INFLUENCE OF SOWING DATE ON THE GROWTH AND YIELD OF WHEAT VARIETIES

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MASTER OF SCIENCE

IN

AGRONOMY

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DHAKA-1207

JUNE, 2014

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By

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REGISTRATION NO. 06-02121

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

MASTER OF SCIENCE

IN

AGRONOMY

SEMESTER: JANUARY-JUNE, 2014

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CERTIFICATE

This is to certify that the thesis entitled, **"INFLUENCE OF SOWING DATE ON THE GROWTH AND YIELD OF WHEAT VARIETIES"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN AGRONOMY,** embodies the result of a piece of *bona fide* research work carried out by **MASUDUR RAHAMAN,** Registration No. **06-02121** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Dated: **(Prof. Dr. A.K.M. Ruhul Amin)**

Place: Dhaka, Bangladesh **Research Supervisor**

DEDICATED TO
MY
BELOVED PARENTS

ACKNOWLEDGEMENTS

Alhamdulillahi Rabbil Al-Amin, all praises are due to the almighty Allah Rabbul Al-Amin for His gracious kindness and infinite mercy in all the endeavors the author to let him successfully complete the research work and the thesis leading to Master of Science.

The author would like to express his heartfelt gratitude and most sincere appreciations to his Supervisor Prof. Dr. A.K.M. Rahul Amin, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his valuable guidance, advice, immense help, encouragement and support throughout the study. Likewise grateful appreciation is conveyed to Co-supervisor Prof. Dr. Tuhin Suvra Roy, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for constant encouragement, cordial suggestions, constructive criticisms and valuable advice to complete the thesis.

The author would like to express his deepest respect and boundless gratitude to all the respected teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, sympathetic co-operation, and inspirations throughout the course of this study and research work.

The author wishes to extend his special thanks to M. Shamim Hasan Mandal, M. Anisur Rahaman for their help during experimentation. Special thanks to all of his friends for their support and encouragement to complete this study.

The author is deeply indebted and grateful to his parents, brother, sister and other relative's for their moral support, encouragement and love with cordial understanding.

Finally, the author appreciate the assistance rendered by the staff member of the Department of Agronomy and farm, Sher-e-Bangla Agricultural University, Dhaka, who have helped him during the period of study.

The Author

INFLUENCE OF SOWING DATE ON THE GROWTH AND YIELD OF WHEAT VARIETIES

ABSTRACT

A field experiment was conducted at the Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November, 2012 to March, 2013 in *rabi* season with a view to find out the optimum sowing date for maximum growth and yield of wheat varieties. The experiment was carried out with three wheat varieties *i.e.* V_1= BARI Gom 21, V_2 = BARI Gom 23 and V_3= BARI Gom 24 and five different sowing dates viz. S_1= 10th November 2012, S_2= 20th November 2012, S_3= 30th November 2012, S_4=10th December 2012, S_5= 20th December 2012 following Randomized Complete Block Design (RCBD) with three replications. The results revealed that among the wheat varieties BARI Gom 24 (V_3) performed best and recorded the highest grain yield (4.51 t ha^{-1}). On the other hand, November 20th, 2012 (S_2) performed better than the other sowing date treatments and recorded the highest grain yield (4.81 t ha^{-1}). Gradual decrease of growth parameters, yield attributes and yield was observed when wheat seeds were planted later than November 20th, 2012. Based on above findings it can be concluded that, wheat seeds of BARI Gom 24 should be sown on 20th November for maximum wheat grain yield. And planting wheat seeds later than 20th November should be discouraged as it reduces wheat yield.

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LIST OF ACRONYMS

AEZ	=	Agro- Ecological Zone
AIS	=	Agriculture Information Service
BARC	=	Bangladesh Agricultural Research Council
BBS	=	Bangladesh Bureau of Statistics
B:C	=	Benefit Cost ratio
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centi-meter
cv.	=	Cultivar
DAT	=	Days after transplanting
^{0} C	=	Degree Centigrade
DF	=	Degree of freedom
EC	=	Emulsifiable Concentrate
et al.	=	and others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram
HI	=	Harvest Index
hr	=	hour
IRRI	=	International Rice Research Institute
Kg	=	kilogram
LV	=	Local variety
LYV	=	Low yielding varieties
LSD	=	Least significant difference
m	=	Meter
m^2	=	meter squares
MV	=	Modern variety
mm	=	Millimeter
viz.	=	As follows
ns	=	Non significant
%	=	Percent
CV %	=	Percentage of Coefficient of Variance
ppm	=	Parts per million
SAU	=	Sher-e- Bangla Agricultural University
BAU	=	Bangladesh Agricultural University
t ha^{-1}	=	Tons per hectare

Chapter 1

INTRODUCTION

CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the world's most widely cultivated cereal crop and it covers the more earth's surface area than any other food crop and wheat production is the third largest cereal production in the world, after maize and rice (FAO, 2013). Wheat is regarded as the key to the emergence of urban societies for millennia by FAO (FAO, 2013). One cup whole wheat grain contains 33% Protein, 29% Carbohydrate, 5% Fat (USDA, 2014). Currently about 65% of wheat crop is used for food, 17% for animal feed and 12% in industrial applications (FAO, 2013). By 2050, the demand for wheat in the developing world is projected to increase 60% from now (CIMMYT, 2013).

In Bangladesh, wheat is the second important cereal crop next to rice (Al-Musa *et al.*, 2012) and the area under wheat cultivation during 2012 was about 0.47 million ha producing 1.38 million ton of wheat with an average yields of 3.32 ton ha^{-1} (BBS, 2013). But the average yield of wheat is very low compared to the average yield of Newzealand, Nethrlands, Ecuador,and France (8.9, 8.6, 8.0, and 7.6 t ha^{-1} respectively) (FAO, 2013). However, the average yield of wheat in Bangladesh can be raised up to 6.8 t ha^{-1} (BARI, 2010).

Moreover, scarcity of food has become a chronic problem of this country. So, the cereal crop production like wheat should be increased to meet the demand of the increasing population. The yield of wheat can be augmented with the use of high yielding varieties and suitable agronomic practices. However, horizontal expansion of wheat area is not possible in Bangladesh due to limited land resources and high population density. So the only avenue left is to increase production of wheat by vertical means i.e. management practices.

Planting the right variety at the right time ensures that wheat flowers at the optimal time, namely when the risk for freeze damage is at its lowest but before the onslaught of heat stress. Soil moisture conditions are another critical

consideration. The key to maximizing wheat yields rides on two related decisions: choosing the right variety and planting it at the right time to ensure optimal flowering and, ultimately, maximum yield. The problem with variety selection and planting is that there are no hard-and-fast rules. Both decisions are essentially a compromise with Mother Nature. Opting to plant early can improve crop establishment but can also cause early flowering, which increases the risk of frost damage. Early planted wheat is also more prone to pests and diseases. So, to select the best variety for a particular area is very difficult and requires field trails.

Among the factors influencing wheat production, the sowing date is of particular importance. This in turn is closely correlated with soil preparation, which has a decisive effect on the periodicity of weed seed germination, allowing the weed species composition to be controlled (Berzsenyi, 2000). The majority farmers in this country usually grow wheat in the same land after T. aman rice harvest and thus, sowing of wheat is often delayed. Sowing of wheat in Bangladesh generally starts from November and ends in late December depending on the weather, topography and harvesting of the preceding crops.

Due to late sowing, the wheat crop experiences high temperature during flowering stage, which results in grain sterility. Under late sown conditions, as wheat plant face low temperature in the earlier part and high temperature in the later part of the growing season it requires favorable moisture for better growth and development. Despite the constraint that winter in Bangladesh is short and moreover, mild compared to the traditional wheat growing countries in the world, the crops has nicely adapted to this climate. Late sowing coupled with boron deficiency might be the principal reason for low productivity of wheat in Bangladesh (Razzaque and Hossain, 1991; Jahiruddin *et al*., 1992; Hossain *et al.*, 1994 and Saifuzzaman, 1996).

When examining the effect of sowing date and N fertilization on wheat crops, Fodor and Pálmai (2008) found that wheat produced less biomass after late sowing, while that of weeds was greater. Therefore, sowing date influences the growth, development and yield of wheat.

Objectives:

1. Compare yield of different varieties according to sowing dates and
2. Find out the effect of sowing dates on different varieties of wheat
3. Identify suitable combination of varieties and date of sowing for wheat cultivation

Chapter 2

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Wheat (*Triticum aestivum* L.) has been established as the second most economic food grain crop to minimize the gap between food production and import in Bangladesh. Selection and identification of right sowing time for wheat varieties is very important. Related research findings on influence of planting time on the growth, yield and yield components of wheat varieties have been reviewed in this chapter.

2.1 Effect of variety

2.1.1 Effect on growth characters

2.1.1.1 Effect on plant height

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected three wheat varieties viz. BARI Gom 19 (Sourov), BARI Gom 21 (Shatabdi) and BARI Gom 24 (Prodip) for their study. They found that, plant height responded significantly among the varieties. BARI Gom 21 (Shatabdi) had the tallest (80.94 cm) plants, which was significantly different from Sourav (78.75 and BARI Gom 24 (Prodip) (78.58 cm).

Alam *et al.* (2013) conducted an experiment to find out the effect of variety and sowing date on the growth and yield of wheat. They concluded that variety had no significant effect on the plant height of wheat.

2.1.1.2 Effect on tillering pattern

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected three wheat varieties viz. BARI Gom 19 (Sourov), BARI Gom 21 (Shatabdi) and BARI Gom 24 (Prodip). They found no significant effect of variety on tillering of the wheat plant.

Tahir *et al*. (2009) conducted a study to find out the effect of sowing date on the yield of wheat and they observed that early sowing resulted in higher dry matter accumulation and total number of tillers per m^2.

2.1.2 Effect on yield and yield contributing characters

2.1.2.1 Effect on spike length (cm)

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected three wheat varieties viz. BARI Gom 19 (Sourov), BARI Gom 21 (Shatabdi) and BARI Gom 24 (Prodip). They found that the wheat variety produced significant effect on spike length. BARI Gom 24 (Prodip) variety produced longer spike than the other two varieties did. The longest spike was found in variety BARI Gom 24 (Prodip) (10.88 cm) and the smallest in BARI Gom 21 (Shatabdi) (8.76 cm).

2.1.2.2 Effect on number of spikelets spike^{-1}

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected three wheat varieties viz. BARI Gom 19 (Sourov), BARI Gom 21(Shatabdi) and BARI Gom 24 (Prodip). They found that variety had a significant influence on the number of spikelets spike^{-1}. The highest number of spikelets spike^{-1} was recorded with Prodip variety (18.31) and the lowest number of spikelets spike^{-1} with Shatabdi variety (16.20).

2.1.2.3 Effect on number of grains spike^{-1}

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected three wheat varieties viz. BARI Gom 19 (Sourov), BARI Gom 21 (Shatabdi) and BARI Gom 24 (Prodip). They found that the variety had significant influence on the number of grains spike^{-1}. The highest number of grains spike^{-1} was recorded for Sourav variety (29.83) and the lowest number of grains spike^{-1} was recorded for Shatabdi variety (26.88).

2.1.2.4 Effect on 1000 grain weight (g)

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected three wheat varieties viz. BARI Gom 19 (Sourov), BARI Gom 21 (Shatabdi) and BARI Gom 24 (Prodip). They found that the 1000-grain weight varied with the varieties and concluded that this might be the varietal characteristics. The 1000-grain weight for Prodip was 42.45g, Shatabdi was 41.25g and Sourav was 41.00g.

2.1.2.5 Effect on grain yield, straw yield and biological yield

Kumar *et al.* (2013) conducted an experiment to find out the effect of sowing dates on several wheat varieties and they found significant influence of variety on the grain yield of what.

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected three wheat varieties viz. BARI Gom 19 (Sourov), BARI Gom 21 (Shatabdi) and BARI Gom 24 (Prodip). They found that the grain yield varied with varieties. Sourav produced the highest yield (2694 kg ha^{-1}) and Shatabdi did the lowest (2510 kg ha^{-1}).

