.01	0.01
Wheat varieties					
V_1	14.78 b	2.42 b	5.34 b	3.24 bc	2.25 b
V_2	14.28 b	2.33 b	5.01 b	3.11 d	2.18 b
V_3	15.69 a	2.61 a	5.95 a	3.55 a	2.37 a
V_4	14.85 ab	2.40 b	5.33 b	3.35 b	2.23 b
V_5	15.06 ab	2.45 b	5.57 ab	3.18 cd	2.28 ab
V_6	14.87 ab	2.39 b	5.32 b	3.33 b	2.22 b
LSD (0.05)	0.810	0.145	0.500	0.101	0.101
Significance level	0.05	0.01	0.01	0.01	0.01
CV(%)	6.60	7.25	11.23	3.76	5.41

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Table 16. Interaction effect of different sowing dates and varieties on dry matter content at maturity of stem, ear, seed, husk and root plant^{-1} of wheat

Treatment	Dry matter content plant^{-1} (g)				
	Stem	Ear	Seed	Husk	Root
S_1V_1	14.29 c-g	2.25 e-h	4.96 c-g	3.33 c-g	2.11 f-i
S_1V_2	14.56 b-g	2.29 e-g	5.11 b-g	3.13 g-j	2.14 f-i
S_1V_3	15.82 a-c	2.59 b-e	5.93 a-d	3.51 b-d	2.35 b-f
S_1V_4	14.78 b-g	2.34 e-g	5.24 b-g	3.29 d-h	2.17 f-h
S_1V_5	15.66 a-d	2.56 b-e	5.84 a-e	3.13 g-j	2.33 b-f
S_1V_6	16.26 ab	2.70 a-c	6.22 ab	3.04 ij	2.42 a-e
S_2V_1	15.48 a-e	2.70 a-c	5.83 a-e	3.49 cd	2.46 a-d
S_2V_2	15.67 a-d	2.75 a-c	5.96 a-d	3.25 e-i	2.49 a-c
S_2V_3	17.35 a	2.94 a	6.80 a	3.82 a	2.60 a
S_2V_4	15.66 a-d	2.74 a-c	5.93 a-d	3.47 c-e	2.48 a-c
S_2V_5	15.42 b-e	2.68 a-d	5.77 a-e	3.52 b-d	2.44 a-e
S_2V_6	14.00 c-g	2.35 d-g	4.87 c-g	3.73 ab	2.21 e-h
S_3V_1	14.06 c-g	2.29 e-g	5.11 b-g	3.07 h-j	2.19 f-h
S_3V_2	13.31 fg	2.16 f-h	4.32 fg	3.01 ij	2.06 g-i
S_3V_3	15.86 a-c	2.79 ab	6.07 a-c	3.49 cd	2.52 ab
S_3V_4	15.67 a-d	2.57 b-e	5.99 a-d	3.17 f-j	2.34 b-f
S_3V_5	15.48 a-e	2.47 b-f	5.58 b-e	3.39 c-f	2.27 c-g
S_3V_6	14.28 c-g	2.18 f-h	4.81 d-g	3.56 bc	2.07 g-i
S_4V_1	15.29 b-e	2.43 c-g	5.47 b-f	3.09 h-j	2.25 d-h
S_4V_2	14.03 c-g	2.14 f-h	4.66 e-g	3.04 ij	2.04 g-i
S_4V_3	13.74 d-g	2.11 gh	5.00 c-g	3.37 c-f	2.01 hi
S_4V_4	12.87 g	1.94 h	4.17 g	2.70 k	1.91 i
S_4V_5	13.68 e-g	2.09 gh	5.07 b-g	3.45 c-e	2.07 g-i
S_4V_6	14.93 b-f	2.34 e-g	5.39 b-f	2.97 j	2.15 f-h
LSD (0.05)	1.620	0.289	1.00	0.201	0.201
Significance level	0.01	0.01	0.01	0.01	0.01
CV(%)	6.60	7.25	11.23	3.76	5.41

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

S_1: Sowing on 17 November, 2012 — V_1: BARI Gom 21 — V_2: BARI Gom 23

S_2: Sowing on 30 November, 2012 — V_3: BARI Gom 24 — V_4: BARI Gom 25

S_3: Sowing on 15 December, 2012 — V_5: BARI Gom 26 — V_6: BARI Gom 27

S_4: Sowing on 30 December, 2012

Dry matter content of stem plant^{-1} showed significant differences due to the interaction effect of sowing dates and different wheat varieties (Table 16). The highest dry matter content of stem plant^{-1} (17.35 g) was observed from S_2V_3 (sowing on 30 November and BARI Gom 24), whereas the lowest dry matter content of stem plant^{-1} (12.87 g) was observed from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.21 Dry matter content of ear plant^{-1}

Different sowing dates showed statistically significant variation in terms of dry matter content of ear plant^{-1} (Table 15). The highest dry matter content of ear plant^{-1} (2.67 g) was found from S_2 (sowing on 30 November) which was closely followed (2.45 g and 2.43 g) by S_1 (sowing on 15 November) and S_3 (sowing on 15 December) and they were statistically similar, while the lowest dry matter content of ear plant^{-1} (2.17 g) was observed from S_4 (sowing on 30 December).

Statistically significant variation was observed due to different wheat varieties in terms of dry matter content of ear plant^{-1} (Table 15). The highest dry matter content of stem plant^{-1} (2.61 g) was found from V_3 (BARI Gom 24), whereas the lowest dry matter content of ear plant^{-1} (2.33 g) was recorded from V_2 (BARI Gom 23) which was closely followed (2.39 g, 2.40 g, 2.42 g and 2.45 g) by V_6 (BARI Gom 27), V_4 (BARI Gom 25), V_1 (BARI Gom 21) and V_5 (BARI Gom 26) and they were statistically similar.

Interaction effect of sowing dates and wheat varieties showed significant differences on dry matter content of ear plant^{-1} (Table 16). Data revealed that the highest dry matter content of ear plant^{-1} (2.94 g) was observed from S_2V_3 (sowing on 30 November and BARI Gom 24), while the lowest dry matter content of ear plant^{-1} (1.94 g) was recorded from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.22 Dry matter content of seeds plant^{-1}

Significant variation was observed in terms of dry matter content of seeds plant^{-1} due to different sowing dates under the present trial (Table 15). The highest dry matter content of seeds plant^{-1} (5.74 g) was found from S_2 (sowing on 30 November) which was statistically identical (5.55 g and 5.43 g) to S_1 (sowing on 17 November) and S_3 (sowing on 15 December), while the lowest dry matter content of seeds plant^{-1} (4.96 g) was recorded from S_4 (sowing on 30 December).

Different wheat varieties showed statistically significant difference on dry matter content of seeds plant^{-1} (Table 15). The highest dry matter content of seeds plant^{-1} (5.95 g) was observed from V_3 (BARI Gom 24), whereas the lowest dry matter content of seeds plant^{-1} (5.01 g) was found from V_2 (BARI Gom 23) which was statistically similar (5.32 g, 5.33 g and 5.34 g) to V_6 (BARI Gom 27), V_4 (BARI Gom 25) and V_1 (BARI Gom 21).

Sowing dates and wheat varieties showed significant differences on dry matter content of seeds plant^{-1} due to interaction effect (Table 16). The highest dry matter content of seeds plant^{-1} (6.80 g) was found from S_2V_3 (sowing on 30 November and BARI Gom 24) and the lowest dry matter content of seeds plant^{-1} (4.17 g) was obtained from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.23 Dry matter content of husk plant^{-1}

Dry matter content of husk plant^{-1} showed statistically significant variation due to different sowing dates under the present trial (Table 15). The highest dry matter content of husk plant^{-1} (3.54 g) was found from S_2 (sowing on 30 November) which was closely followed (3.28 g and 3.24 g) by S_3 (sowing on 15 December) and S_1 (sowing on 17 November) and they were statistically similar, whereas the lowest dry matter content of husk plant^{-1} (3.10 g) was obtained from S_4 (sowing on 30 December).

