YIELD AND YIELD ATTRIBUTES AS EVALUATED BY BORON APPLICATION AT SEEDLING AND TILLERING STAGES OF WHEAT

BY

SANJOY KUMAR SARKAR

DEPARTMENT OF AGRONOMY

FACULTY OF AGRICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2016

YIELD AND YIELD ATTRIBUTES AS EVALUATED BY BORON APPLICATION AT SEEDLING AND TILLERING STAGES OF WHEAT

BY

SANJOY KUMAR SARKAR

Registration No. 10-03962

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
IN
AGRONOMY

SEMESTER: JANUARY-JUNE, 2016

(Prof. Dr. H. M. M. Tariq Hossain)	**(Prof. Dr. Parimal Kanti Biswas)**
Supervisor	**Co-Supervisor**

(Prof. Dr. Md. Fazlul Karim)
Chairman
Examination Committee

ACKNOWLEDGEMENTS

The author seems it a much privilege to express his enormous sense of gratitude to the almighty God for the ever ending blessings for the successful completion of the research work.

The author feels proud to express his deep sense of gratitude, sincere appreciation and immense indebtedness to his supervisor ***Prof. Dr. H.M.M. Tariq Hossain****, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his continuous guidance, cooperation, constructive criticism and helpful suggestions, valuable opinion in carrying out the research work and preparation of this thesis.*

The author feels proud to express his deepest respect, sincere appreciation and immense indebtedness to his co-supervisor ***Prof. Dr. Parimal Kanti Biswas****, Department of Agronomy, SAU, Dhaka, for his scholastic and continuous guidance during the entire period of course, research work and preparation of this thesis.*

The author expresses his sincere respect to ***Prof. Dr. Md. Fazlul Karim,Chairman, Prof. Dr. Hazrat Ali, Prof. Dr. Md Jafar Ullah, Prof. Dr. A. K. M. Ruhul Amin, Prof. Dr. Tuhin Suvra Roy , Dr. Md. Abdullahil Baque and Dr. Mirza Hasanuzzaman,*** *Department of Agronomy, SAU, Dhaka, for their valuable suggestions and cooperation during the study period. The author expresses his heartfelt thanks to all the teachers of the Department of Agronomy, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.*

The author expresses his sincere appreciation to his father, ***Khagendra Nath Sarkar*** *and beloved mother,* ***Sobita Rani Sarkar****, sisters, Sonchita Rani Sarkar & Swarna Sarkar, brother-in-law, Gopal Chandra Sarkar and his all friends.*

The Author

YIELD AND YIELD ATTRIBUTES AS EVALUATED BY BORON APPLICATION AT SEEDLING AND TILLERING STAGES OF WHEAT

ABSTRACT

A pot experiment was carried out at the net house of the Dept. of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to March 2016 to study the effect of boron (B) application at seedling and tillering stages on the grain yield of two wheat varieties. The experiment consisted of three levels of boron viz. 0, 0.50 and 1 $kgBha^{-1}$and two wheat varieties viz. BARI Gom 23 and BARI Gom 24. The effect of B on different plant characters, yield components and yield of wheat was found significant. The tallest plant (53.17 cm) was found when the crop was fertilized @ 0.5 $kgBha^{-1}$ which was statistically identical with 1 $kgBha^{-1}$ and the shortest plant height (39.56 cm) from control at 40 days after sowing in tillering stage. The highest seed weight $plant^{-1}$ (10.67g) was found in BARI Gom 24 at tillering stage with the application of boron @ 0.50 $kgha^{-1}$. The highest 1000 grain weight (46.62 g) was found by applying B @ 0.5 $kgha^{-1}$ and the second highest 1000 grain weight (40.82 g) was found from control. The production of highest straw yield was (6.15 tha^{-1}) in 1 kg B ha^{-1} might be due to the fact that B tends primarily to encourage vegetative growth. The highest biological yield (10.53 tha^{-1}) was found in BARI Gom 24 with the dose of 0.5 $kgha^{-1}$, whereas the BARI Gom 23 showed 9.43 tha^{-1}. The highest biological yield (7.92 tha^{-1}) and the lowest (6.94 tha^{-1}) were found in tillering and seedling stage, respectively. The highest harvest index (43.62%) was observed in 0.5 $kgBha^{-1}$ which was statistically similar (41.82%) with 1 $kgBha^{-1}$ and the lowest (39.94%) was found from the control. The BARI Gom 24 showed the maximum harvest index (44.10%) with the application of 0.5 $kgBha^{-1}$, whereas BARI Gom 23 showed the nearest result (43.14%).