Islam and Jahiruddin (2008) found that the straw yield of wheat was significantly affected by crop variety. Shatabdi variety demonstrated the highest straw yield (4355 kg ha^{-1}) and the other two varieties viz. Prodip and Sourav showed an identical yield. Hossain *et al.* (1994) also found similar results.

Kumar *et al.* (2013) conducted an experiment to find out the effect of sowing dates on several wheat varieties and they concluded that there were no significant variations of straw yield due to wheat variety.

2.1.2.6 Effect on harvest index

Kumar *et al.* (2013) conducted an experiment to find out the effect of sowing dates on several wheat varieties and they concluded that the harvest index of wheat was affected significantly by wheat variety.

2.2 Effect of sowing date

2.2.1 Effect on growth characters

2.2.1.1 Effect on plant height

Alam *et al.* (2013) conducted an experiment to find out the effect of variety and sowing date on the growth and yield of wheat. They concluded that, date of sowing significantly influenced the plant height. Plant height was significantly more on 25th November than the 20th December.

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected four sowing dates viz. November 18, November 28, December 08 and December 18 and found that plant height did not respond significantly to the sowing dates.

2.2.1.2 Effect on tillering pattern

Alam *et al.* (2013) conducted an experiment to find out the effect of variety and sowing date on the growth and yield of wheat. They concluded that, date of sowing significantly influenced the total number of tillers per m^2 at maturity. Total tiller per m^2 were significantly more on 25th November than the 20th December.

Hossain *et al.* (2013) conducted an experiment to find out the growth, yield performance of eight wheat genotypes under heat stress conditions. They found that the number of total tillers of wheat cultivars was significantly affected by sowing date.

Islam and Jahiruddin (2008) found significant variation of tillering due to sowing dates. The maximum tillering was found in the 2nd sowing (28 November) and minimum in the 4th sowing (18 December). The highest number of tillers plant^{-1} (4.26) was observed at 28 November sowing and the lowest tillers plant^{-1} (3.52) at 18 December was sowing.

2.2.1.3 Effect on leaf area index

Alam *et al.* (2013) conducted an experiment to find out the effect of variety and sowing date on the growth and yield of wheat. They found significantly higher number of leaf area index in the treatment where wheat was sown at 25th November as compared to 20th December.

Haider (2007) conducted an experiment on several wheat varieties to find out the effect of sowing dates and found that LAR increased in few cases at early stage but in all cases declined steadily with increasing plant age.

2.2.2 Effect on yield contributing characters

2.2.2.1 Effect on spike length (cm)

Alam *et al.* (2013) conducted an experiment to find out the effect of variety and sowing date on the growth and yield of wheat. They found significantly longer spike length in the treatment where wheat was sown at 25th November as compared to 20th December.

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected four sowing dates viz. November 18, November 28, December 08 and December 18 and found that the sowing dates produced significant effect on spike length. The longest spike was recorded from 28 November sowing (10.45 cm) and the lowest was found on 18 December sowing (9.28 cm).

2.2.2.2 Effect on number of spikelets spike^{-1}

Alam *et al.* (2013) conducted an experiment to find out the effect of variety and sowing date on the growth and yield of wheat. They found significantly higher number of spikelets spike^{-1} in the treatment where wheat was sown at 25th November as compared to 20th December.

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected four sowing dates viz. November 18, November 28, December 08 and December 18. They found that sowing date had a significant influence on the number of spikelets spike^{-1} and the second sowing (28 November) produced the highest number of spikelets spike^{-1} (18.93) and the last sowing (18 December) had the lowest number of spikelets spike^{-1} (16.13).

2.2.2.3 Effect on number of grains spike^{-1}

Alam *et al.* (2013) conducted an experiment to find out the effect of variety and sowing date on the growth and yield of wheat. They found significantly higher number of grains spike^{-1} in the treatment where wheat was sown at 25th November as compared to 20th December.

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected four sowing dates viz. November 18, November 28, December 08 and December 18. The 28 November sowing gave the highest number of grains spike^{-1} (31.81) and the 18 December sowing did the lowest number of grains spike^{-1} (23.18).

2.2.2.4 Effect of weight of 1000 grain (g)

Alam *et al.* (2013) conducted an experiment to find out the effect of variety and sowing date on the growth and yield of wheat. They found significantly higher weight of 1000-grain in the treatment where wheat was sown at 25th November as compared to 20th December.

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected four sowing dates viz. November 18, November 28, December 08 and December 18. They found that the 1000-grain weight varied with sowing dates. The highest 1000-grain weight was recorded in the 18 November sowing (48.45 g) and the lowest 1000-grain weight was recorded in the 18 December sowing (36.75 g) (Table 1).

Patil *et al.* (2003) conducted an experiment to find out the effect of temperatures on wheat and found that the 1000-grain weight decreased significantly with delay in sowing dates

2.2.2.5 Effect on grain yield, straw yield, biological yield

Ram *et al.* (2012) reported higher grain yield in case of timely planting wheat due to increased higher growing degree days, photo-thermal units and yield attributes.

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected four sowing dates viz. November 18, November 28, December 08 and December 18. They concluded that there was no significant difference in yield among the three varieties. The 28 November sowing had the highest yield (3330 kg ha^{-1}). The yield recorded from the last sowing (18 December) was remarkably low (1879 kg ha^{-1}).

Shirpurkar *et al.* (2006) conducted an experiment to find the effect of sowing dates on the yield of wheat. They concluded that the grain yield decreased as the date of sowing was delayed, particularly after 26th November.

Kumar *et al.* (2013) conducted an experiment to find out the effect of sowing dates on several wheat varieties and they found significant variation in grain yield due to owing dates.

Hossain *et al.* (2013) conducted an experiment to find out the growth, yield performance of eight wheat genotypes under heat stress conditions. They found that the grain yield of wheat cultivars was significantly affected by sowing date. Higher grain yield was observed in early planting than the late planting.

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected four sowing dates viz. November 18, November 28, December 08 and December 18. They found that the straw yield of wheat was significantly affected by the sowing dates. The straw yield was recorded maximum for the 28 November sowing (4712 kg ha^{-1}) and minimum for the 18 December sowing (3456 kg ha^{-1}). Hossain *et al.* (1994) also found similar results.

Kumar *et al.* (2013) conducted an experiment to find out the effect of sowing dates on several wheat varieties and they concluded that significant variation of straw yield due to various sowing dates.

2.2.2.6 Effect on harvest index

Alam *et al.* (2013) conducted an experiment to find out the effect of variety and sowing date on the growth and yield of wheat. They concluded that, date of sowing significantly influenced harvest index of wheat. Harvest index of wheat was significantly more on 25^{th} November than the 20^{th} December.

Kumar *et al.* (2013) conducted an experiment to find out the effect of sowing dates on several wheat varieties and they concluded that the harvest index of wheat was affected significantly by date of sowing.

2.2.3 Interaction effect of variety and sowing date

Islam and Jahiruddin (2008) conducted an experiment to find out the effect of sowing dates on wheat varieties. They selected three wheat varieties viz. BARI Gom 19 (Sourov), BARI Gom 21 (Shatabdi) and BARI Gom 24 (Prodip) and four sowing dates viz. November 18, November 28, December 08 and December 18. And they found no significant interaction between sowing dates and variety in terms of plant height, tillers plant^{-1}, spike length, spikelets spike^{-1}, 1000- grain weight, straw yield. But significant variation was observed in case of grains spike^{-1} and grain yield,

Mandal and Das (1988) also reported that there were no significant interaction between wheat variety and sowing dates in case of plant height, tiller production and spike length.

Kumar *et al.* (2013) conducted an experiment to find out the effect of sowing dates on several wheat varieties and they found significant interaction between variety and sowing dates on the grain yield and straw yield of wheat.

Chapter 3

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, intercultural operations, data collection and statistical analyses.

3.1 Location

The field experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from October 2012 to March 2013. Geographically the experimental field is located at 23°46' N latitude and 90° 22' E longitude (Google maps, 2014) at an elevation of 8.2 m above the sea level belonging to the Agro-ecological Zone "AEZ-28" of Madhupur Tract (BBS, 2011).

3.2 Soil

The soil of the research field is slightly acidic in reaction with low organic matter content. The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. The experimental plot was also high land, having p^H 5.8.

3.3 Climate

The experimental area is situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of April to September (Kharif Season) and scanty rainfall during the rest period of the year (Biswas, 1987). The Rabi season (October to March) is characterized by comparatively low temperature and plenty of sunshine from November to February (SRDI, 1991).

3.4 Plant materials and features

Wheat Research Centre, Bangladesh Agricultural Research Institute (BARI) so far released 28 wheat varieties. BARI Gom 21, BARI Gom 23 and BARI Gom 24 were used as plant material for the present study. Seeds were collected from the Wheat Research Centre, BARI, Joydebpur, Gazipur.

3.5 Treatments

The experiment consisted of two treatment factors as mentioned below:

a) Factor A: Variety (3)

V_1= BARI Gom 21 (Shatabdi)

V_2= BARI Gom-23 (Bijoy)

V_3=BARI Gom-24 (Prodip)

b) Factor B: Sowing dates (5)

S_1= 10th November 2012

S_2= 20th November 2012

S_3= 30th November 2012

S_4= 10th December 2012

S_5=20th December 2012

3.6 Design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The size of the individual plot was 4.0 m x 2.5 m and total numbers of plots were 45. There were 15 treatment combinations. Each block was divided into 15 unit plots. Layout of the experiment was done on November 9, 2012 with interplot spacing of 0.50 m and inters block spacing of 1.0 m.

3.7 Land preparation

The land of the experimental field was first opened on October 12, 2012 with a power tiller. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field. The soil was treated with Furadan 5G was used @ 8 kg ha^{-1} to protect young plants from the attack of mole cricket, ants, and cutworms.

3.8 Fertilizer application

All the fertilizers were applied at the rate of BARI recommended dose as 200 kg ha^{-1} Urea, 180 kg ha^{-1} TSP, 50 kg ha^{-1} MOP, 120 kg ha^{-1} Gypsum (BARI, 2010). Fertilizers other than nitrogen were given during final land preparation.

3.9 Seed treatment

Seeds were treated with Vitavex-200 @ 0.25% before sowing to prevent seeds from the attack of soil borne disease.

3.10 Seed sowing

Seeds were sown according to treatment dates continuously in 20 cm apart rows opened by specially made iron hand tine. The seed rate was 120 kg ha^{-1}. After sowing, the seeds were covered with soil and slightly pressed by hands.

3.11 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop.

3.11.1 Thinning

Emergence of seedling was completed within 10 days after sowing. Overcrowded seedlings were thinned out for two times. First thinning was done after 15 days of sowing which was done to remove unhealthy and lineless seedlings. The second thinning was done 10 days after first thinning keeping one or two or three healthy seedlings in each hill according to the treatment.

3.11.2 Weeding

The experimental field was kept free from weeds by mechanical weeding as per requirements.

3.11.3 Irrigation

The first irrigation was done at 21 DAS, crown root initiation stage. Second irrigation was provided at 55 DAS which was the panicle initiation stage of wheat and the last irrigation was done at 75 DAS, grain filling stage. Proper drainage system was also made for draining out excess water.

3.11.4 Disease and pest management

Mole cricket and cutworm attacked the crop during the early growing stages of seedlings. Spraying Diazinon 60EC controlled these insects. The insecticide was sprayed three times at seven days interval.

3.12 General observations of the experimental field

Regular observations were made to see the growth stages of the crop. In general, the field looked nice with normal green plants which were vigorous and luxuriant in the treatment plots than that of control plots.

3.13 Sampling

Ten plants of the inner rows were selected randomly and tagged properly. All the growth characters data were taken from these 10 plants at maturity.