Statistically significant variation was observed due to different wheat varieties on dry matter content of husk plant^{-1} under the present trial (Table 15). The highest dry matter content of husk plant^{-1} (3.55 g) was found from V_3 (BARI Gom 24) which was closely followed (3.35 g and 3.33 g) by V_4 (BARI Gom 25) and V_6 (BARI Gom 27) and they were statistically similar, again the lowest dry matter content of husk plant^{-1} (3.11 g) was recorded from V_2 (BARI Gom 23) which was statistically similar (3.18 g) to V_5 (BARI Gom 26).

Dry matter content of husk plant^{-1} showed significant differences due to interaction effect of sowing dates and wheat varieties (Table 16). The highest dry matter content of husk plant^{-1} (3.82 g) was found from S_2V_3 (sowing on 30 November and BARI Gom 24), while the lowest dry matter content of husk plant^{-1} (2.70 g) was observed from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.24 Dry matter content of root plant^{-1}

Dry matter content of root plant^{-1} showed statistically significant variation in terms of different sowing dates under the present trial (Table 15). Data revealed that the highest dry matter content of root plant^{-1} (2.43 g) was observed from S_2 (sowing on 30 November) which was closely followed (2.26 g and 2.25 g) by S_3 (sowing on 15 December) and S_1 (sowing on 17 November) and they were statistically similar, while the lowest dry matter content of root plant^{-1} (2.07 g) was found from S_4 (sowing on 30 December).

Different wheat varieties showed statistically significant difference on dry matter content of root plant^{-1} (Table 15). The highest dry matter content of root plant^{-1} (2.37 g) was recorded from V_5 (BARI Gom 26), whereas the lowest dry matter content of root plant^{-1} (2.18 g) was obtained from V_2 (BARI Gom 23) which was statistically similar (2.22 g, 2.23 g and 2.25 g) to V_6 (BARI Gom 27), V_4 (BARI Gom 25) and V_1 (BARI Gom 21).

Interaction effect sowing dates and wheat varieties showed significant differences on dry matter content of root plant^{-1} (Table 16). The highest dry matter content of root plant^{-1} (2.60 g) was recorded from S_2V_3 (sowing on 30 November and BARI Gom 24) and the lowest dry matter content of root plant^{-1} (1.91 g) was found from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.25 Number of filled grains spike^{-1}

Statistically significant variation was recorded in terms of number of filled grain spike^{-1} due to different sowing dates under the present trial (Table 17). The maximum number of filled grain spike^{-1} (45.16) was recorded from S_2 (sowing on 30 November) which was statistically identical (42.04 and 42.03) to S_3 (sowing on 15 December) and S_2 (sowing on 30 November), while the minimum number (39.11) was observed from S_4 (sowing on 30 December). 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 filled grain spike^{-1} showed statistically significant difference due to different wheat varieties (Table 17). The maximum number of filled grain spike^{-1} (45.51) was obtained from V_3 (BARI Gom 24) which was statistically similar (44.61) to V_5 (BARI Gom 26), whereas the minimum number (38.39) was found from V_2 (BARI Gom 23) which was statistically similar (40.81 and 40.93) to V_6 (BARI Gom 27) and V_4 (BARI Gom 25).

Statistically significant variation was observed due to the interaction effect of sowing dates and wheat varieties in terms of number of filled grain spike^{-1} under the present trial (Table 18). The maximum number of filled grain spike^{-1} (51.50) was attained from S_3V_3 (sowing on 30 November and BARI Gom 24) and the minimum number (30.57) was observed from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

Table 17. Effect of different sowing dates and varieties on number of filled and unfilled grains spike^{-1} and 1000 seeds weight of wheat

Treatment	Filled grains spike^{-1} (No.)	Unfilled grains spike^{-1} (No.)	1000 seeds weight (g)
Sowing dates			
S_1	42.03 ab	4.11 b	46.70 b
S_2	45.16 a	3.97 b	48.62 a
S_3	42.04 ab	4.02 b	47.23 ab
S_4	39.11 b	4.33 a	44.85 c
LSD (0.05)	3.133	0.205	1.653
Significance level	0.01	0.01	0.01
Wheat varieties			
V_1	42.25 a-c	4.19 a-c	46.96 ab
V_2	38.39 c	4.36 a	44.88 b
V_3	45.51 a	3.81 d	48.33 a
V_4	40.93 bc	4.07 bc	46.40 ab
V_5	44.61 ab	3.93 cd	47.91 a
V_6	40.81 bc	4.28 ab	46.62 ab
LSD (0.05)	3.837	0.251	2.025
Significance level	0.01	0.01	0.05
CV(%)	11.09	7.41	5.26

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Table 18. Interaction effect of different sowing dates and varieties on number of filled and unfilled grains spike^{-1} and 1000 seeds weight of wheat

Treatment	Filled grains spike^{-1} (No.)	Unfilled grains spike^{-1} (No.)	1000 seeds weight (g)
S_1V_1	34.67 e-g	4.43 a-e	43.65 e-h
S_1V_2	32.00 fg	4.33 a-g	43.46 f-h
S_1V_3	45.57 a-d	3.97 c-h	49.01 a-d
S_1V_4	39.87 b-f	3.90 e-h	47.07 a-g
S_1V_5	48.57 ab	4.00 b-h	48.36 a-e
S_1V_6	46.47 a-c	3.80 f-h	48.65 a-d
S_2V_1	46.43 a-c	3.93 d-h	49.21 a-d
S_2V_2	47.10 a-c	3.97 c-h	48.56 a-d
S_2V_3	51.50 a	4.00 b-h	51.34 a
S_2V_4	48.87 ab	3.90 e-h	50.07 ab
S_2V_5	47.97 ab	3.67 h	49.55 a-d
S_2V_6	34.10 e-g	4.57 ab	44.70 d-h
S_3V_1	41.17 b-e	4.50 a-d	47.37 a-f
S_3V_2	37.30 d-g	4.60 a	45.07 c-h
S_3V_3	51.47 a	3.00 i	49.64 a-c
S_3V_4	44.43 a-d	3.77 gh	46.88 a-g
S_3V_5	43.17 a-e	3.87 e-h	47.79 a-f
S_3V_6	34.70 e-g	4.40 a-f	44.94 c-h
S_4V_1	46.73 a-c	3.90 e-h	47.61 a-f
S_4V_2	37.17 d-g	4.53 a-c	42.45 gh
S_4V_3	38.53 c-g	4.47 a-e	43.34 f-h
S_4V_4	30.57 g	4.73 a	41.58 h
S_4V_5	38.73 c-g	4.20 a-h	45.94 b-h
S_4V_6	42.93 a-e	4.17 a-h	48.18 a-f
LSD (0.05)	7.673	0.501	4.049
Significance level	0.01	0.01	0.01
CV(%)	11.09	7.41	5.26

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

4.26 Number of unfilled grains spike^{-1}

Statistically significant variation was recorded in terms of number of unfilled grain spike^{-1} due to different sowing dates (Table 17). The maximum number of unfilled grain spike^{-1} (4.33) was found from S_4 (sowing on 30 December). On the other hand, the minimum number (3.97) was obtained from S_2 (sowing on 30 November) which was statistically identical (4.02 and 4.4.11) to S_3 (sowing on 15 December) and S_1 (sowing on 17 November).