CONTENTS

CONTENTS (CONTD.)

LIST OF TABLES

LIST OF TABLES (CONTD.)

LIST OF FIGURES

LIST OF FIGURES (CONTD.)

LIST OF ACRONYMS AND ABBREVIATIONS

BARI	Bangladesh Agricultural Research Institute
Cm	Centimeter
CV	Coefficient of Variance
DAS	Days after sowing
Df	Degree of freedom
Environ.	Environmental
et al.	And others
Etc	Etcetra
G	Gram (s)
HI	Harvest Index
i.e.	Id est (L), that is
J.	Journal
Kg	Kilogram (s)
m^2	Meter squares
M.S.	Master of Science
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
tha^{-1}	Ton per hectare
viz.	Namely
%	Percentage
^0C	Degree centigrade
@	At the rate of

CHAPTER I
INTRODUCTION

Wheat (*Triticum aestivum* L.) is an essential cereal crop, source of staple food and thus the most important crop in food security potential. More of the earth's surface is wrapped by wheat than by any additional food crop. Wheat production is the first major cereal production in the world, following maize and rice. In conditions of nutritional eating, however, wheat comes second to rice as a major food crop, known the more general use of maize as animal feed (FAO, 2013). It was grown on an area of 1988 thousand ha in 2012/2013 with the total production 5215 thousand metric tons with an average yield of 2.623 tha^{-1} (INS, 2013).

Being a staple food for most of the people of our universe, it is cultivated on about eight million hectares in the country with 13.7% contribution to the value addition in agriculture sector and 3% in the gross domestic products (Nawab *et al.*, 2011). Wheat yield in Pakistan is almost two and half times low as compared to other wheat producing countries of the world while bridging up this gap is a challenging scenario for the scientists as well as the farmers (Nadim *et al.*, 2011; Hussain *et al.,* 2012). Different factors such as seed quality, soil salinity, water logging, higher prices, poor management and distribution of irrigation water, improper and inadequate use of fertilizers supplied with no additional micronutrients are the limiting factors towards higher production (Iftikhar *et al.,* 2010). The yield of wheat in Bangladesh is low which can be attributed to boron deficiency (Jahiruddin *et al.*, 1992).

However, macro-nutrients as well micronutrients are of primary importance in our agriculture system but due to unawareness of our farmers about importance of applying micronutrients to soils which are becoming deficient in micronutrients. Boron is one of those micronutrients which are rapidly being deficient in soils. Boron deficiency impairs grain setting in wheat, resulting in increased number of open spikelets and decreased number of grains per spike. The difference in the number of open spikelets under normal and Boron deficient soil conditions has been used to compare wheat genotypes for boron efficiency (Rerkasem and Loneragan, 1994). Boron deficiency in crops is more pervasive than the deficiency of any other micronutrient (Gupta, 1979). Visual symptoms of Boron deficiency generally become evident in dicots, corn and wheat at tissue concentrations of less than 20-30, 10-20 and 10 mg kg^{-1} weight, respectively

In addition, in Boron deficient soils seeds generate abnormal seedlings. Dell and Haung, (1997) stated that deficiency of Boron inhibits root elongation through limiting cell enlargement and cell division in the growing zone of root tips. Deficiency of Boron causes inhibition of leaf expansion and reduction in photosynthesis, though exact role of Boron in photosynthesis remain to be explored. In the field, sexual reproduction is often more affected by low Boron and significant grain yield reductions may occur without visual symptoms expressed during vegetative growth (Mandal, 1987, 1993; Mandal and Das, 1988).

Zinc is involved in several enzymatic and metabolic processes (Marschner, 1995). The deficiency of zinc is well documented in flooded rice soils (Yoshida and Tanaka, 1969). Various researches (Rashid, 1989; Tahir, 1981; Rashid, 1979) recorded increase in yield of maize, rice, wheat, cotton, vegetable and fruit trees by the application of Zn fertilizer. The productivity of wheat crop was improved by 10 % by the addition of 2.5 kg Zn ha^{-1} over control. Makhdum *et al.* (1988) also found positive response of 10 kg Zn ha^{-1} on wheat grain yield. Yilmaz *et al.* (1997) reported 100 % increases in wheat grain yield by foliar spray of Zn fertilizer. The concentration of zinc was raised from 10 mg ha^{-1} to 18 mg kg^{-1} in shoot and grain parts of the plant. Khan *et al.* (2006, 2008) also found an increase of 31.6% in wheat grain yield over control by the addition of 5 kg Zn ha^{-1}.