3.14 Harvest and post-harvest operation

The crop was harvested when it reached maturity. At maturity, when leaves, stems and pods became yellowish in colors, then the plants were harvested. One square meter area from the central position of each plot was harvested for yield data and it was converted to t ha^{-1}. The harvested plants were tied into bundles and carried to the threshing floor. The crops were sun dried by spreading on the threshing floor. The seeds were separated from the plants by pedal thresher and thereafter were cleaned, dried and weighed. The weights of the dry straw were also taken from the same demarcated area and were converted to t ha^{-1}.

3.15 Collection of data

3.15.1 Crop growth parameters

a. Plant height (cm) at 30 DAS after that 15 days interval up to harvest.
b. Number of total tillers m^{-2} at 30 DAS after that 15 days interval up to harvest.
c. Leaf area index 30 DAS after that 15 days interval up to 75DAS.

3.15.2 Yield contributing characters

a. Effective tillers m^{-2}
b. Spike length (cm)
c. Number of spikelets $spike^{-1}$
d. Number of filled grains $spike^{-1}$
e. Weight of 1000 grains (g)

3.15.3 Yield and harvest index

a. Grain yield (t ha^{-1})
b. Straw yield (t ha^{-1})
c. Biological yield (t ha^{-1})
d. Harvest index (%)

3.16 Procedure of sampling for growth study during the crop growth period

Plant height (cm)

The height of the wheat plants was recorded from 30 days after sowing (DAS) at 15 days interval up to 75 DAS. Height of the plant was measured from the ground level up to tip of the flag leaf. The average height of ten preselected plants was considered as the height of the plant for each plot.

Number of tillers m^{-2}

Total tiller number was taken from 30 DAS at 15 days interval up to 75 DAS. The average number of tillers of one linear meter was counted and then multiplied with wheat row per meter.

Leaf area index

Leaf area index was taken from 30 DAS at 15 days interval up to 75 DAS.

3.17 Procedure of data collection for yield and yield components

For assessing attributes, data were collected from 10 randomly selected plants from each of the plots. For yield measurement, an area of 1.0 m^2 from center of each plot was harvested.

Number of effective tillers m^{-2}

The panicles which had at least one grain was considered as effective tiller. The average number of effective tillers of one linear meter was counted and then expressed as effective tiller per m^2.

Spike length (cm)

The length of spike was measured by using a meter scale. The measurement was taken from the base to tip of the spike. Average length of spike was taken

from ten randomly selected spikes from inner row plants of each plot. Data was recorded at harvest time. Mean data was expressed in centimeter (cm).

Number of spikelets spike^{-1}

Data on the number of spikelets spike^{-1} was counted. Ten spike bearing plants were randomly selected and the average data were collected from inner rows of each plot except harvest area during the time of harvesting.

Number of filled grains spike^{-1}

Presence of any food material in the grains was considered as filled grain. The total numbers of filled grains from randomly selected 10 spikes were counted and average them to have the number of filled grains spike^{-1}.

Weight of 1000 grains (g)

One thousand cleaned dried grains were randomly collected from the seed stock of each plot and were sun dried properly at 14% moisture content and weight by using an electric balance.

Grain and straw yield (t ha^{-1})

An area of 1.0 m^2 was harvested for yield measurement. The crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were threshed and dried in open sunshine and then grains were cleaned. The grain and straw weights for each plot were recorded after proper drying in sun.

Biological yield

Biological yield was calculated by using the following formula:

Biological yield= Grain yield + straw yield

Harvest index (%)

Harvest index is the relationship between grain yield and biological yield (Gardner *et al.,* 1985). It was calculated by using the following formula:

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.18 Statistical analysis

The recorded data were subjected to statistical analysis. Analysis of variance was done following two factors Randomized Complete Block Design with the help of computer package MSTAT-C. The mean differences among the treatments were adjusted by Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

Chapter 4

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

4.1. Crop growth characters

4.1.1 Plant height

4.1.1.1 Effect of variety

Plant height varied significantly among the tested three varieties (Fig. 1). At, 30 DAS, BARI Gom 24 showed the tallest plant height (30.14 cm) and BARI Gom 21 recorded the shortest plant height (23.81cm) which was statistically similar with BARI Gom 23. At, 45 DAS, BARI Gom 24 recorded the highest plant height (45.28 cm) which was statistically similar with BARI Gom 23. However, BARI Gom 21 recorded the shortest plant height (39.84 cm) which was also statistically similar with BARI Gom 23. Similar trend was observed at 60 and 75 DAS where BARI Gom 24 recorded the highest plant height and BARI Gom 21 recorded the lowest plant height. Both were statistically similar with BARI Gom 23. At harvest,

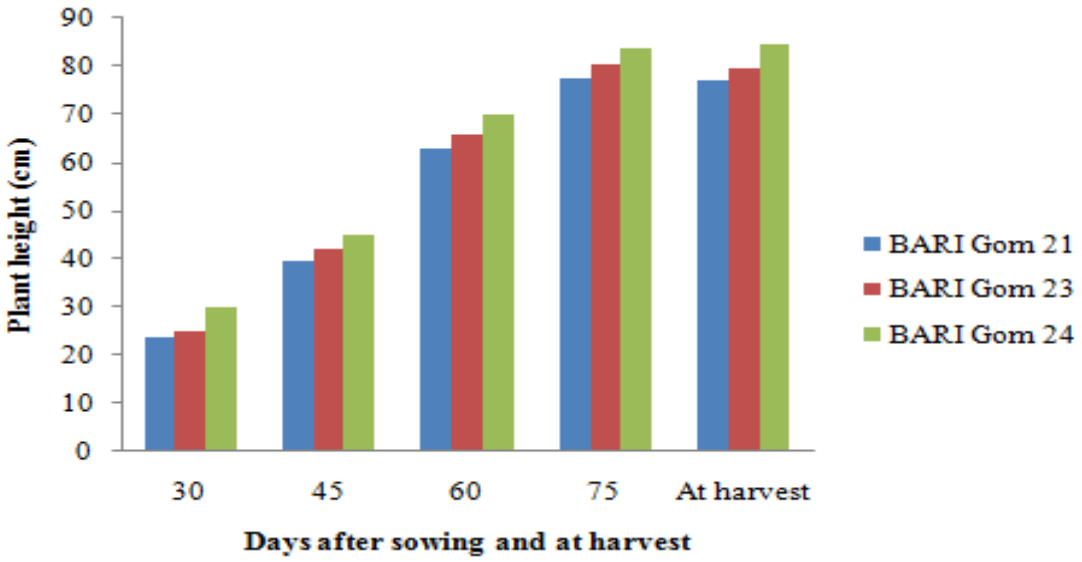

Fig. 1. Effect of variety on the plant height (cm) of wheat at different days after sowing (SE= 1.05, 1.08, 1.60, 1.59 and 1.65 for 30, 45, 60, 75 DAS and at harvest respectively**)**

the tallest plant (84.65 cm) was observed in BARI Gom 24. BARI Gom 21 recorded the shortest plant (77.06 cm) which was statistically similar with BARI Gom 23. Islam and Jahiruddin (2008) also concluded that plant height varied significantly due to various wheat varieties.

4.1.1.2 Effect of sowing date

Plant height varied significantly due to various sowing dates (Fig. 2). At 30 DAS, S_2 showed the tallest plant (29.39 cm) which was statistically similar with S_1, S_3 and S_4. However, the shortest plant (21.70 cm) was observed in S_5. At 45 DAS, S_2 recorded the highest (48.14 cm) plant height which was statistically similar with S1. The lowest plant height (35.57 cm) was observed in case of treatment S_5. At 60 DAS, S_2 again produced the highest plant height which was statistically similar with S_1 and S_3. Meanwhile, the lowest plant height (59.36 cm) was observed in S_5 which was statistically similar with S4.

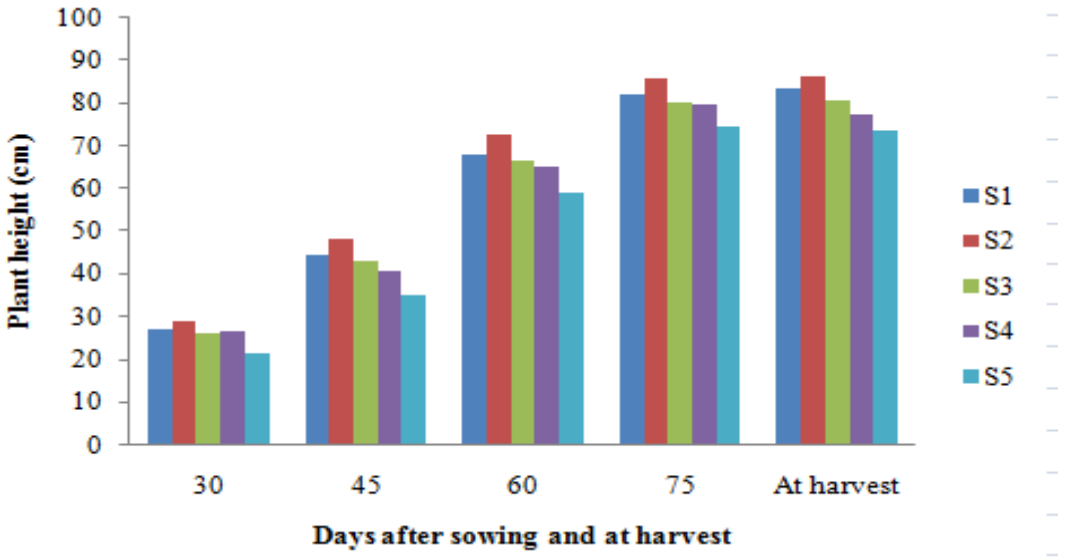

Fig. 2. Effect of sowing date on the plant height (cm) of wheat at different days after sowing (SE= 1.35, 1.40, 2.06, 2.05 and 2.13 for 30, 45, 60, 75 DAS and at harvest, respectively**)**

At 75 DAS, S_2 again recorded the longest plant (86.14 cm) which was statistically similar with S_1, S_3 and S_4. However, the shortest plant was observed in case of S_5 which was also statistically similar with S_3 and S_4. At

harvest, the longest plant (86.47 cm) was observed in S_2 which was statistically similar with S_1 and S_3. However, S_5 recorded the shortest plant (73.82 cm) which was statistically similar with S_4.

Alam *et al.* (2013) concluded that the date of sowing significantly influenced the plant height of wheat and plant height was higher when planted on 25th November than the 20th December. However, conflicting results were also reported by Islam and Jahiruddin (2008) who found no significant variation of plant height due to planting dates.

4.1.1.3 Interaction of variety and sowing date

Plant height varied significantly due to various treatment combinations of variety and sowing dates (Table 1). At 30 DAS, the treatment combinations of

Table 1. Interaction effect of different wheat varieties and sowing dates on the plant height (cm) of wheat

Treatment combination	Days after sowing and at harvest				
	30	45	60	75	At harvest
V_1S_1	26.52 bc	43.45 b	67.44 ab	81.61 ab	79.03 a-c
V_1S_2	25.35 bc	45.05 b	71.06 ab	83.35 ab	84.06 ab
V_1S_3	25.23 bc	41.66 b	61.52 bc	77.28 bc	78.28 a-c
V_1S_4	24.99 bc	40.07 b	61.91 bc	77.57 bc	75.23 bc
V_1S_5	16.96 d	28.96 c	54.00 c	68.00 c	68.69 c
V_2S_1	25.55 bc	44.03 b	67.06 ab	81.03 ab	83.39 ab
V_2S_2	26.74 bc	46.24 ab	71.52 ab	83.83 ab	85.34 ab
V_2S_3	25.87 bc	42.61 b	67.96 ab	81.61 ab	81.14 ab
V_2S_4	25.04 bc	40.42 b	63.34 bc	78.01 bc	74.63 bc
V_2S_5	22.29 cd	38.00 b	60.00 bc	77.66 bc	73.00 bc
V_3S_1	29.52 a-c	45.74 b	69.33 ab	83.74 ab	88.17 a
V_3S_2	36.07 a	53.13 a	75.59 a	91.26 a	90.01 a
V_3S_3	28.72 a-c	44.62 b	70.32 ab	82.44 ab	82.38 ab
V_3S_4	30.56 ab	43.17 b	70.68 ab	83.68 ab	82.92 ab
V_3S_5	25.85 bc	39.76 b	64.10 a-c	78.44 bc	79.77 a-c
SE	2.35	2.42	3.58	3.55	3.69
CV (%)	15.42	9.88	9.33	7.63	7.94

V_1= BARI Gom 21 (Shatabdi), V_2= BARI Gom 23 (Bijoy), V_3= BARI Gom 24 (Prodip); S_1= 10th November 2012, S_2= 20th November 2012, S_3= 30th November 2012, S_4= 10th December 2012, S_5= 20th December 2012

V_3S_2 recorded the tallest plant (36.07 cm) which was statistically similar with V_3S_1, V_3S_3 and V_3S_4. However, the treatment combination V_1S_5 recorded the shortest plant (16.96 cm). At 45 DAS, the treatment combination of V_3S_2

recorded the tallest plant (53.13 cm) which was statistically similar with V_2S_2. The shortest plant (28.96 cm) height was observed in the treatment combination of V_1S_5.