Different wheat varieties showed statistically significant difference on number of unfilled grain spike^{-1} (Table 17). The maximum number of unfilled grain spike^{-1} (4.36) was obtained from V_2 (BARI Gom 23) which was statistically similar (4.28) to V_6 (BARI Gom 27), whereas the minimum number (3.81) from V_3 (BARI Gom 24) which was statistically similar (3.93) to V_5 (BARI Gom 26).

Sowing dates and wheat varieties showed significant differences on number of unfilled grain spike^{-1} due to interaction effect (Table 18). The maximum number of unfilled grain spike^{-1} (4.73) was observed from S_4V_4 (sowing on 30 December and BARI Gom 25), again the minimum number (3.00) from the treatment combination S_3V_3 (sowing on 15 December and BARI Gom 24).

4.27 Number of total grains spike^{-1}

Number of total grain spike^{-1} varied significantly due to different sowing dates (Figure 7). The maximum number of total grain spike^{-1} (49.13) was observed from S_2 (sowing on 30 November) which was statistically identical (46.13 and 46.06) to S_1 (sowing on 17 November) and S_3 (sowing on 15 December), again the minimum number (43.44) was found from S_4 (sowing on 30 December). 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 observed due to different wheat varieties on number of total grain spike^{-1} under the present trial (Figure 8). The maximum number of total grain spike^{-1} (49.32) was recorded from V_3 (BARI Gom 24) which was statistically similar (48.54) to V_5 (BARI Gom 26), while the minimum number (42.75) was obtained from V_2 (BARI Gom 23) which was statistically similar (45.01 and 45.09) to V_4 (BARI Gom 25) and V_6 (BARI Gom 27). Wheat Research Center (2003) reported that the varieties Shatabdi produced maximum grain spike^{-1}.

Number of total grain spike^{-1} showed significant differences due to the interaction effect of sowing dates and wheat varieties (Figure 9). The maximum number of total grain spike^{-1} (55.50) was recorded from S_2V_3 (sowing on 30 November and BARI Gom 24), whereas the minimum number (35.30) was found from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.28 1000-seeds weight

Statistically significant variation was recorded in terms of 1000-seeds weight due to different sowing dates (Table 17). The highest 1000-seeds weight (48.62 g) was found from S_2 (sowing on 30 November) which was statistically identical (47.23 g) to S_3 (sowing on 15 December) and closely followed (46.70 g) by S_1 (sowing on 17 November), while the lowest 1000-seeds weight (44.85 g) was observed from S_4 (sowing on 30 December). 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.

Different wheat varieties varied significantly on 1000-seeds weight (Table 17). The highest 1000-seeds weight (48.33 g) was recorded from V_3 (BARI Gom 24) which was statistically similar (47.91 g) to V_5 (BARI Gom 26), whereas the lowest 1000-seeds weight (44.88 g) was found from V_2 (BARI Gom 23).

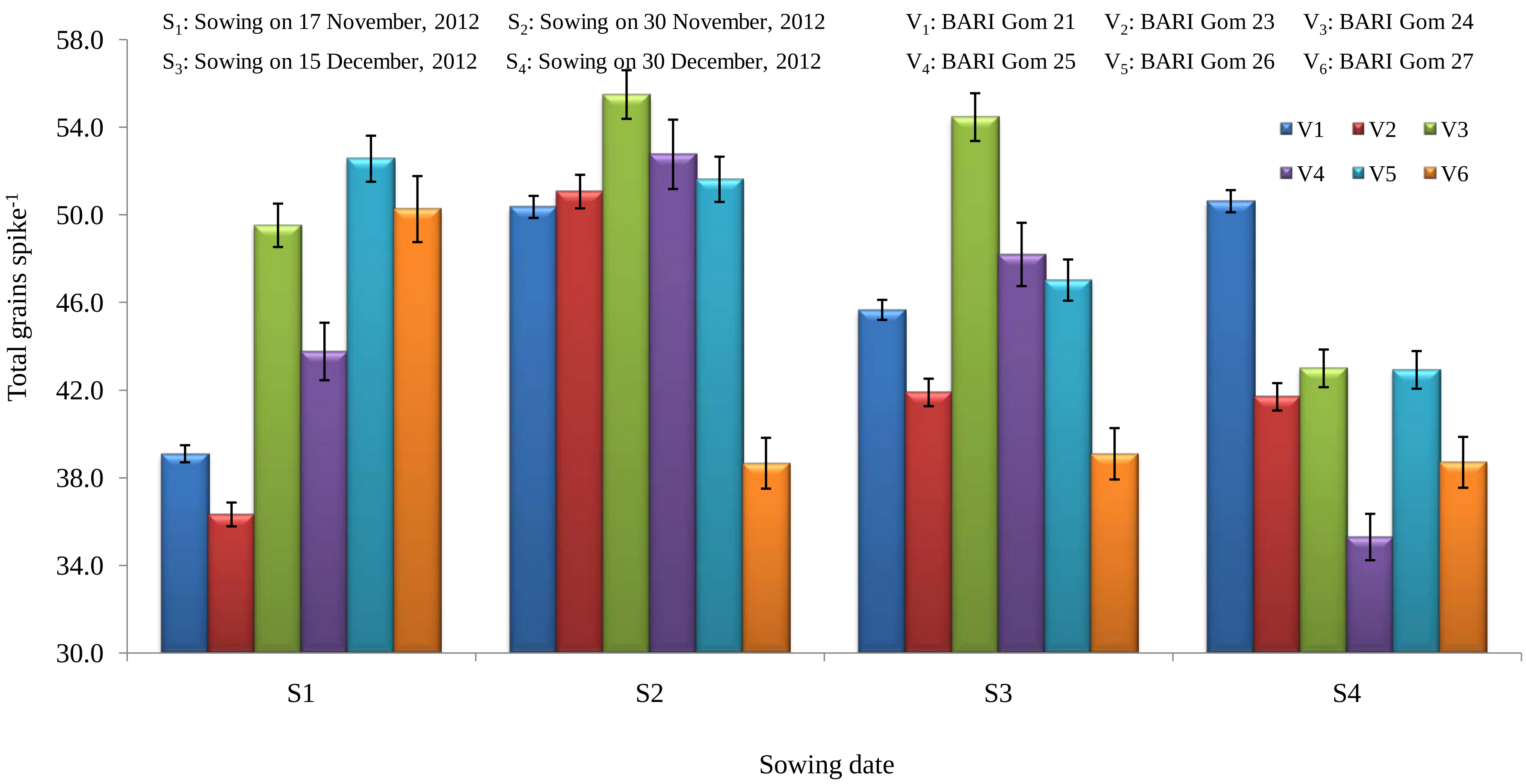


Figure 9. Interaction effect of different sowing date and wheat varieties on number of total grains spike^{-1}. Vertical bars represent LSD value.

Sowing dates and wheat varieties showed significant differences on 1000-seeds weight due to interaction effect (Table 18). The highest 1000-seeds weight (51.34 g) was found from S_2V_3 (sowing on 30 November and BARI Gom 24), again the lowest 1000-seeds weight (41.58 g) was recorded from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.29 Grain yield m^{-2}

Different sowing dates showed statistically significant differences in terms of grain yield m^{-2} (Table 19). The highest grain yield m^{-2} (392.85 g) was found from S_2 (sowing on 30 November) which was closely followed (366.24 g and 356.96 g) to S_3 (sowing on 15 December) and S_1 (sowing on 17 November) and they were statistically similar, while the lowest grain yield m^{-2} (309.27 g) was recorded from S_4 (sowing on 30 December). Wheat sown in November to ensure optimal crop growth and avoid high temperature and 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. Islam *et al*., (1993) reported that late planted wheat plants face a period of high temperature stress during reproductive stages causing reduced kernel number spike^{-1} as well as the reduction of seed yield.