Keeping above facts in view, the present investigation was undertaken to find out the effects of boron on the growth, yield and quality of wheat with the following objectives-

1. To observe the effect of boron on growth and yield of wheat.
2. To assess the interaction of boron and growth stages on yield and yield components of wheat varieties.

CHAPTER II

REVIEW OF LITERATURE

2.1 Effect of Boron on yield and yield components of wheat varieties

Kapoor *et al.* (2016) conducted a research with the sixteen treatment combinations consisting of four levels of N (0, 50,100 and 150 per cent of recommended dose), two levels of Zn (0 and 10 $kgha^{-1}$) and two levels of B (0 and 1 $kgha^{-1}$) were evaluated in a silty clay loam soil at Palampur, that was medium in organic carbon, low in available N, medium in available P and K, adequate in DTPA extractable Fe, Mn and Cu, marginally adequate in DTPA Zn and insufficient in hot water soluble B. In general, application of nitrogen increased the concentrations of Mn, Fe, Cu, Zn and B in wheat grains and straw. In grain, Mn, and Cu concentration increased upto 150% of recommended N; Zn and Fe upto 100% N and B upto 50% N. In straw, Fe and Cu concentration increased upto 150% N; Mn upto 100% N; and Zn and B upto 50% N. In grain, application of Zn @ 10 kg ha^{-1} resulted in increased Zn and B concentration and decreased Fe, Mn and Cu concentrations. In straw, Zn concentration increased while Fe, Mn and Cu concentration decreased with the addition of Zn. Boron @ 1 kg ha^{-1} significantly increased Zn and B concentration in grains and Zn, Fe, Cu and B concentration in straw over no boron application. In general, there was consistent increase in uptake of Fe, Mn, Cu, Zn and B in wheat grain and straw and thereby of total with application of nitrogen. Application of Zn @10 $kgha^{-1}$ resulted in increased Zn and B uptake by grain and straw of wheat. Boron @1 $kgha^{-1}$ significantly increased Zn, Fe, Mn, Cu and B uptake by grains and straw. Grain yield of wheat increased with increase in dose of N upto 150 per cent of recommended. Application of 10 kg $Znha^{-1}$ increased grain yield by 9.7 per cent. Similarly, boron application @ 1 $kgha^{-1}$ increased grain yield by 8.1 per cent.

Muhammad *et al.* (2016) performed a field experiment on salt affected soil was performed to evaluate the response of wheat (cv. Sehar) to soil boron (B) application. Boron was applied at 0, 0.5, 1.0, 1.5 and 2.0 $kgha^{-1}$. There was antagonistic influence of B application on various plant growth parameters of wheat under salt affected conditions and minimum yields were observed at 2 $kgha^{-1}$. The pre-sowing soil analysis indicated that soil had optimum B level for growth of wheat crop. Addition of B increased phyto-available B concentration in soil as confirmed in post-harvest soil analysis. With the incremental of B, plant accumulated greater B concentrations. However, B concentration in plant tissues was not upto toxic limits generally accepted for wheat crop. Therefore, B mediated reduced the plant growth and grain yield under salt conditions might be related to interactions among N, P and K. Based on findings, it is concluded that B application is not required for sodic soils.

Biswas *et al.* (2015) stated that the production of wheat (*Triticum aestivum* L.), an important staple food in the world, is often restricted due to micronutrients status in soil. Micronutrient deficiency in soil including boron (B) and zinc (Zn) is quite widespread in Asian countries including India due to prevalent soil and environmental conditions. A field experiment was conducted following randomized complete block design over a two-year period in an acid soil of Terai region of West Bengal to study the effect of Zn and Boron the yield and uptake of nutrients by wheat. The highest grain yield (4.4 tha^{-1}) was obtained after the combined application of Zn and B over that of other treatment combinations (variable rates of B and Zn application with nitrogen (N), phosphorus (P) and potassium (K)) or control (no NPK, B and Zn). Application of one micronutrient might have accelerated the uptake of other micro- and macro-nutrients (such as B, Zn, N, P and K) resulting in higher yield. A positive correlation was observed between the grain yield and the uptake of different nutrients with the weakest with Zn. An enhancement of the nutrients in soils was also observed at the harvest. High response from a combined application of B and Zn clearly demonstrated the necessity of micronutrients for improving production in the studied regions with acid soils. Therefore, an application of a mixture of micronutrients is recommended over a single micronutrient for the acid soil regions of West Bengal in order to get a better response from the applied nutrient sources and thus the production.