At 60 DAS, again the treatment combination of V_3S_2 recorded the highest plant height (75.59 cm) which was statistically similar with V_1S_1, V_1S_2, V_2S_1, V_2S_2, V_2S_3, V_3S_1, V_3S_3 and V_3S_4. At 75 DAS, the highest plant height (91.26 cm) was observed from V_3S_2 which was statistically similar with V_1S_1, V_1S_2, V_2S_1, V_2S_2, V_2S_3, V_3S_1, V_3S_3 and V_3S_4. At harvest, again the highest plant height (90.01 cm) was observed in the treatment combination of V_3S_2 which was statistically similar with V_1S_1, V_1S_2, V_1S_3, V_2S_1, V_2S_2, V_2S_3, V_3S_1, V_3S_3 and V_3S_4. The lowest plant height (68.69 cm) was observed in the treatment combination of V_1S_5 which was statistically similar with V_1S_1, V_1S_3, V_1S_4, V_2S_4, V_2S_5 and V_3S_5. Significant variation among the interaction of variety and sowing date was reported by Kumar *et al.* (2013). However, conflicting results were also reported by Islam and Jahiruddin (2008) and Mandal and Das (1988).

4.1.2 Number of total tillers m^{-2}

4.1.2.1 Effect of variety

Number of total tillers m^{-2} did not vary significantly due to various varietal treatments (Figure 3). Islam and Jahiruddin (2008) also reported that the number of total tillers m^{-2} did not vary significantly due to variety. However, At 30 DAS, numerically the highest (229.6) number of total tillers m^{-2} was observed in BARI Gom 23 and BARI Gom 21 recorded the lowest (214.8) number of total tillers m^{-2}. At 45, 60, 75 DAS and at harvest BARI Gom 24 numerically recorded the highest number of total tillers m^{-2} and BARI Gom 21 recorded the lowest number of total tillers m^{-2}.

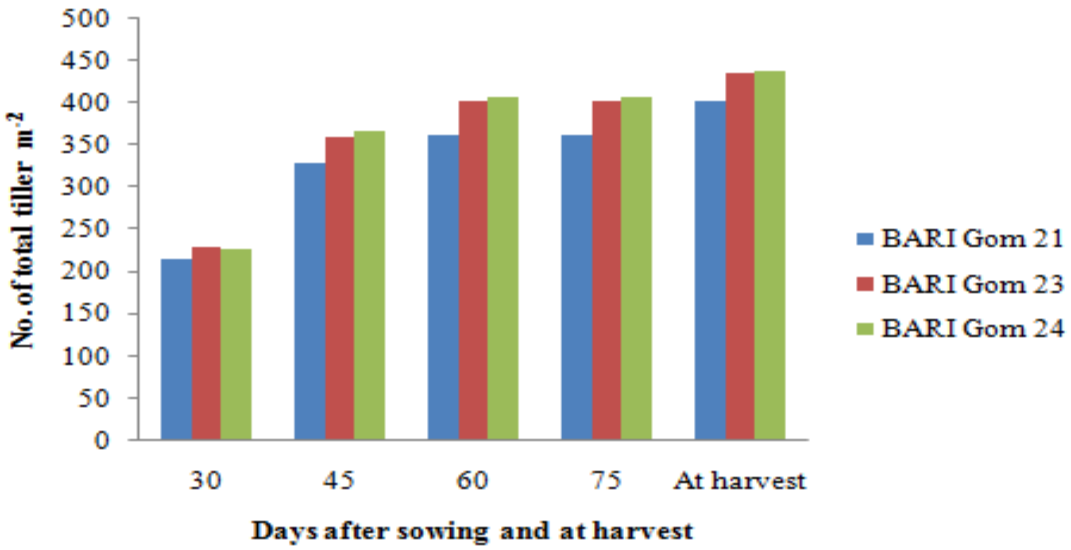

Fig. 3. Effect of variety on the number of total tillers m^{-2} of wheat at different days after sowing and at harvest (SE= 9.04, 20.42, 23.31, 23.31 and 20.93 for 30, 45, 60, 75 DAS and at harvest respectively**)**

4.1.2.2 Effect of sowing date

Number of total tillers m^{-2} also did not vary significantly due to various sowing dates treatments (Fig. 4). However, At 30, 45, 60, 75 DAS and at harvest numerically the highest number of total tillers m^{-2} was observed in S_2 and lowest number of total tillers m^{-2} was observed in S_5. Tahir *et al*. (2009) concluded that early sowing results in total number of total tillers m^{-2}. Total number of total tillers m^{-2} were significantly more on 20th November than the 20th December (Alam *et al.*, 2013; and Islam and Jahiruddin, 2008).

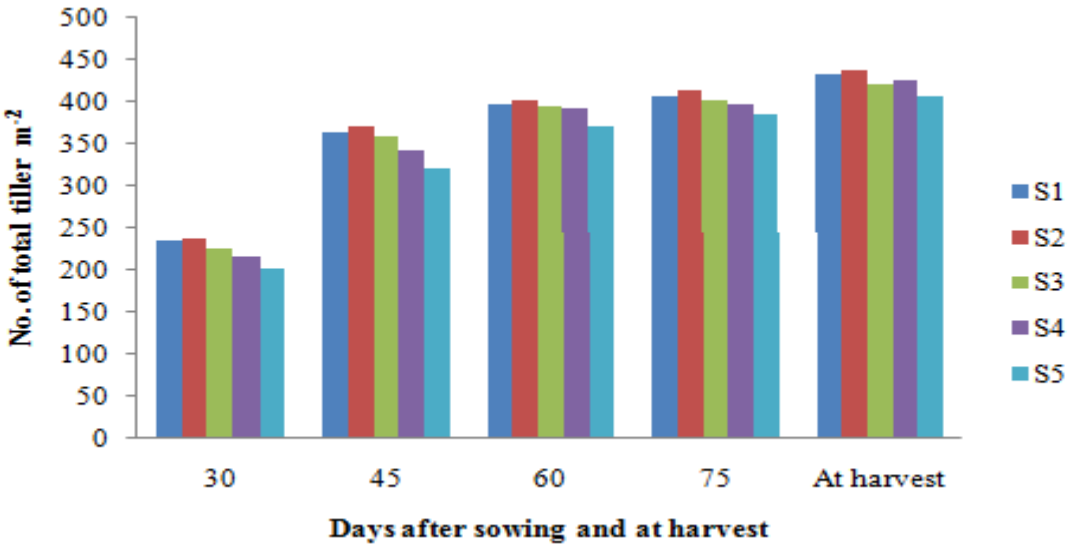

Fig. 4. Effect of sowing date on the number of total tillers m^{-2} of wheat at different days after sowing and at harvest (SE= 11.67, 26.36, 30.09, 32.21 and 27.02 for 30, 45, 60, 75DAS and at harvest respectively**)**

4.1.2.3 Interaction of variety and sowing date

The number of total tillers m^{-2} did not vary significantly due to various treatment combinations of variety and sowing dates (Table 2). However, at 30, 45, 60, 75 DAS and at harvest numerically it was observed that the treatment combination of V_3S_3 recorded the highest number of total tillers m^{-2} and V_1S_5 recorded the lowest number of total tillers m^{-2}.

4.1.3 Leaf area index

4.1.3.1 Effect of variety

Leaf area index of wheat did not vary significantly due to various varietal treatments of wheat (Fig. 5). Leaf area index increased rapidly between 30 DAS and 45 DAS. After that, it increased slowly till 75 DAS. Numerically the highest leaf area index was observed from BARI Gom 23 and lowest leaf area index from BARI Gom 21 for all sampling dates.

Table 2. Interaction effect of variety and sowing date on the number of tillers m^{-2} of wheat

Treatment combination	Days after sowing and at harvest				
	30	45	60	75	At harvest
V_1S_1	227.1	346.0	373.0	382.9	410.0
V_1S_2	228.5	351.9	374.0	384.7	411.7
V_1S_3	223.9	334.3	368.3	379.4	408.0
V_1S_4	209.9	324.4	367.9	377.2	406.7
V_1S_5	184.6	288.7	333.6	352.6	375.2
V_2S_1	234.7	369.9	408.3	414.6	446.3
V_2S_2	238.0	371.8	413.8	421.0	450.3
V_2S_3	230.3	374.2	405.7	412.6	418.6
V_2S_4	227.9	348.7	401.4	404.6	440.3
V_2S_5	216.9	338.7	384.9	399.9	421.9
V_3S_1	243.3	379.5	412.1	423.8	441.4
V_3S_2	248.9	391.5	421.4	435.4	451.9
V_3S_3	224.7	372.9	408.8	416.0	439.4
V_3S_4	215.4	352.4	405.8	410.2	431.8
V_3S_5	206.1	339.1	393.9	405.9	423.0
SE	ns	ns	ns	ns	ns
CV (%)	15.63	22.45	23.06	24.08	19.07

V_1= BARI Gom 21 (Shatabdi), V_2= BARI Gom 23 (Bijoy), V_3= BARI Gom 24 (Prodip); S_1= 10th November 2012, S_2= 20th November 2012, S_3= 30th November 2012, S_4= 10th December 2012, S_5= 20th December 2012

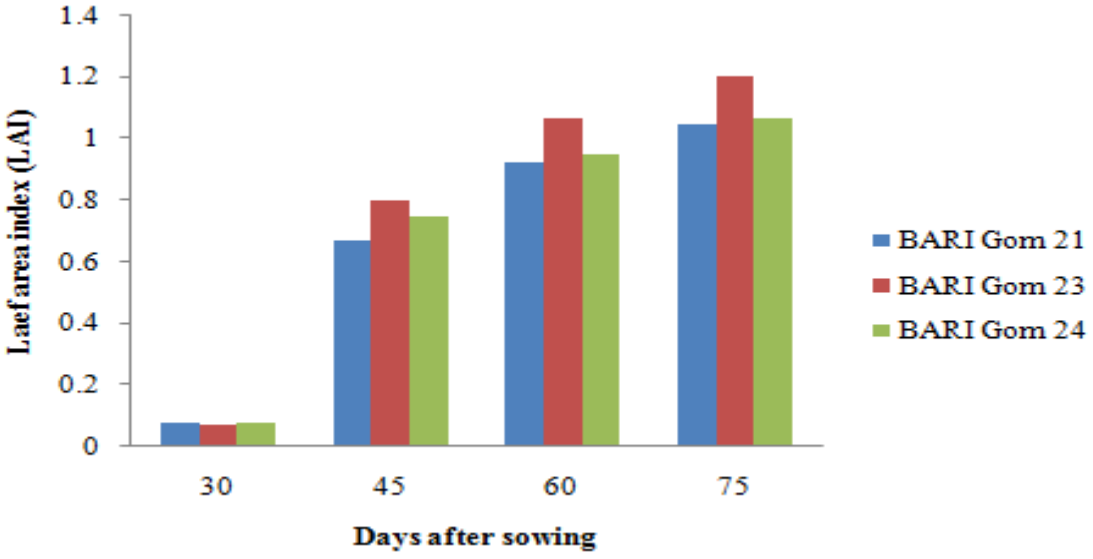

Fig. 5. Effect of variety on the leaf area index of wheat at different days after sowing of wheat (SE= 0.03, 0.07, 0.04 and 0.07 for 30, 45, 60, 75 DAS respectively**)**

4.1.3.2 Effect of sowing date

Leaf area index varied significantly due to different sowing dates (Fig. 6). At 30 DAS, numerically the highest leaf area index (0.10) was recorded from S_2 and lowest (0.05) from S_5. At 45 DAS, S_2 recorded the highest leaf area index (0.98) which was statistically similar with S_1 and S_3. However, the lowest leaf area index (0.51) was recorded from S_5 which was statistically similar with S_4. At 60 DAS, the highest leaf area index (1.27) was observed in S_2 which was statistically similar with S_1 and lowest leaf area index (0.70) was observed in S_5 which was statistically similar with S_4. At 75 DAS, S_2 recorded the highest leaf area index (1.37) which was statistically similar with S_1 and S_3. However, the lowest leaf area index (0.85) was recorded from S_5 which was statistically similar with S_3 and S_4. Similar results were also reported by Alam *et al.* (2013).