Grain yield m^{-2} showed statistically significant difference due to different wheat varieties (Table 19). The highest grain yield m^{-2} (370.35 g) was obtained from V_3 (BARI Gom 24) which was statistically similar (364.85 g, 362.52 g, 359.84 g and 350.54 g) to V_5 (BARI Gom 26), V_1 (BARI Gom 21), V_4 (BARI Gom 25) and V_6 (BARI Gom 27), whereas the lowest grain yield m^{-2} (329.87 g) was found from V_2 (BARI Gom 23).

Statistically significant variation was observed due to interaction effect sowing dates and wheat varieties in terms of grain yield m^{-2} (Table 20). The highest grain yield m^{-2} (413.62 g) was attained from S_2V_3 (sowing on 30 November and BARI Gom 24) and the lowest grain yield m^{-2} (283.00 g) from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

Table 19. Effect of different sowing dates and varieties on grain and straw yield and harvest index of wheat

Treatment	Grain yield ($g\ m^{-2}$)	Grain yield ($t\ ha^{-1}$)	Straw yield ($g\ m^{-2}$)	Straw yield ($t\ ha^{-1}$)	Harvest Index (%)
Sowing dates					
S_1	356.96 b	3.57 b	480.19 a	4.80 a	42.67 b
S_2	392.85 a	3.93 a	495.94 a	4.96 a	44.25 a
S_3	366.24 b	3.66 b	487.42 a	4.87 a	42.94 ab
S_4	309.27 c	3.09 c	443.55 b	4.44 b	41.09 c
LSD (0.05)	16.72	0.167	20.90	0.209	1.407
Significance level	0.01	0.01	0.01	0.01	0.01
Wheat varieties					
V_1	362.52 a	3.63 a	481.49 ab	4.81 ab	42.92
V_2	329.87 b	3.30 b	450.68 c	4.51 c	42.29
V_3	370.35 a	3.70 a	505.99 a	5.06 a	42.16
V_4	359.84 a	3.60 a	468.20 bc	4.68 bc	43.42
V_5	364.85 a	3.65 a	488.58 ab	4.89 ab	42.65
V_6	350.54 a	3.51 a	465.70 bc	4.66 bc	42.99
LSD (0.05)	20.48	0.205	25.60	0.256	--
Significance level	0.01	0.01	0.01	0.01	NS
CV(%)	7.00	7.00	6.53	6.53	4.91

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

S_1: Sowing on 17 November, 2012
S_2: Sowing on 30 November, 2012
S_3: Sowing on 15 December, 2012
S_4: Sowing on 30 December, 2012

V_1: BARI Gom 21 V_2: BARI Gom 23
V_3: BARI Gom 24 V_4: BARI Gom 25
V_5: BARI Gom 26 V_6: BARI Gom 27

Table 20. Interaction effect of different sowing dates and varieties on grain and straw yield and harvest index of wheat

Treatment	Grain yield (g m^{-2})	Grain yield (t ha^{-1})	Straw yield (g m^{-2})	Straw yield (t ha^{-1})	Harvest Index (%)
S_1V_1	349.52 d-h	3.50 d-h	442.65 d-h	4.43 d-h	44.12 a-c
S_1V_2	326.67 e-i	3.27 e-i	450.34 c-h	4.50 c-h	42.04 a-d
S_1V_3	378.64 a-d	3.79 a-d	510.84 bc	5.11 bc	42.58 a-d
S_1V_4	359.78 b-f	3.60 b-f	460.08 b-g	4.60 b-g	43.89 a-c
S_1V_5	375.76 a-d	3.76 a-d	504.25 bc	5.04 bc	42.70 a-d
S_1V_6	351.39 c-g	3.51 c-g	513.01 b	5.13 b	40.68 b-d
S_2V_1	399.86 a-c	4.00 a-c	503.23 bc	5.03 bc	44.28 ab
S_2V_2	382.82 a-d	3.83 a-d	513.69 b	5.14 b	42.81 a-d
S_2V_3	413.62 a	4.14 a	578.67 a	5.79 a	41.68 a-d
S_2V_4	403.82 ab	4.04 ab	510.29 bc	5.10 bc	44.18 ab
S_2V_5	399.83 a-c	4.00 a-c	498.43 b-d	4.98 b-d	44.59 ab
S_2V_6	364.63 b-f	3.65 b-f	433.06 e-h	4.33 e-h	45.71 a
S_3V_1	352.23 c-g	3.52 c-g	491.33 b-e	4.91 b-e	41.67a-d
S_3V_2	303.67 hi	3.04 hi	408.00 gh	4.08 gh	42.67 a-d
S_3V_3	406.16 ab	4.06 ab	516.95 b	5.17 b	43.97 a-c
S_3V_4	372.96 a-e	3.73 a-e	511.01 bc	5.11 bc	42.04 a-d
S_3V_5	387.72 a-d	3.88 a-d	496.16 b-d	4.96 b-d	43.96 a-c
S_3V_6	367.22 a-e	3.67 a-e	439.35 d-h	4.39 d-h	45.60 a
S_4V_1	348.45 d-h	3.48 d-h	488.75 b-f	4.89 b-f	41.63 a-d
S_4V_2	306.33 g-i	3.06 g-i	430.71 f-h	4.31 f-h	41.64 a-d
S_4V_3	302.78 hi	3.03 hi	417.53 gh	4.18 gh	40.42 b-d
S_4V_4	283.00 i	2.83 i	391.44 h	3.91 h	41.99 b-d
S_4V_5	296.10 i	2.96 i	455.49 b-g	4.55 b-g	39.33 d
S_4V_6	318.93 f-i	3.19 f-i	477.39 b-f	4.77 b-f	39.96 cd
LSD (0.05)	40.97	0.409	51.19	0.512	3.447
Significance level	0.01	0.01	0.01	0.01	0.01
CV(%)	7.00	7.00	6.53	6.53	4.91

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

S_1: Sowing on 17 November, 2012 V_1: BARI Gom 21 V_2: BARI Gom 23

S_2: Sowing on 30 November, 2012 V_3: BARI Gom 24 V_4: BARI Gom 25

S_3: Sowing on 15 December, 2012 V_5: BARI Gom 26 V_6: BARI Gom 27

S_4: Sowing on 30 December, 2012

4.30 Grain yield ha^{-1}

Grain yield ha^{-1} varied significantly due to different sowing dates under the present trial (Table 19). The highest grain yield ha^{-1} (3.93 ton) was observed from S_2 (sowing on 30 November) which was closely followed (3.66 ton and 3.57 ton) to S_3 (sowing on 15 December) and S_1 (sowing on 17 November) and they were statistically similar, while the lowest grain yield ha^{-1} (3.09 ton) was found from S_4 (sowing on 30 December). 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) and reduced kernel weight (Acevedo *et al*., 1991) 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).

Statistically significant variation was observed for different wheat varieties in terms of grain yield ha^{-1} (Table 19). The highest grain yield ha^{-1} (3.70 ton) was recorded from V_3 (BARI Gom 24) which was statistically similar (3.65 ton, 3.63 ton, 3.60 ton and 3.51 ton) to V_5 (BARI Gom 26), V_1 (BARI Gom 21), V_4 (BARI Gom 25) and V_6 (BARI Gom 27), again the lowest grain yield ha^{-1} (3.30 ton) was obtained from V_2 (BARI Gom 23). 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 $spike^{-1}$.