Nadim *et al.* (2011) conducted an experiment to study the varietals/genotypic potentiality in producing maximum yield under different soil and environmental conditions and N-use efficiency of different genotypes and to support wheat breeding program in selecting the genotype with relatively higher yield potential. The experiment was conducted in split plot design with three replications to evaluate the two soil management practices: (i) Recommended fertilizer ($N_{100}P_{30}K_{50}S_{20}$) with all the production package of Wheat Research Center (WRC) (timely sowing, one weeding, 3 irrigations) (ii) Treatment (i) plus soil treatment (application of granular fungicide in moist soil before seeding) with plant protection (foliar application of tilt at anthesis and grain filling). One additional irrigation (schedules: 17-21, 35-40, 55-60, 75-80 DAS) in the main plot and eight varieties/lines, varities: i) Shatabdi ii) Prodip iii) Bijoy iv) BARI Gom 25 v) BARI Gom 26, lines: vi) BAW 1051 vii) BAW 1135 and viii) BAW 1141 in subplot were adopted. The results conclude that best management practice with Prodip, Bijoy and BAW 1141 are best performance among the genotypes/varieties and will give a new concept on identification of the strategy for the improvement of wheat cultivation and yield.

Debnath *et al.* (2014) assessed the effect of nitrogen (N) and boron (B) fertilization on the performance of wheat. The experiment comprised of four levels of N viz., 0, 80, 120, 160 kgha^{-1} and three levels of B viz., 0, 1 and 2 kgha^{-1}. The experiment showed that there were significant differences in yield due to the application of N and B though some of the yield attributes were not found significant. Grain yield was found to be significantly and positively correlated with number of effective tillers plant^{-1}, number of fertile spikelets spike^{-1}, number of gains spike^{-1} and straw yield. A result showed that grain yield of wheat was increased with increasing levels of both N and B up to 120 kg ha^{-1} and 2 kgha^{-1}, respectively. The interaction effect of N and B on both the parameters was significant.

Nadim *et al.* (2013) investigated the effect of micronutrients and their application methods on wheat variety Gomal-8 under the agro-ecology of Dera Ismail Khan, Pakistan, during the year 2010-11. The trial was laid out in a randomized complete block design with split-plot arrangements. Main plot possessed five micronutrients viz., Zn, Cu, Fe, Mn and B while application methods (side dressing, foliar application and soil application) were assigned to sub-plots. The results revealed that boron application @2 kgha^{-1} recorded higher crop growth rate (30.14 g m^{-2} day^{-1}), net assimilation rate (2.78 mg m^{-2} day^{-1}), number of tillers (307.00 m^{-2}), number of grains spike^{-1} (61.08) and grain yield (5.63 tha^{-1}). The use of copper @8 kgha^{-1} also showed encouraging results similar to boron. Among various application methods, soil application (at sowing) showed the best results as compared to side dressing and foliar application both at 4 weeks after sowing (WAS). Also, different micronutrients significantly interacted with the application methods for physiological and agronomic traits including leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR) and grain yield. Soil application best interacted with boron for producing higher number of tillers, grains spike^{-1}, grain yield and almost all the physiological traits. This combination also resulted in the best net returns with higher benefit cost ratio.