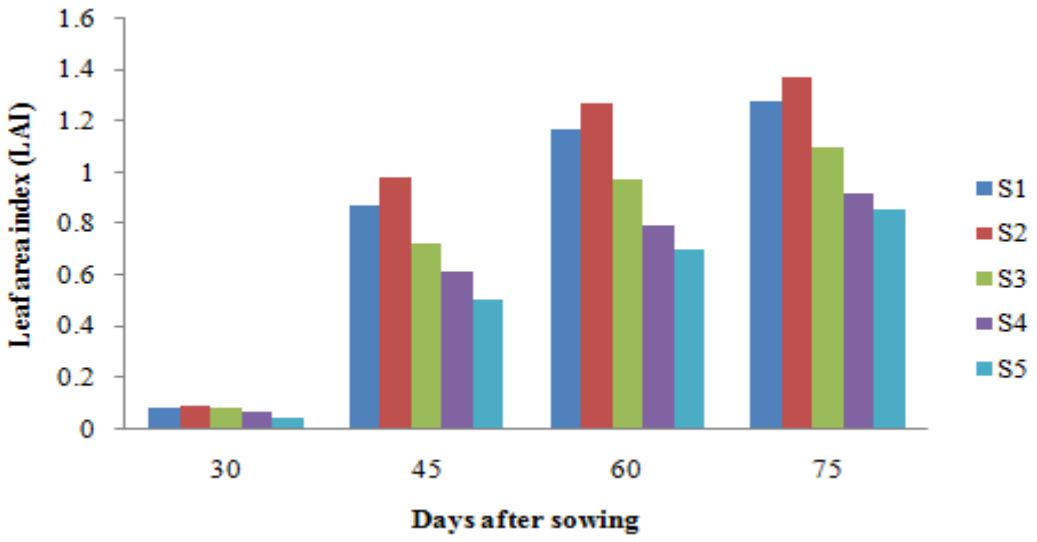

Fig. 6. Effect of sowing date on the leaf area index at different days after sowing of wheat (SE= 0.03, 0.09, 0.06 and 0.09 for 30, 45, 60, 75 DAS respectively**)**

4.1.3.3 Interaction of variety and sowing date

Leaf area index of wheat varied significantly due to various treatment combinations of variety and sowing date at 45, 60 and 75 DAS (Table 3). At 30 DAS, leaf area index did not vary significantly due to treatment combinations of variety and sowing date. Numerically, the highest leaf area index (0.12) was observed in the treatment combinations of V_3S_1 and lowest leaf area index (0.04) was observed from V_3S_5. At 45 DAS, the treatment combination of V_2S_1 produced the highest leaf area index (1.05) which was statistically similar with V_1S_1, V_1S_2, V_1S_3, V_1S_4, V_2S_3, V_2S_4, V_2S_5, V_3S_1, V_3S_2, V_3S_3, V_3S_4 and V_3S_5.

Table 3. Interaction effect of variety and sowing date on the leaf area index of wheat

Treatment combination	Days after sowing			
	30	**45**	**60**	**75**
V_1S_1	0.09	0.71 ab	1.03 b-e	1.14 ab
V_1S_2	0.11	0.91 ab	1.23 a-c	1.34 ab
V_1S_3	0.08	0.72 ab	0.91 c-f	1.05 ab
V_1S_4	0.08	0.55 ab	0.75 ef	0.88 b
V_1S_5	0.04	0.47 b	0.70 f	0.83 b
V_2S_1	0.06	1.05 a	1.37 a	1.48 a
V_2S_2	0.08	1.03 a	1.35 ab	1.46 a
V_2S_3	0.09	0.76 ab	1.08 a-d	1.16 ab
V_2S_4	0.07	0.66 ab	0.83 d-f	0.98 ab
V_2S_5	0.05	0.51 ab	0.72 ef	0.93 ab
V_3S_1	0.12	0.87 ab	1.10 a-d	1.21 ab
V_3S_2	0.09	1.01 ab	1.22 a-c	1.31 ab
V_3S_3	0.09	0.69 ab	0.94 c-f	1.10 ab
V_3S_4	0.05	0.65 ab	0.80 d-f	0.90 b
V_3S_5	0.04	0.54 ab	0.69 f	0.81 b
SE	ns	0.16	0.10	0.16
CV (%)	28.22	37.43	28.61	25.78

V_1= BARI Gom 21 (Shatabdi), V_2= BARI Gom 23 (Bijoy), V_3= BARI Gom 24 (Prodip); S_1= 10th November 2012, S_2= 20th November 2012, S_3= 30th November 2012, S_4= 10th December 2012, S_5= 20th December 2012

At 60 DAS, the highest leaf area index (1.37) was observed in the treatment combinations of V_2S_1 which was statistically similar with V_1S_2, V_2S_2, V_3S_1 and V_3S_2. However, the treatment combinations of V_3S_5 produced the lowest leaf

area index (0.69) which was statistically similar with V_1S_3, V_1S_4, V_1S_5, V_2S_4, V_2S_5, V_3S_3 and V_3S_4. At 75 DAS, the highest leaf area index (1.48) was observed in V_2S_1 which was statistically similar with V_1S_1, V_1S_2, V_1S_3, V_2S_2, V_2S_3, V_2S_4, V_2S_5, V_3S_1, V_3S_2 and V_3S_3.

4.2 Yield contributing characters

4.2.1 No. of effective tiller m^{-2}

4.2.1.1 Effect of variety

Number of effective tillers m^{-2} of wheat varied significantly due to varieties (Table 4). BARI Gom 24 produced the highest number of effective tillers m^{-2} (302.70) and the lowest number of effective tillers m^{-2} (178.50) was observed in BARI Gom 21.

4.2.1.2 Effect of sowing date

Significant variation of effective tillers m^{-2} was observed due to various sowing date treatments (Table 4). It was observed that S_2 produced the highest number of grains $spike^{-1}$ (256.1) and the lowest number of effective tillers m^{-2} (222.30) was observed from S_5.

4.2.1.3 Interaction of variety and sowing date

Number of effective tillers m^{-2} varied significantly due to various treatment combinations of variety and sowing date (Table 4). It was observed that the treatment combination of V_3S_2 produced the highest number of effective tillers m^{-2} (320.4) which was statistically similar with V_3S_1, V_3S_3 and V_3S_4. However, the lowest number of effective tillers m^{-2} (159.10) was observed in V_1S_5 which was statistically similar with V_1S_3 and V_1S_4.

4.2.2 Spike length

4.2.2.1 Effect of variety

Spike length varied significantly due to various varietal treatments (Table 4). BARI Gom 24 (V_3) recorded the highest spike length (17.15 cm) which was statistically similar with BARI Gom 23 (V_2). However, BARI Gom 21 (V_1) recorded the lowest spike length (16.01 cm) which was also statistically similar with BARI Gom 23 (V_2). Islam and Jahiruddin (2008) also reported that BARI Gom 24 produced the longest spike length.

4.2.2.2 Effect of sowing date

Spike length also varied significantly due to various sowing date treatments (Table 4). The highest spike length (18.23 cm) was observed in S_2 which was statistically similar with S_1 and S_3. However, the lowest spike length (14.81 cm) was observed from S_5 which was statistically similar with S4. This results are in agreement with Alam *et al.* (2013) and Islam and Jahiruddin (2008).

4.2.2.3 Interaction of variety and sowing date

Spike length varied significantly due to various treatment combinations of variety and sowing date. The treatment combination of V_3S_2 recorded the highest spike length (19.06 cm) which was statistically similar with V_2S_1, V_2S_2, V_2S_3, V_3S_1 and V_3S_3. However, the lowest spike length (14.29 cm) was obtained from the treatment combination of V_2S_5 which was statistically similar with V_1S_1, V_1S_3, V_1S_4, V_1S_5, V_2S_4, V_3S_4 and V_3S_5.

Table 4. Effect of different wheat varieties and sowing dates on the yield contributing characters of wheat

Treatment combinations	Spike length (cm)	No. of spikelet spike^{-1}	No. of fertile spikelet spike^{-1}	No. of grains spike^{-1}	No. of effective tiller m^{-2}	1000-grain weight (g)
V_1	16.01 b	16.96 b	13.37 c	27.05 c	178.5 c	48.09 b
V_2	16.50 ab	16.56 b	15.77 b	31.96 b	244.8 b	47.40 b
V_3	17.15 a	17.96 a	16.85 a	39.99 a	302.7 a	51.21 a
SE	0.29	0.27	0.28	0.4	3.34	0.58
S_1	17.22 a	18.47 b	15.86 b	34.13 b	248.6 ab	49.73 ab
S_2	18.23 a	19.81 a	17.61 a	37.18 a	256.1 a	51.05 a
S_3	17.12 a	17.42 c	15.26 bc	33.13 b	242.9 b	49.35 ab
S_4	15.38 b	15.48 d	14.40 cd	31.36 c	240.1 b	48.00 bc
S_5	14.81 b	14.63 d	13.54 d	29.19 d	222.3 c	46.37 c
SE	0.38	0.34	0.36	0.52	4.31	0.75
V_1S_1	16.18 b-e	18.00 b-d	13.73 e-h	27.55 hi	185.0 e	48.28 bc
V_1S_2	17.14 a-d	19.33 ab	14.96 d-g	30.57 g	187.7 e	49.48 bc
V_1S_3	16.11 b-e	17.27 c-e	13.37 f-h	27.14 h-j	181.0 ef	47.60 b-d
V_1S_4	15.45 c-e	15.61 e-g	12.97 gh	25.34 ij	179.7ef	48.55 bc
V_1S_5	15.19 c-e	14.59 g	11.82 h	24.62 j	159.1 f	46.56 cd
V_2S_1	17.33 a-c	17.89 b-d	16.40 b-d	33.77 ef	250.7 cd	48.93 bc
V_2S_2	18.48 a	18.98 bc	18.25 ab	37.01 cd	260.3 bc	49.45 bc
V_2S_3	17.22 a-c	16.61 def	15.89 cd	32.37 fg	243.7cd	48.85 bc
V_2S_4	15.17 c-e	15.15 fg	14.60 d-g	29.85 gh	240.0 cd	46.11 cd
V_2S_5	14.29 e	14.19 g	13.74 e-h	26.81 ij	229.3 d	43.66 d
V_3S_1	18.15 ab	19.51 ab	17.45 bc	41.07 b	310.1 a	51.99 ab
V_3S_2	19.06 a	21.11 a	19.63 a	43.96 a	320.4 a	54.22 a
V_3S_3	18.05 ab	18.38 b-d	16.52 b-d	39.89 b	304.0 a	51.60 ab
V_3S_4	15.52 c-e	15.67 e-g	15.63 c-e	38.89 bc	300.7 a	49.34 bc
V_3S_5	14.96 de	15.11 fg	15.05 d-f	36.14 de	278.4 b	48.89 bc
SE	0.66	0.59	0.63	0.89	7.47	1.30
CV (%)	6.9	5.99	7.06	4.69	5.34	4.62

V_1= BARI Gom 21 (Shatabdi), V_2= BARI Gom 23 (Bijoy) , V_3= BARI Gom 24 (Prodip); S_1= 10th November 2012, S_2= 20th November 2012, S_3= 30th November 2012, S_4= 10th December 2012, S_5= 20th December 2012

4.2.3 Number of spikelet spike^{-1}

4.2.3.1 Effect of variety

Number of spikelet spike^{-1} of wheat varied significantly due to varietal difference (Table 4). BARI Gom 24 (V_3) produced the highest number of

spikelet spike^{-1} (17.96) and the lowest number of spikelet spike^{-1} (16.56) was observed in BARI Gom 23 (V_2) which was statistically similar with BARI Gom 21 (V_1). Similar results were also reported by Islam and Jahiruddin (2008).