Interaction effect of sowing dates and wheat varieties showed significant differences on grain yield ha^{-1} (Table 20). The highest grain yield ha^{-1} (4.14 ton) was recorded from S_2V_3 (sowing on 30 November and BARI Gom 24), whereas the lowest grain yield ha^{-1} (2.83 ton) was found from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.31 Straw yield m^{-2}

Statistically significant variation was recorded in terms of straw yield m^{-2} due to different sowing dates under the present trial (Table 19). The highest straw yield m^{-2} (495.94 g) was recorded from S_2 (sowing on 30 November) which was statistically identical (487.42 g and 480.19 g) to S_3 (sowing on 15 December) and S_1 (sowing on 17 November), whereas the lowest straw yield m^{-2} (443.55 g) was obtained from S_4 (sowing on 30 December).

Different wheat varieties showed statistically significant difference on straw yield m^{-2} (Table 19). The highest straw yield m^{-2} (505.99 g) was found from V_3 (BARI Gom 24) which was statistically similar (488.58 g and 481.49 g) to V_5 (BARI Gom 26) and V_1 (BARI Gom 21), again the lowest straw yield m^{-2} (450.68 g) was recorded from V_2 (BARI Gom 23) which was statistically similar (465.70 g and 468.20 g) to V_6 (BARI Gom 27) and V_4 (BARI Gom 25).

Sowing dates and wheat varieties showed significant differences on straw yield m^{-2} due to interaction effect (Table 20). The highest straw yield m^{-2} (578.67 g) was attained from S_2V_3 (sowing on 30 November and BARI Gom 24), while the lowest straw yield m^{-2} (391.44 g) was observed from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.32 Straw yield ha^{-1}

Straw yield ha^{-1} showed statistically significant differences due to different sowing dates under the present trial (Table 19). The highest straw yield ha^{-1} (4.96 ton) was recorded from S_2 (sowing on 30 November) which was statistically identical (4.87 ton and 4.80 ton) to S_3 (sowing on 15 December) and S_1 (sowing on 17 November), while the lowest straw yield ha^{-1} (4.44 ton) was observed from S_4 (sowing on 30 December).

Statistically significant variation was observed due to different wheat varieties in terms of straw yield ha^{-1} (Table 19). The highest straw yield ha^{-1} (5.06 ton) was attained from V_3 (BARI Gom 24) which was statistically similar (4.89 ton and

4.81 ton) to V_5 (BARI Gom 26) and V_1 (BARI Gom 21), whle, the lowest straw yield ha^{-1} (4.51 ton) was found from V_2 (BARI Gom 23) which was statistically similar (4.66 ton and 4.68 ton) to V_6 (BARI Gom 27) and V_4 (BARI Gom 25).

Interaction effect of sowing dates and wheat varieties showed significant differences on straw yield ha^{-1} (Table 20). The highest straw yield ha^{-1} (5.79 ton) was found from S_2V_3 (sowing on 30 November and BARI Gom 24) and the lowest straw yield ha^{-1} (3.91 ton) was recorded from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

4.33 Biological yield ha^{-1}

Significant variation was recorded for biological yield ha^{-1} due to different sowing dates (Figure 10). The highest biological yield ha^{-1} (8.89 ton) was found from S_2 (sowing on 30 November) which was followed (8.54 ton and 8.37 ton) to S_3 (sowing on 15 December) and S_1 (sowing on 17 November) and they were statistically similar, whereas the lowest biological yield ha^{-1} (7.53 ton) from S_4 (sowing on 30 December). 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.

Different wheat varieties showed statistically significant difference on biological yield ha^{-1} under the present trial (Figure 11). Data revealed that the highest biological yield ha^{-1} (8.76 ton) was found from V_3 (BARI Gom 24) which was statistically similar (8.53 ton and 8.44 ton) to V_5 (BARI Gom 26) and V_1 (BARI Gom 21), again the lowest biological yield ha^{-1} (7.81 ton) was found from V_2 (BARI Gom 23) which was similar (8.16 ton) to V_6 (BARI Gom 27).

Biological yield ha^{-1} showed significant differences due to interaction effect of sowing dates and wheat varieties (Figure 12). The highest biological yield ha^{-1} (9.92 ton) was found from S_2V_3 (sowing on 30 November and BARI Gom 24), while the lowest biological yield ha^{-1} (6.74 ton) from the treatment combination S_4V_4 (sowing on 30 December and BARI Gom 25).

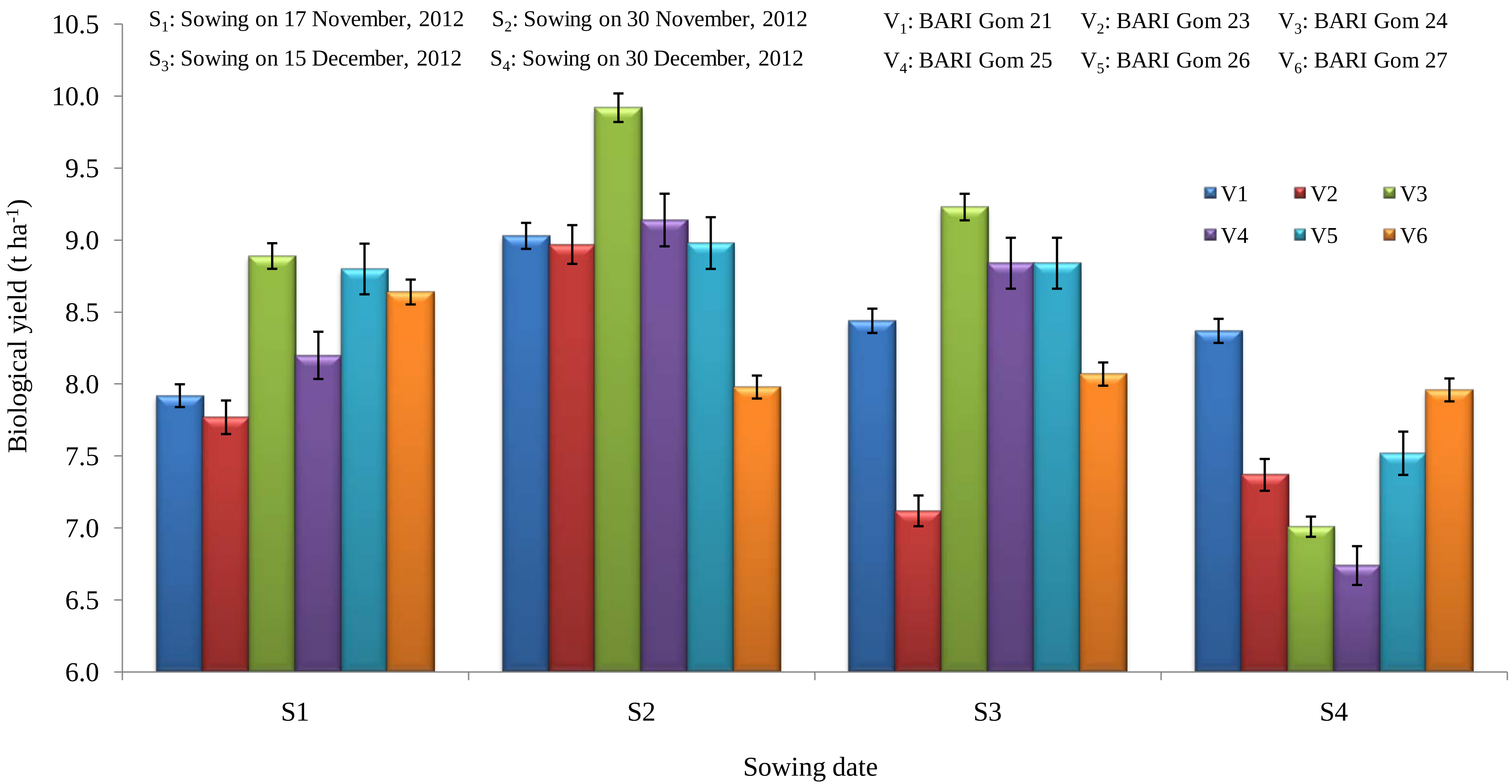


Figure 12. Interaction effect of different sowing date and wheat variety on biological yield. Vertical bars represent LSD value.