4.2.3.2 Effect of sowing date

Significant variation of number of spikelet spike^{-1} was observed due to various sowing date treatments (Table 4). It was observed that S_2 produced the highest number of spikelet spike^{-1} (19.81) and the lowest number of spikelet spike^{-1} (14.63) was observed from S_5. This results are in agreement with Alam *et al.* (2013) and Islam and Jahiruddin (2008).

4.2.3.3 Interaction of variety and sowing date

Number of spikelet spike^{-1} varied significantly due to various treatment combinations of variety and sowing date (Table 4). It was observed that the treatment combination of V_3S_2 produced the highest number of spikelet spike^{-1} (21.11) which was statistically similar with V_1S_2 and V_3S_1. However, the lowest number of spikelet spike^{-1} (14.19) was observed in V_2S_5 which was statistically similar with V_1S_4, V_1S_5, V_2S_4, V_3S_4 and V_3S_5.

4.2.4 Number of fertile spikelet spike^{-1}

4.2.4.1 Effect of variety

Number of fertile spikelet spike^{-1} of wheat varied significantly due to varietal differences (Table 4). BARI Gom 24 (V_3) produced the highest number of fertile spikelet spike^{-1} (16.85) and the lowest number of fertile spikelet spike^{-1} (13.37) was observed in BARI Gom 21 (V_1).

4.2.4.2 Effect of sowing date

Significant variation of number of fertile spikelet spike^{-1} was observed due to differences in sowing date treatments (Table 4). It was observed that S_2

produced the highest number of fertile spikelet spike^{-1} (17.61) and the lowest number of fertile spikelet spike^{-1} (13.34) was observed from S_5.

4.2.4.3 Interaction of variety and sowing date

Number of fertile spikelet spike^{-1} varied significantly due to various treatment combinations of variety and sowing date (Table 4). It was observed that the treatment combination of V_3S_2 produced the highest number of fertile spikelet spike^{-1} (19.63) which was statistically similar with V_2S_2. However, the lowest number of fertile spikelet spike^{-1} (11.82) was observed in V_1S_5 which was statistically similar with V_1S_1, V_1S_2, V_1S_3, V_1S_4, V_1S_5 and V_2S_5.

4.2.5 Number of grains spike^{-1}

4.2.5.1 Effect of variety

Number of grains spike^{-1} of wheat varied significantly due to varietal treatments (Table 4). BARI Gom 24 (V_3) produced the highest number of grains spike^{-1} (39.99) and the lowest number of grains spike^{-1} (27.05) was observed in BARI Gom 21 (V_1). Islam and Jahiruddin (2008) also reported similar results.

4.2.5.2 Effect of sowing date

Significant variation of number of grains spike^{-1} was observed due to various sowing date treatments (Table 4). It was observed that S_2 produced the highest number of grains spike^{-1} (37.18) and the lowest number of grains spike^{-1} (29.19) was observed from S_5. Similar results were also reported by Alam *et al.* (2013) and Islam and Jahiruddin (2008).

4.2.5.3 Interaction of variety and sowing date

Number of grains spike^{-1} varied significantly due to various treatment combinations of variety and sowing date (Table 4). It was observed that the treatment combination of V_3S_2 produced the highest number of grains spike^{-1}

(43.96). However, the lowest (24.62) number of grains spike^{-1} was observed in V_1S_5 which was statistically similar with V_1S_1, V_1S_3, V_1S_4 and V_2S_5.

4.2.6 Weight of 1000-grain (g)

4.2.6.1 Effect of variety

Significant variation of 1000-grain weight of wheat was observed due to varieties (Table 4). It was observed that, BARI Gom 24 (V_3) produced the highest 1000-grain weight (51.21 g) and BARI Gom 23 (V_2) produced the lowest 1000-grain weight (47.40 g) which was statistically similar with BARI Gom 21 (V_1). Islam and Jahiruddin (2008) also found higher 1000-grain weight of BARI Gom 24 (V_3) and concluded that this might be the varietal characteristics.

4.2.6.2 Effect of sowing date

Weight of 1000-grain wheat varied significantly due to different sowing date treatments (Table 4). It was observed that S_2 produced the highest 1000-grain weight (51.05 g) and the lowest 1000-grain weight (46.37 g) was observed from S_5. These results are in the line with those of Shehzad *et al*. (2002). Decreased weight in December 20th due to delay sowing might be due to reduction in growth period and shriveling of grain due to high temperature prevailed during milk and grain filling stage (Alam *et al.*, 2013).

4.2.6.3 Interaction of variety and sowing date

Weight of 1000-grain wheat varied significantly due to combinations of variety and sowing date (Table 4). It was observed that the treatment combination of V_3S_2 produced the highest 1000-grain weight (54.22 g) which was statistically similar with V_3S_3. However, the lowest 1000-grain weight (43.66 g) was observed in V_2S_5 which was statistically similar with V_1S_3 and V_2S_4.

4.3 Yield

4.3.1 Grain yield

4.3.1.1 Effect of variety

Grain yield of wheat varied significantly due to varieties (Fig. 7). Significant variation due to variety was also reported by Kumar *et al.* (2013). BARI Gom 24 produced the highest grain yield (4.51 t ha^{-1}) and BARI Gom 21 produced the lowest grain yield (3.18 t ha^{-1}). The higher yield attributes of BARI Gom 24 might be due to prevailing of favorable temperature required for wheat crop variety for higher Photosynthate accumulation consequently resulting in higher yield. Akhtar *et al.* (2002) and Kumar *et al.* (2005) also observed similar trend among the different varieties.

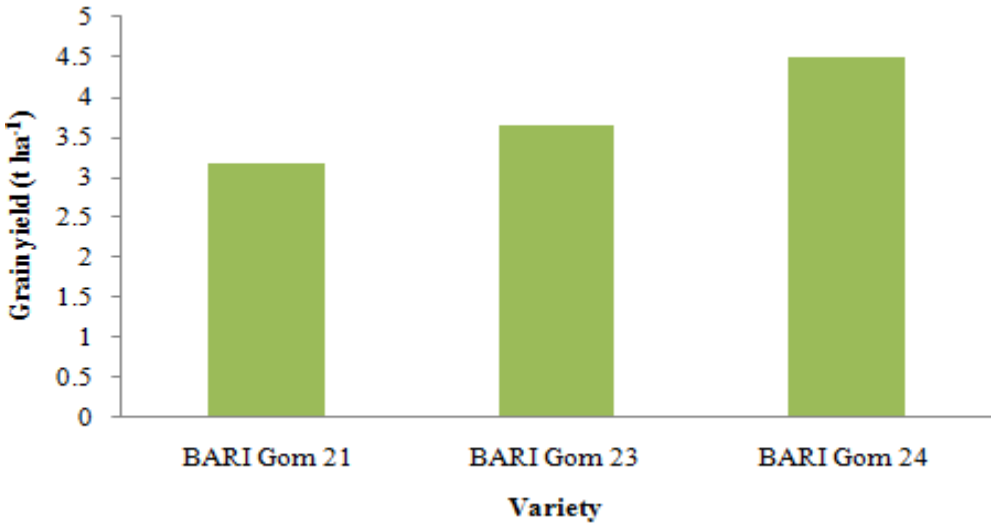

Fig. 7. Effect of variety on the grain yield of wheat (SE= 0.52, 0.40, 0.57, 0.55 and 0.34 for 30, 45, 60, 75DAS and at harvest respectively**)**

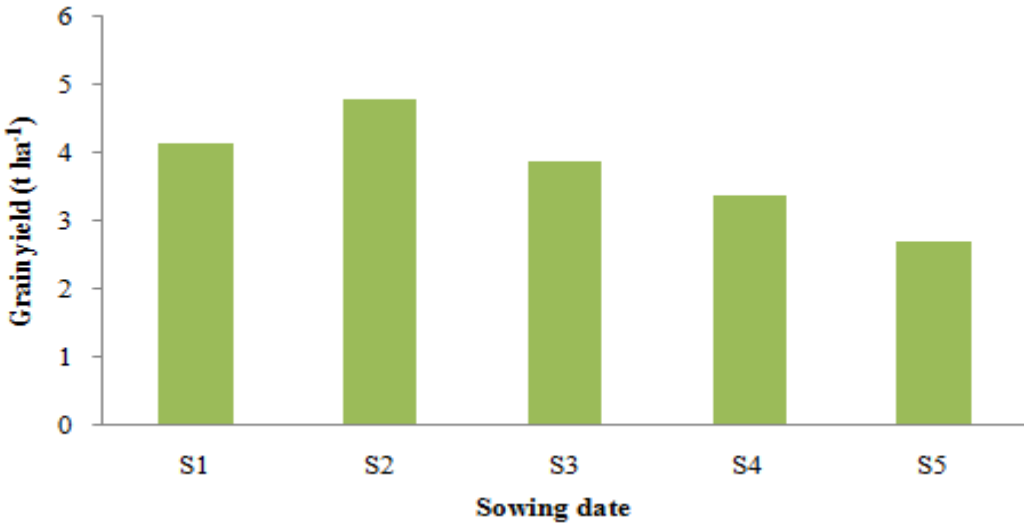

Fig. 8. Effect of sowing date on the grain yield of wheat (SE= 0.52, 0.40, 0.57, 0.55 and 0.34 for 30, 45, 60, 75DAS and at harvest respectively**)**

Table 5. Interaction effect of variety and sowing date on the yield and harvest index of wheat

Treatment combination	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1S_1	3.34 e	5.92 d-g	9.257 e	36.05 de
V_1S_2	4.14 cd	7.33 a	11.47 bc	36.05 de
V_1S_3	3.16 ef	5.38 g-i	8.54 ef	36.99 c-e
V_1S_4	2.76 e-g	5.05 hi	7.81 fg	35.26 de
V_1S_5	2.51 fg	4.91 i	7.42 g	33.70 e
V_2S_1	4.10 d	6.48 b-d	10.58 cd	38.74 b-d
V_2S_2	4.77 bc	6.82 a-c	11.59 b	41.13 a-c
V_2S_3	4.04 d	6.30 c-e	10.33 d	39.05 b-d
V_2S_4	3.00 e-g	5.55 f-h	8.55 ef	35.07 de
V_2S_5	2.46 g	4.89 i	7.35 g	33.43 e
V_3S_1	4.98 ab	6.45 b-e	11.43 bc	43.54 a
V_3S_2	5.52 a	7.02 ab	12.54 a	44.01 a
V_3S_3	4.47 b-d	6.12 d-f	10.59 cd	42.18 ab
V_3S_4	4.40 b-d	5.88 e-g	10.28 d	42.76 ab
V_3S_5	3.18 ef	5.57 f-h	8.750 ef	36.05 de
SE	0.21	0.18	0.31	1.35
CV (%)	9.5	5.29	5.53	6.12

V_1= BARI Gom 21 (Shatabdi), V_2= BARI Gom 23 (Bijoy), V_3= BARI Gom 24 (Prodip); S_1= 10th November 2012, S_2= 20th November 2012, S_3= 30th November 2012, S_4= 10th December 2012, S_5= 20th December 2012

4.3.1.2 Effect of sowing date

Grain yield of wheat varied significantly due to sowing date treatments (Fig. 8). S_2 produced the highest grain yield (4.81 t ha^{-1}) and S_5 produced the lowest grain yield (2.72 t ha^{-1}). Higher grain yield in early planting than the late planting is due to favorable environmental condition. These results are in agreement with the findings of Hossain *et al.* (2013) and Kumar *et al.* (2013).