4.34 Harvest index

Harvest index showed statistically significant differences due to different sowing dates (Table 19). The highest harvest index (44.25%) was found from S_2 (sowing on 30 November) which was statistically identical (42.94%) to S_3 (sowing on 15 December) and closely followed (42.67%) by S_1 (sowing on 17 November), while the lowest harvest index (41.09%) was observed from S_4 (sowing on 30 December). 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.

Statistically non-significant variation was observed in terms of harvest index due to different wheat varieties under the present trial (Table 19). The highest harvest index (43.42%) was found from V_4 (BARI Gom 25), whereas the lowest harvest index (42.16%) was recorded from V_3 (BARI Gom 24).

Interaction effect of sowing dates and wheat varieties showed significant differences on harvest index (Table 20). The highest harvest index (45.71%) was observed from S_2V_6 (sowing on 30 November and BARI Gom 27) and the lowest harvest index (39.33%) was recorded from the treatment combination S_4V_5 (sowing on 30 December and BARI Gom 26).

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2012 to March 2013 in rabi season to find out the effect of sowing dates on growth, reproductive behavior and yield of wheat. The experiment comprised of two factors; Factors A: Sowing date (4 times) - S_1: Sowing at 17 November, 2012; S_2: Sowing at 30 November, 2012; S_3: Sowing at 15 December, 2012; S_4: Sowing at 30 December, 2012 and Factor B: Wheat varieties (6 wheat varieties) - V_1: BARI Gom 21; V_2: BARI Gom 23; V_3: BARI Gom 24; V_4: BARI Gom 25; V_5: BARI Gom 26; V_6: BARI Gom 27. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different yield contributing characters and yield were recorded and significant variation was recorded due to the effect of sowing dates, wheat varieties and their interaction effect.

For different sowing dates, the maximum days to starting of seedling emergence (5.94) was recorded from S_4, whereas the minimum days (4.78) from S_1. The maximum days to 50% seedling emergence (8.11) was observed from S_4, while the minimum days (7.67) from S_1. The maximum days to 100% seedling emergence (11.44) was found from S_4 and the minimum days (10.67) from S_1. At 25, 35, 45, 55, 65 DAS and harvest, the longest plant (30.43, 48.49, 69.37, 79.77, 85.60 and 95.15 cm, respectively) was observed from S_2, while the shortest plant (27.51, 43.62, 63.50, 74.36, 81.06 and 88.51 cm, respectively) from S_4. At 25, 35, 45, 55 and 65 DAS, the maximum number of tillers plant^{-1} (3.24, 3.92, 4.20, 4.56 and 4.67, respectively) was observed from S_2, again the minimum (2.87, 3.44, 3.98, 4.27 and 4.44, respectively) from S_4. The maximum days to starting of booting (47.11) was found from S_1 and the minimum days (44.17) from S_4. The maximum days to starting of ear emergence (59.17) was recorded from S_1, while the minimum days (55.00) from S_4. The maximum days to starting of anthesis (77.94) was found from S_1, whereas the minimum days (69.28) from S_4. The maximum days to starting of maturity (89.94) was attained from S_2, while the minimum days (84.72) from S_3. The maximum number of leaves plant^{-1} (5.84) was observed from S_2, while the minimum (5.41) from S_4. The highest length of flag leaf (21.02 cm) was obtained from S_2, whereas the lowest (18.66 cm) from S_4. The highest breadth of flag leaf (1.38 cm) was recorded from S_2, while the lowest (1.17 cm) from S_4. The highest area of flag leaf (29.12 cm^2) was recorded from S_2, again the lowest (21.92 cm^2) from S_4. The maximum number of effective tillers plant^{-1} (4.89) was observed from S_2, whereas the minimum number (4.34) from S_4. The maximum number of non-effective tillers plant^{-1} (0.89) was recorded from S_1, whereas the minimum number (0.66) from S_2. The maximum number of total tillers plant^{-1} (5.55) was found from S_2, whereas the minimum number (5.10) from S_4. The longest ear (15.43 cm) was observed from, while the shortest ear (14.33 cm) from S_4. The maximum number of spikelets spike^{-1} (22.81) was recorded from S_2, while the minimum number (17.19) from S_4. The maximum number of fertile florets spikelets^{-1} (2.93) was obtained from S_2, whereas the minimum number (2.28) from S_4. The highest dry matter content of stem plant^{-1} (15.35 g) was obtained from S_2, while the lowest (14.16 g) from S_4. The highest dry matter content of ear plant^{-1} (2.67 g) was found from S_2, while the lowest (2.17 g) from S_4. The highest dry matter content of seeds plant^{-1} (5.74 g) was found from S_2, while the lowest (4.96 g) from S_4. The highest dry matter content of husk plant^{-1} (3.54 g) was found from S_2, whereas the lowest (3.10 g) from S_4. The highest dry matter content of root plant^{-1} (2.43 g) was observed from S_2, while the lowest (2.07 g) from S_4. The maximum number of filled grain spike^{-1} (45.16) was recorded from S_2, while the minimum number (39.11) from S_4. The maximum number of unfilled grain spike^{-1} (4.33) was found from S_4 and the minimum number (3.97) from S_2. The maximum number of total grain spike^{-1} (49.13) was observed from S_2, again the minimum number (43.44) from S_4. The highest 1000 seeds weight (48.62 g) was found from S_2, while the lowest (44.85 g) from S_4. The highest grain yield m^{-2} (392.85 g) was found from S_2, while the lowest (309.27 g) was recorded from S_4. The highest grain yield ha^{-1} (3.93 ton) was observed from S_2, while the lowest (3.09 ton) was found from S_4. The highest straw yield m^{-2} (495.94 g) was recorded from S_2, whereas the lowest (443.55 g) from S_4. The highest straw yield ha^{-1} (4.96 ton) was recorded from S_2, while the lowest (4.44 ton) from S_4. The highest biological yield ha^{-1} (8.89 ton) was found from S_2, whereas the lowest (7.53 ton) from S_4. The highest harvest index (44.25%) was found from S_2, while the lowest (41.09%) from S_4.

In case of different wheat varieties, the maximum days to starting of seedling emergence (5.50) was observed from V_5, whereas the minimum days (5.33) from V_1. The maximum days to 50% seedling emergence (8.25) was recorded from V_5 and the minimum days (7.92) from V_1. The maximum days to 100% seedling emergence (11.50) was obtained from V_2, whereas the minimum days (10.67) from V_3. At 25, 35, 45, 55, 65 DAS and harvest, the longest plant (30.46, 48.68, 68.71, 79.49, 86.78 and 96.03 cm, respectively) was found from V_3, again the shortest plant (27.76, 43.14, 63.97, 74.43, 80.69 and 88.51 cm, respectively) from V_2. At 25, 35, 45, 55 and 65 DAS, the maximum number of tillers plant^{-1} (3.19, 4.00, 4.58, 4.66 and 4.74, respectively) was found from V_3, while the minimum number (2.81, 3.42, 3.87, 4.24 and 4.37, respectively) from V_2. The maximum days to starting of booting (46.92) was found from V_2, again the minimum days (44.15) from V_4. The maximum days to starting of ear emergence (59.17) was recorded from V_4 and the minimum days (55.17) from V_3. The maximum days to starting of anthesis (75.83) was found from V_5 and the minimum days (71.00) from V_3. The maximum days to starting of maturity (90.75) was obtained from V_4 (BARI Gom 25), whereas the minimum days (83.25) from V_3 the others were in better this range. The maximum number of leaves plant^{-1} (5.97) was recorded from V_3 and the minimum number (5.48) from V_2. The highest length of flag leaf (22.52 cm) was found from V_3, again the lowest (18.19 cm) from V_2. The highest breadth of flag leaf (1.39 cm) was found from V_3, while the lowest (1.20 cm) from V_2. The highest area of flag leaf (31.54 cm^2) was observed from V_3, while the lowest (22.07 cm^2) from V_2. The maximum number of effective tillers plant^{-1} (4.89) was recorded from V_3, while the minimum number (4.37) from V_2. The maximum number of non-effective tillers plant^{-1} (0.80) was recorded from V_2, whereas the minimum number (0.70) from V_3. The maximum number of total tillers plant^{-1} (5.63) was observed from V_4 and the minimum number (5.17) from V_2. The longest ear (16.49 cm) was recorded from V_3, whereas the shortest ear

(13.61 cm) from V_2. The maximum number of spikelets spike^{-1} (20.83) was found from V_3 and the minimum number (18.77) was recorded from V_2. The maximum number of fertile florets spikelets^{-1} (2.92) was obtained from V_3, again the minimum number (2.41) from V_2. The highest dry matter content of stem plant^{-1} (15.69 g) was attained from V_3 and the lowest (14.28 g) from V_2. The highest dry matter content of stem plant^{-1} (2.61 g) was found from V_3, whereas the lowest (2.33 g) from V_2. The highest dry matter content of seeds plant^{-1} (5.95 g) was observed from V_3, whereas the lowest (5.01 g) from V_2. The highest dry matter content of husk plant^{-1} (3.55 g) was found from V_3, again the lowest (3.11 g) from V_2. The highest dry matter content of root plant^{-1} (2.37 g) was recorded from V_5, whereas the lowest (2.18 g) from V_2. The maximum number of filled grain spike^{-1} (45.51) was obtained from V_3, whereas the minimum number (38.39) from V_2. The maximum number of unfilled grain spike^{-1} (4.36) was obtained from V_2, whereas the minimum number (3.81) from V_3. The maximum number of total grain spike^{-1} (49.32) was recorded from V_3, while the minimum number (42.75) from V_2. The highest 1000 seeds weight (48.33 g) was recorded from V_3, whereas the lowest (44.88 g) from V_2. The highest grain yield m^{-2} (370.35 g) was obtained from V_3, whereas the lowest (329.87 g) from V_2. The highest grain yield ha^{-1} (3.70 ton) was recorded from V_3, again the lowest (3.30 ton) from V_2. The highest straw yield m^{-2} (505.99 g) was found from V_3, again the lowest (450.68 g) from V_2. The highest straw yield ha^{-1} (5.06 ton) was obtained from V_3 and the lowest (4.51 ton) from V_2. The highest biological yield ha^{-1} (8.76 ton) was found from V_3, again the lowest (7.81 ton) from V_2. The highest harvest index (43.42%) was found from V_4, whereas the lowest (42.16%) from V_3.

Significant differences were found in case of interaction effects for different characters of wheat varieties sown in different sowing dates. The maximum days to starting of seedling emergence (6.33) were found from S_4V_5, while the minimum days (4.33) from the treatment combination S_1V_1. The maximum days to 50% seedling emergence (9.00) was recorded from S_4V_3 and the minimum days (6.67) from S_1V_4. The maximum days to 100% seedling emergence (10.00) was observed from S_1V_5, again the minimum days (12.33) was recorded from

S_3V_2. At 25, 35, 45, 55, 65 DAS and harvest, the longest plant (32.46, 52.94, 71.29, 83.24, 91.51 and 99.52 cm, respectively) was observed from S_3V_3 and the shortest plant (24.62, 38.72, 61.04, 70.22, 75.90 and 83.06 cm, respectively) from S_4V_4. At 25, 35, 45, 55 and 65 DAS, the maximum number of tillers plant^{-1} (3.40, 4.27, 4.83, 4.93 and 4.97, respectively) was recorded from S_2V_4, whereas the minimum number (2.60, 3.23, 3.63, 3.97 and 4.13, respectively) from S_4V_4. The maximum days to starting of booting (49.00) was found from S_2V_2, while the minimum days (42.67) from S_3V_4. The maximum days to starting of ear emergence (62.00) was recorded from S_1V_6 and the minimum days (50.00) from S_3V_3. The maximum days to starting of anthesis (87.00) was attained from S_1V_6, while the minimum days (64.33) from S_4V_6. The maximum days to starting of maturity (94.33) was observed from S_2V_4, and the minimum days (71.33) from S_4V_3. The maximum number of leaves plant^{-1} (6.27) was observed from S_2V_3, while the minimum number (5.00) from S_4V_4. The highest length of flag leaf (26.71 cm) was found from S_2V_3 and the lowest (15.91 cm) from S_4V_4. The highest breadth of flag leaf (1.50 cm) was found from S_2V_3, whereas the lowest (1.02 cm) from S_4V_4. The highest area of flag leaf (39.99 cm^2) was found from S_2V_3 and the lowest (18.19 cm^2) from S_4V_4. The maximum number of effective tillers hill^{-1} (5.60) was recorded from S_2V_3, whereas the minimum number (3.90) from S_4V_4. The maximum number of non-effective tillers plant^{-1} (0.97) was recorded from S_1V_1, again the minimum number (0.53) from S_2V_3. The maximum number of total tillers plant^{-1} (6.13) was observed from S_2V_3, while the minimum number (4.80) from S_4V_4. The longest ear (17.22 cm) was observed from S_2V_3, again the shortest ear (12.47 cm) from S_4V_4. The maximum number of spikelets spike^{-1} (23.90) was observed from S_2V_3 and the minimum number (15.40) from S_4V_4. The maximum number of fertile florets spikelets^{-1} (3.47) was found from S_2V_3, while the minimum number (2.00) from the treatment combination S_4V_4. The highest dry matter content of stem plant^{-1} (17.35 g) was observed from S_2V_3, whereas the lowest (12.87 g) from the treatment combination S_4V_4. The highest dry matter content of ear plant^{-1} (2.94 g) was observed from S_2V_3, while the lowest (1.94 g) from the treatment combination S_4V_4. The highest dry matter content of seeds plant^{-1} (6.80 g) was found from

S_2V_3 and the lowest (4.17 g) from the treatment combination S_4V_4. The highest dry matter content of husk plant^{-1} (3.82 g) was found from S_2V_3, while the lowest (2.70 g) from S_4V_4. The highest dry matter content of root plant^{-1} (2.60 g) was recorded from S_2V_3 and the lowest (1.91 g) from S_4V_4. The maximum number of filled grain spike^{-1} (51.50) was attained from S_3V_3 and the minimum number (30.57) from S_4V_4. The maximum number of unfilled grain spike^{-1} (4.73) was observed from S_4V_4, whereas the minimum number (3.00) from S_3V_3 The maximum number of total grain spike^{-1} (55.50) was recorded from S_2V_3, whereas the minimum (35.30) from S_4V_4. The highest 1000 seeds weight (51.34 g) was found from S_2V_3, again the lowest (41.58 g) from S_4V_4. The highest grain yield m^{-2} (413.62 g) was obtained from S_2V_3 and the lowest (283.00 g) from S_4V_4. The highest grain yield ha^{-1} (4.14 ton) was recorded from S_2V_3, whereas the lowest (2.83 ton) from S_4V_4. The highest straw yield m^{-2} (578.67 g) was attained from S_2V_3, while the lowest (391.44 g) from S_4V_4. The highest straw yield ha^{-1} (5.79 ton) was found from S_2V_3 and the lowest (3.91 ton) from S_4V_4. The highest biological yield ha^{-1} (9.92 ton) was found from S_2V_3, while the lowest (6.74 ton) from S_4V_4. The highest harvest index (45.71%) was observed from S_2V_6 and the lowest (39.33%) from S_4V_5.