4.3.1.3 Interaction of variety and sowing date

Significant variation of grain yield was observed due to various combinations of variety and sowing date (Table 5). It was observed that the treatment combination of V_3S_2 produced the highest grain yield (5.22 t ha^{-1}) which was statistically similar with V_3S_1. However, the lowest grain yield (2.46 t ha^{-1}) was observed in the treatment combination of V_2S_5 which was statistically similar with V_1S_4, V_1S_5 and V_2S_4. Kumar *et al.* (2013) also reported significant variation of grain yield due to interaction of variety and sowing date.

4.3.2 Straw yield

4.3.2.1 Effect of variety

Straw yield of wheat varied significantly due to various varietal treatments (Fig. 9). It was observed that BARI Gome 24 produced the highest straw yield (6.21 t ha^{-1}) which was statistically similar with BARI Gom 23. However, BARI Gom 21 produced the lowest straw yield (5.72 t ha^{-1}). Non significant variation of straw yield due to various wheat varieties was reported by Kumar *et al.* (2013) which contradicted with the present findings. However, Islam and Jahiruddin (2008) in their study reported significant variation due to varieties. They reported that BARI Gom 21 produced higher straw yield than other BARI Gom 24 which is contrary to the findings of this study.

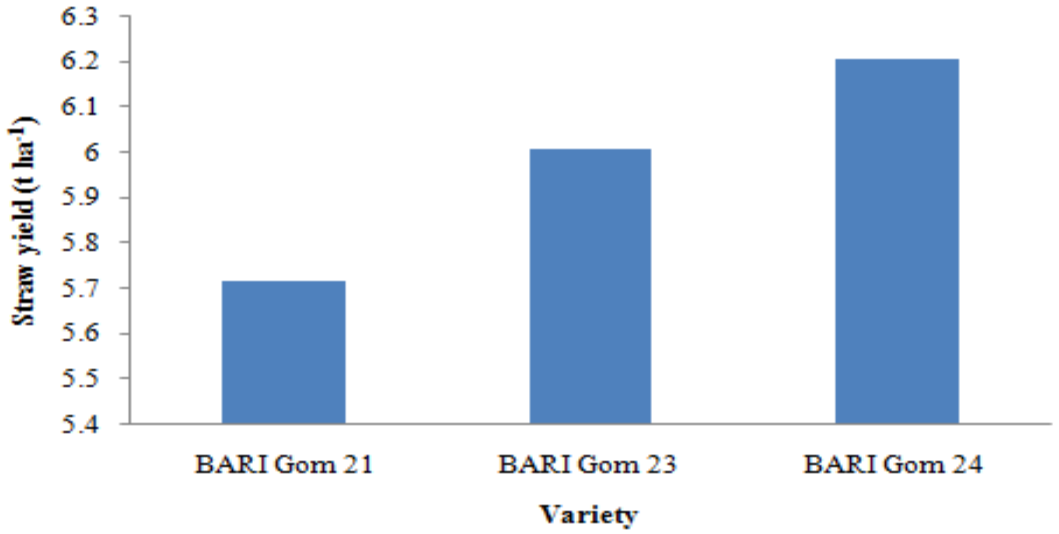

Fig. 9. Effect of variety on the straw yield of wheat (SE= 0.52, 0.40, 0.57, 0.55 and 0.34 for 30, 45, 60, 75DAS and at harvest respectively**)**

4.3.2.2 Effect of sowing date

Straw yield of wheat varied significantly due to various sowing date treatments (Fig. 10). S_2 produced the highest straw yield (7.06 t ha^{-1}) and S_5 produced the lowest straw yield (5.13 t ha^{-1}). Straw yield was higher in the early planting dates especially than those of late planting dates. Islam and Jahiruddin (2008) and Hossain *et al.* (1994) also found similar results.

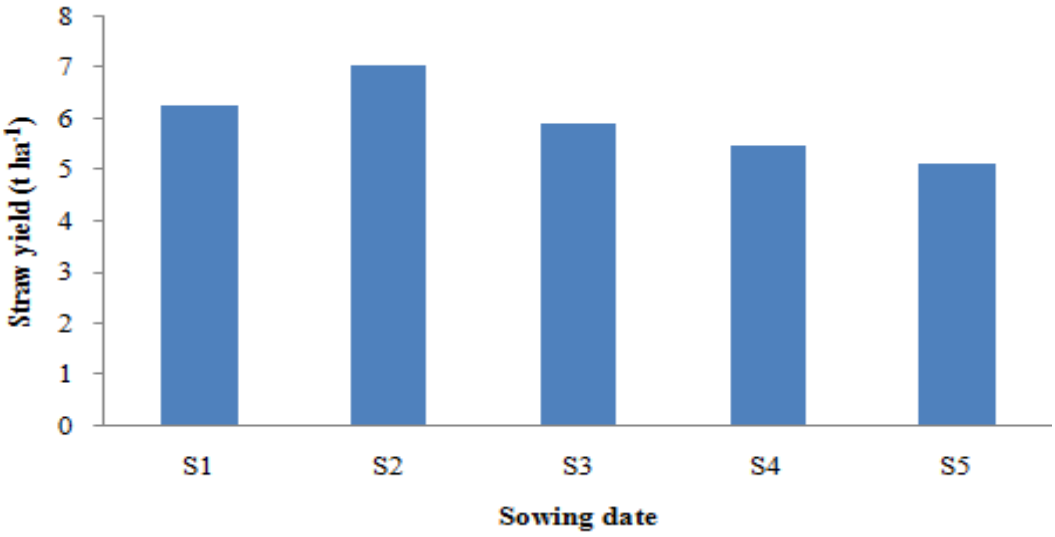

Fig. 10. Effect of sowing date on the straw yield of wheat (SE= 0.52, 0.40, 0.57, 0.55 and 0.34 for 30, 45, 60, 75DAS and at harvest respectively**)**

4.3.2.3 Interaction of variety and sowing date

Significant variation of straw yield was observed due to various treatment combinations of variety and sowing date (Table 5). It was observed that the treatment combination of V_1S_2 produced the highest straw yield (7.33 t ha^{-1}) which was statistically similar with V_2S_2 and V_3S_2. However, the lowest straw yield (4.89 t ha^{-1}) was observed in the treatment combination of V_2S_5 which was statistically similar with V_1S_3, V_1S_4 and V_1S_5. Kumar *et. al.* (2013) also found similar results.

4.3.3 Biological yield

4.3.3.1 Effect of variety

Biological yield of wheat showed significant variation due to varietal differences (Fig. 11). It was observed that BARI Gome 24 produced the highest biological yield (10.72 t ha^{-1}) and BARI Gom 21 produced the lowest biological yield (8.90 t ha^{-1}).

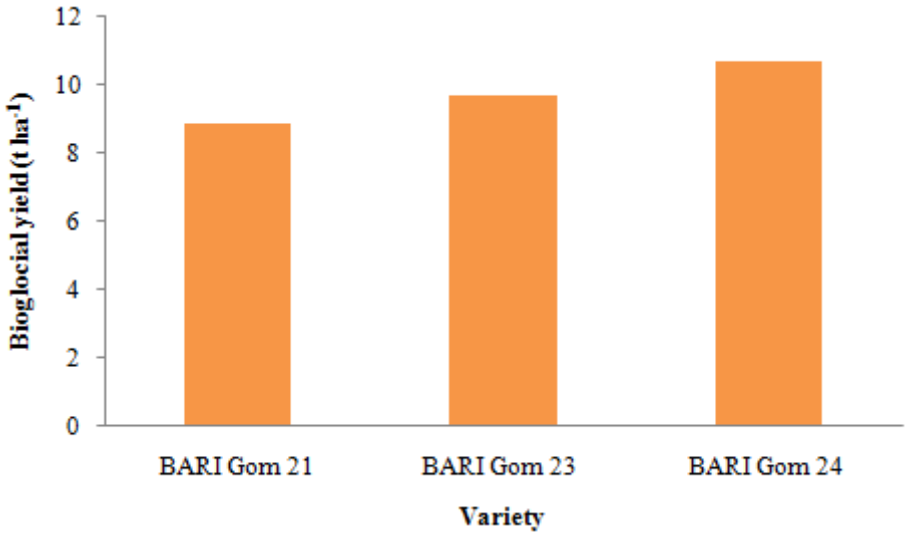

Fig. 11. Effect of variety on the biological yield of wheat (SE= 0.52, 0.40, 0.57, 0.55 and 0.34 for 30, 45, 60, 75DAS and at harvest respectively**)**

4.3.3.2 Effect of sowing date

Biological yield of wheat varied significantly due to various sowing date treatments (Fig. 12). S_2 produced the highest biological yield (10.72 t ha^{-1}) and S_5 produced the lowest biological yield (8.90 t ha^{-1}).

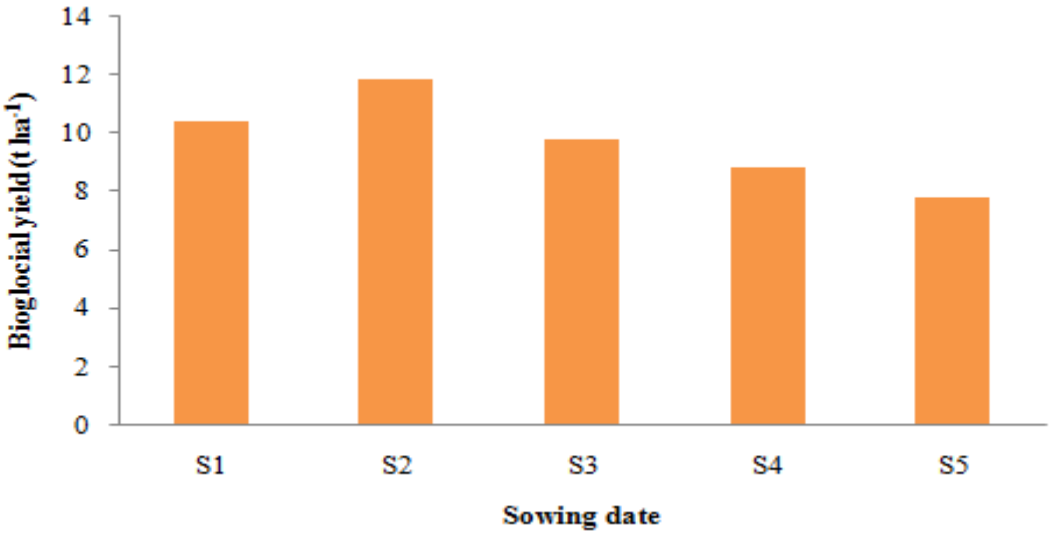

Fig. 12. Effect of sowing date on the biological yield of wheat (SE= 0.52, 0.40, 0.57, 0.55 and 0.34 for 30, 45, 60, 75DAS and at harvest respectively**)**

4.3.3.3 Interaction of variety and sowing date

Biological yield varied significantly due to different combinations of variety and sowing date (Table 5). It was observed that the treatment combination of V_3S_2 produced the highest biological yield (12.54 t ha^{-1}). However, the lowest biological yield (7.35 t ha^{-1}) was observed in the treatment combination of V_2S_5 which was statistically similar with V_1S_4 and V_1S_5.

4.3.4 Harvest index

4.3.4.1 Effect of variety

Harvest index of wheat varied significantly due to varieties (Fig. 13). It was observed that BARI Gom 24 produced the highest harvest index (41.71%) and BARI Gom 21 produced the lowest harvest index (35.61%). Kumar *et al.* (2013) also reported that harvest index of wheat was affected significantly by wheat varieties.

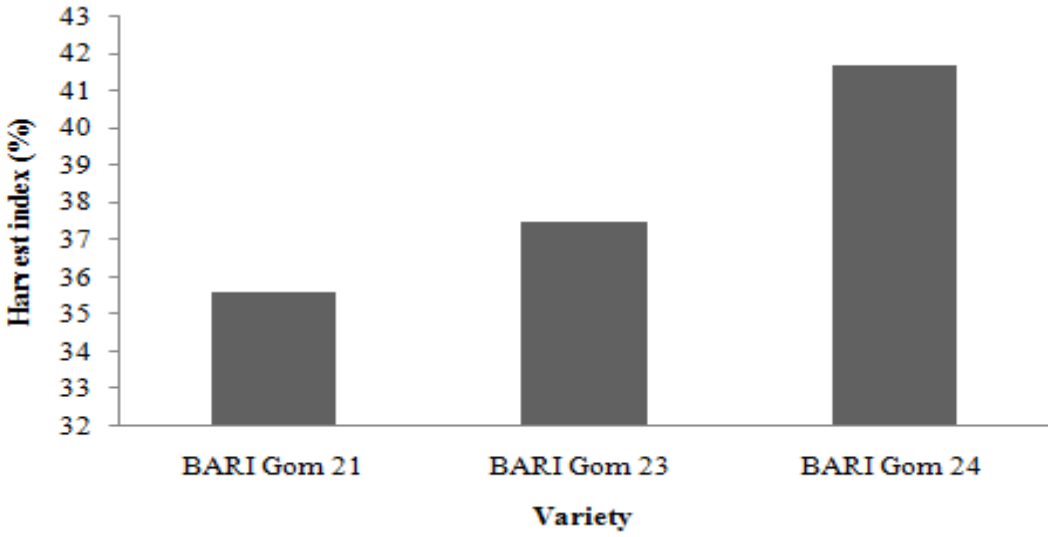

Fig. 13. Effect of variety on the harvest index of wheat (SE= 0.52, 0.40, 0.57, 0.55 and 0.34 for 30, 45, 60, 75DAS and at harvest respectively**)**

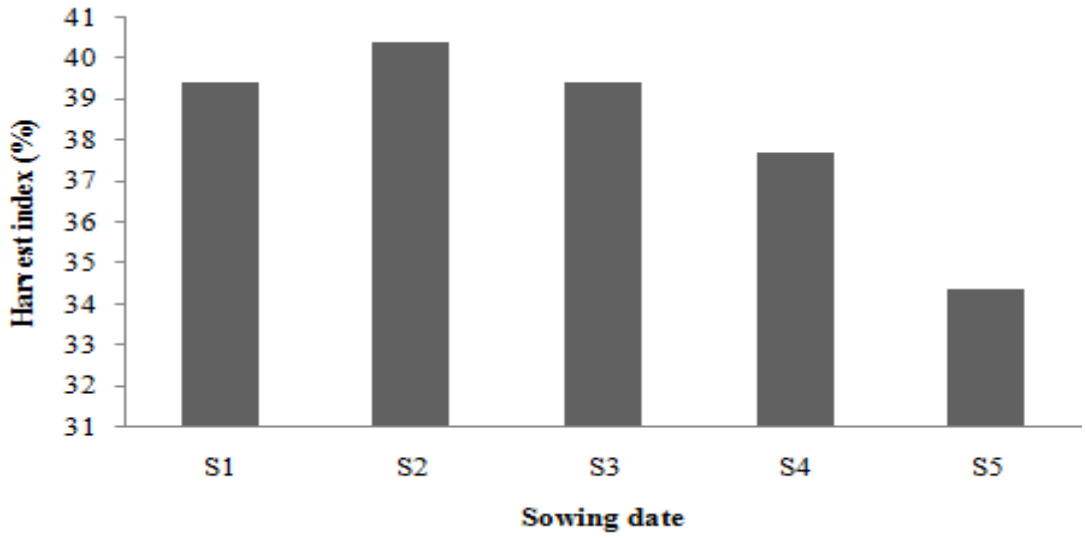

Fig. 14. Effect of sowing date on the harvest index of wheat (SE= 0.52, 0.40, 0.57, 0.55 and 0.34 for 30, 45, 60, 75DAS and at harvest respectively**)**

4.3.4.2 Effect of sowing date

Harvest index of wheat varied significantly due to different sowing date treatments (Fig. 14). S_2 produced the highest harvest index (41.71%) and S_5 produced the lowest harvest index (35.61%). Harvest index of wheat was

significantly more on 20th November than the 20th December. Similar results were also reported by Alam *et al.* (2013) and Kumar *et al.* (2013).

4.3.4.3 Interaction of variety and sowing date

Significant variation of harvest index was observed due to various treatment combinations of variety and sowing date (Table 5). The result revealed that the treatment combination of V_3S_2 produced the highest harvest index (44.01%) which was statistically similar with V_2S_2, V_3S_1, V_3S_3 and V_3S_4. However, the lowest harvest index was observed in the treatment combination of V_2S_5 which was statistically similar with V_1S_1, V_1S_2, V_1S_3, V_1S_4, V_1S_5, V_2S_4 and V_3S_5.

Chapter 5

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The present piece of work was done at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2012 to March, 2013 to find out the influence of wheat varieties and sowing dates on growth and yield of wheat.

The experiment was laid out in a RCBD design with three replications. The size of the individual plot was 4.0 m x 2.5 m and total numbers of plots were 45. There were 15 treatment combinations. The experiment was carried out with three wheat varieties *i.e.* V_1= BARI Gom 21, V_2 = BARI Gom 23 and V_3= BARI Gom 24 and five different sowing dates viz. S_1= 10th November 2012, S_2= 20th November 2012, S_3= 30th November 2012, S_4=10th December 2012, S_5= 20th December 2012 in RCBD design. Seeds were collected from the Wheat Research Centre, BARI, Joydebpur, Gazipur.

The land of the experimental field was first opened on October 12, 2012 with a power tiller. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. All the weeds and stubbles were removed from the experimental field. The soil was treated with insecticides at the time of final ploughing. Insecticides Furadan 5G was used @ 8 kg ha^{-1} to protect young plants from the attack of mole cricket, ants, and cutworms. Lay out of the experiment was done on November 1, 2012 with interplot spacing of 0.50 m and inter block spacing of 1 m. Sowing was done as per sowing date treatments.

The data on growth parameters viz. plant height (cm) and total plants m^{-2} were recorded during the period from 30 to 75 DAS. At harvest, characters like plant height (cm), total plants m^{-2}, number of spikelets spike^{-1}, number of fertile spikelet spike^{-1}, number of grains spike^{-1}, effective tillers m^{-2}, 1000 grain

weight, grain yield, straw yield, biological yield and harvest index were recorded.

The highest grain yield was recorded from the wheat variety BARI Gom 24 (V_3) (4.51 t ha^{-1}). BARI Gom 21 (V_1) produced the lowest grain yield (3.18 t ha^{-1}). BARI Gom 24 (V_3) produced the highest (437.50) total plants m^{-2}, the highest effective tiller m^{-2} (302.70), longest spike (17.15 cm), highest number of spikelets $spike^{-1}$(17.96), the highest fertile spikelet $spike^{-1}$(16.85), the highest 1000-grain weight (51.21 g). Thus it recorded the highest grain yield (4.51 t ha^{-1}), highest straw yield (6.21 t ha^{-1}), maximum biological yield (10.72 t ha^{-1}) and the highest harvest index (41.71).

Among the sowing dates, S_2 (20^{th} November 2012) produced the highest grain yield (4.81 t ha^{-1}), the highest straw yield (7.06 t ha^{-1}), the highest biological yield (11.87 t ha^{-1}) and the highest harvest index (40.40). S_5 (20^{th} December 2012) however produced the lowest grain yield (2.72 t ha^{-1}), straw yield (5.13 t ha^{-1}), biological yield (7.84 t ha^{-1}) and harvest index (34.39).

Based on the results of the present experiment, the following conclusion can be drawn:

1. BARI Gom 24 (V_3) is the best wheat variety among the treated varieties in respect of highest yield performance.
2. Among the sowing date treatments, S_2 (November 20, 2012) performed better than the other sowing date treatments.
3. BARI Gom 24 (V_3) seems to be promising when planted on 20^{th} November.

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APPENDICES

APPENDICES

Appendix I. Mean square values for plant height (cm) of wheat at different days after sowing and at harvest

Sources of variation	df	Means square values				
		30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Replication	2	227.235	72.241	255.084	139.401	58.313
Variety (V)	2	168.114*	111.650*	176.231*	151.617*	225.311*
Sowing	4	71.741 ns	191.831*	209.495*	154.383*	220.200*
V x S	8	11.977*	16.488*	13.237*	18.206*	9.436*
Error	28	16.506	17.613	38.345	37.871	40.797
CV (%)		15.42	9.88	9.33	7.63	7.94

*Significant at 5% level ns- Non significant

Appendix II. Mean square values for Leaf area index of wheat at different days after sowing

Sources of variation	df	Means square values at different days after sowing			
		30 DAS	45 DAS	60 DAS	75 DAS
Replication	2	0.003	0.013	0.011	0.012
Variety (V)	2	0.000ns	0.064 ns	0.088 ns	0.105 ns
Sowing dates (S)	4	0.004 ns	0.333*	0.518 ns	0.443*
V x S	8	0.001 ns	0.013*	0.013 ns	0.009*
Error	28	0.000	0.077	0.079	0.081
CV (%)		28.22	37.43	28.61	25.78

*Significant at 5% level ns- Non significant

Appendix III. Mean square values for the number of total tillers per m^2 at different DAS and at harvest

Sources of variation	df	Mean square for				
		No. of total tillers m^{-2} at different days after sowing				
		30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Replication	2	183.507	2161.372	3364.678	3958.331	3007.358
Variety (V)	2	969.870*	6215.270*	9038.806*	7842.84*	5864.26*
Sowing dates	4	1880.64*	3663.262 ns	1369.993*	977.731*	1284.06*
V x S	8	160.596*	152.997*	71.212*	75.857*	195.013*
Error	28	1225.737	6255.907	8150.128	9340.028	6572.127
CV (%)		15.63	22.45	23.06	24.08	19.07

*Significant at 5% level ns- Non significant

Appendix IV. Mean square values for yield contributing characters of Wheat

Sources of variation	df	Means square values					
		No. of effective tillers m^{-2}	Spike length (cm)	Spikelet $spike^{-1}$ (no.)	No. of fertile $spike\ plant^{-1}$	No. of Grain $spike^{-1}$ (no.)	1000-grain weight (g)
Replication	2	399.15	3.53	3.27	9.03	155.20	6.42
Variety (V)	3	57967.32*	4.86*	7.72*	47.68*	640.27*	61.67*
Sowing dates (S)	6	1429.11*	17.94*	40.52*	21.56*	80.94*	28.67*
V x S	3	39.01*	1.14*	0.48*	0.54*	2.42*	3.59*
Error	9	167.22	1.30	1.06	1.17	2.40	5.11
CV (%)		5.34	6.9	5.99	7.06	4.69	4.62

*Significant at 5% level ns- Non significant

Appendix V. Means square values for grain yield, straw yield, biological yield and harvest index of Wheat at different days after sowing

Sources of variation	df	Means square values			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.053	0.196	0.440	0.914
Variety (V)	3	6.741*	0.916*	12.464*	146.360*
Sowing dates (S)	6	5.578*	5.008*	20.989*	50.742*
V x S	3	0.219*	0.316*	0.642*	7.486*
Error	9	0.129	0.100	0.292	5.483
CV (%)		9.5	5.29	5.53	6.12

*Significant at 5% level ns- Non significant