From the above results it can be concluded that-

- 30 November sowing provided best yield for most of the varieties; and
- Among the varieties BARI Gom 24 and BARI Gom 26 provided better yield than the other varieties.

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). (2011). 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 scrcening content of spring-sown malting baeley. *Irish J. Agrial. & 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 Agricultural Organization of the United Nations Rome, Italy. **42**: 190-193.

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

FAO. (2000). Production Year Book. Food and Agricultural 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 (2^{nd} edn.). Int. Rice Res. Inst., A Willey Int. Sci., pp. 28-192.

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

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 of Agri. 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 products & industries,* **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. Exp. 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. *Pak. 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. Agri. 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 2012 to March 2013

Month	*Air temperature (^oC)		*Relative humidity (%)	*Total rainfall (mm)
	Maximum	Minimum		
October, 2012	26.5	19.4	81	22
November, 2012	25.8	16.0	78	00
December, 2012	22.4	13.5	74	00
January, 2013	25.2	12.8	69	00
February, 2013	27.3	16.9	66	39
March, 2013	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	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix III. Analysis of variance of the data on days to seedling emergence as influenced by different sowing dates and wheat varieties

Source of variation	Degrees of freedom	Mean square		
		Percentage of seedling emergence (days)		
		Starting of emergence	50% emergence	100% emergence
Replication	2	0.014	0.211	0.542
Sowing date (A)	3	5.940**	3.594**	2.167**
Varieties (B)	5	0.047	0.263	1.367*
Interaction (A×B)	15	0.384*	0.603*	0.811*
Error	46	0.173	0.267	0.455

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

Appendix IV. Analysis of variance of the data on plant height as influenced by different sowing dates and wheat varieties

Source of variation	Degrees of freedom	Mean square					
		Plant height (cm) at					
		25 DAS	35 DAS	45 DAS	55 DAS	65 DAS	Harvest
Replication	2	0.126	1.828	5.967	3.727	6.985	3.865
Sowing date (A)	3	27.23**	79.41**	105.19**	95.52**	69.88**	168.12**
Varieties (B)	5	11.23*	42.97**	30.592**	36.66**	51.02*	78.305**
Interaction (A×B)	15	8.739*	30.37**	13.314**	26.49**	36.30*	35.031*
Error	46	4.309	9.647	5.580	7.978	17.290	20.240

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

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

Source of variation	Degrees of freedom	Mean square				
		Number of tillers plant^{-1} at				
		25 DAS	35 DAS	45 DAS	55 DAS	65 DAS
Replication	2	0.004	0.013	0.007	0.032	0.037
Sowing date (A)	3	0.436**	0.721**	0.782**	0.673**	0.466**
Varieties (B)	5	0.193**	0.447**	0.672**	0.293**	0.273**
Interaction (A×B)	15	0.066**	0.124*	0.273**	0.195**	0.175**
Error	46	0.024	0.067	0.092	0.079	0.073

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

Appendix VI. Analysis of variance of the data on days required for starting of booting, ear emergence, anthesis and maturity as influenced by different sowing dates and wheat varieties

Source of variation	Degrees of freedom	Mean square			
		Days required for			
		Starting of booting	Starting of ear emergence	Starting of anthesis	Starting of maturity
Replication	2	0.722	4.264	10.181	1.500
Sowing date (A)	3	26.384**	77.236**	258.685**	137.088**
Varieties (B)	5	12.981**	21.847**	40.822*	81.358**
Interaction (A×B)	15	6.018*	16.336**	66.252**	64.655**
Error	46	3.432	6.018	16.485	20.891

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

Appendix VII. Analysis of variance of the data on leaf plant^{-1}, length, breadth and area of flag leaf as influenced by different sowing dates and wheat varieties

Source of variation	Degrees of freedom	Mean square			
		Leaf plant^{-1} (No.)	Length of flag leaf (cm)	Breadth of flag leaf (cm)	Area of flag leaf (cm^2)
Replication	2	0.105	0.028	0.004	0.854
Sowing date (A)	3	0.644**	17.417**	0.152**	181.995**
Varieties (B)	5	0.342**	28.175**	0.066**	136.673**
Interaction (A×B)	15	0.226*	11.256**	0.051**	60.876**
Error	46	0.101	4.454	0.011	17.386

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

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

Source of variation	Degrees of freedom	Mean square		
		Number of tillers plant^{-1}		
		Effective	Non-effective	Total
Replication	2	0.128	0.001	0.115
Sowing date (A)	3	0.925**	0.168**	0.806**
Varieties (B)	5	0.596**	0.018*	0.431**
Interaction (A×B)	15	0.554**	0.021**	0.432**
Error	46	0.140	0.006	0.133

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

Appendix IX. **Analysis of variance of the data on ear length, spikelets spike^{-1} and fertile floret spikelet^{-1} as influenced by different sowing dates and wheat varieties**

Source of variation	Degrees of freedom	Mean square		
		Ear length (cm)	Spikelets Spike^{-1}	Fertile floret Spikelet^{-1}
Replication	2	0.008	0.349	0.004
Sowing date (A)	3	3.615**	96.792**	1.271**
Varieties (B)	5	10.154**	5.490**	0.380**
Interaction (A×B)	15	2.366**	6.309**	0.262**
Error	46	0.768	1.500	0.049

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

Appendix X. **Analysis of variance of the data on stem, ear, seed, husk, root and total dry matter content plant^{-1} at maturity as influenced by different sowing dates and wheat varieties**

Source of variation	Degrees of freedom	Mean square				
		Dry matter content plant^{-1} (g)				
		Stem	Ear	Seed	Husk	Root
Replication	2	0.115	0.040	0.036	0.003	0.010
Sowing date (A)	3	5.092**	0.739**	1.982**	0.611**	0.394**
Varieties (B)	5	2.520*	0.106**	1.180**	0.280**	0.051**
Interaction (A×B)	15	3.269**	0.145**	1.079**	0.105**	0.066**
Error	46	0.971	0.031	0.370	0.015	0.015

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

Appendix XI. **Analysis of variance of the data on no. of filled, no. of unfilled and no. of total grains spike^{-1}as influenced by different sowing dates and wheat varieties**

Source of variation	Degrees of freedom	Mean square			
		No. of filled grains spike^{-1}	No. of unfilled grains spike^{-1}	No. of total grains spike^{-1}	1000 seeds weight (g)
Replication	2	48.320	0.061	51.817	0.096
Sowing date (A)	3	109.666**	0.460**	97.125**	43.828**
Varieties (B)	5	83.305**	0.533**	71.533**	17.917*
Interaction (A×B)	15	127.912**	0.426**	117.018**	17.525**
Error	46	21.798	0.093	21.281	6.070

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

Appendix XII. Analysis of variance of the data grain and straw yield as influenced by different sowing dates and wheat varieties

Source of variation	Degrees of freedom	Mean square					
		Grain		Straw		Biological yield ($t\ ha^{-1}$)	Harvest Index (%)
		Yield ($g\ m^{-2}$)	Yield ($t\ ha^{-1}$)	Yield ($g\ m^{-2}$)	Yield ($t\ ha^{-1}$)		
Replication	2	141.922	0.014	88.010	0.009	0.040	0.476
Sowing date (A)	3	21884.9 **	2.188**	9575.9 **	0.958**	5.991**	30.28**
Varieties (B)	5	2527.96**	0.253**	4541.3**	0.454**	1.314**	2.643
Interaction (A×B)	15	1664.23**	0.166**	5437.8**	0.544**	1.176**	6.343**
Error	46	621.314	0.062	970.256	0.097	0.194	4.398

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