Ali *et al.* (2013) performed field study to evaluate the effect of boron (B) and zinc (Zn) fertilizer alone and in combination on yield, yield components and nutrient concentration in various plant parts. The treatments consisted of (a) untreated control (b) three levels of B (0, 1, 2 kgBha^{-1}) and (c) three levels of Zn (0, 5, 10 kgZnha^{-1}). The basal dose of NPK at the rate of 150, 110, 60 kg ha^{-1}, respectively, was applied to all treatments except control. The treatments were arranged in randomized complete block design with four replications. Results showed that combined addition of 2.0 kgB and 5 kgZnha^{-1} produced significant impact on the grain yield and its components i.e., number of tillers m-^{2}, spike length, number of grains spike^{-1} and 1000 grain weight. The improvement in dry matter production and grain yield was 14.5% and 9.4%, over control, respectively, by the combined application of 2.0 kg B ha^{-1} and 5.0 kg Zn ha^{-1}. There was substantial increase in B concentration in grains i.e., 129.6% and 47.6% by individual addition of 2.0 kgB and 5.0 kgZnha^{-1} over control, respectively. The level of Zn content was raised from 15.2 to 37.4 mg kg^{-1} by application of 10.0 kgZnha^{-1}. Thus, substantial improvement in wheat productivity could be harvested with simultaneous increased concentration of Zn nutrient in grain for alleviation of syndrome caused due to Zn deficiency across rural and peri-urban communities.

Nadim *et al.* (2011) evaluated the growth and yield response of wheat variety Gomal-8 using micronutrients and their application methods. The results revealed that application of boron @2 kgha^{-1} produced higher crop growth rate (23.58 m^{-2}day^{-1}), net assimilation rate (2.82 mg m^{-2} day^{-1}), number of tillers (234.5 m^{-2}), number of grains (52.92 spike^{-1}) and grain yield (3.14 tha^{-1}). The use of iron @ 12 kgha^{-1} also showed encouraging results similar to boron. Among various application methods, side dressing at 4 weeks after sowing (WAS) showed the best results as compared to soil application and foliar spray. Higher leaf area index and crop growth rate was obtained with the application of zinc @10 $kgha^{-1}$. Also, different micronutrients had significant interaction with application methods for physiological and agronomic traits including number of tillers, leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR) and grain yield. Side dressing best interacted with boron for producing higher number of tillers, grains per spike, net assimilation rate and grain yield. This method showed better combination with iron for higher number of tillers, LAI and grain yield.

Moghadam *et al.* (2012) reported the quantitative information regarding effects of micronutrients such as Boron, Zinc and Copper in wheat (*Triticum aestivum*) is scarce. Foliar application can guarantee the availability of nutrients to crops for obtaining higher yield. So to study the response of wheat to foliar application of these micronutrients, two experiments were a factorial on randomized complete block design with four replications conducted at Chenaran and Mashhad, Iran during 2010-11. Treatments of these experiments were type of elements (Zinc, Boron and Copper) doses of foliar application (0, 1 and 2 lit/ha) and Varieties (Gaskojen and Pishtaz). The experiments were conducted under well watered conditions. Type of elements was significant on the number of spikes per plant, Grain per spike, grain in square meter, Harvest Index (HI) and Grain yield (kg/ha) but had no effect on thousand grain weigh. Boron and Zinc showed higher amounts in mentioned traits than Copper, although Boron in Chenaran, and Zinc in Mashhad were more effective. the number of spikes per plant, grain in square meter, and grain yield increased with raising in doses of foliar application, so that highest of these were in dose of 2 lit/ha. Varieties and locations resulted different in evaluated traits generally. Chenaran was better than Mashhad, and Gaskojen than Pishtaz in yield and yield components. The findings found at this study can be used in management recommendations of wheat. Further, it is recommended that more attention should be paid to Zn and B nutrition in mentioned locations.

Debnath *et al.* (2011) observed the effect of different rates of boron application on wheat cv. Bijoy was studied through a field experiment at Bangladesh Agricultural University (BAU) farm, Mymensingh during 2009-10 rabi season. The BAU farm belongs to Old Brahmaputra Floodplain agro-ecological zone (AEZ 9). Texturally the soil was silt loam, with 7.2 pH, 0.81% organic matter and 0.15 mg kg^{-1} available boron content. The experiment was laid out in a randomized complete block design with five boron rates and four replications. Boron rates were 0, 0.75, 1.5, 2.25 and 3.0 kg ha^{-1}, with boric acid as a source. Every plot received blanket doses of 115 kg N, 25 kg P, 75 kgK and 15 kg Sha^{-1} from urea, TSP, MoP and gypsum, respectively. Treatment receiving B @2.25 kg ha^{-1} produced the highest grain yield (4.22 tha^{-1}) which was statistically identical with that obtained with 1.75 kg Bha^{-1}. However, the crop response curve showed 1.90 kgha^{-1} to be the optimum boron rate for the maximization of wheat yield. The lowest grain yield (2.84 t/ha) was recorded with control treatment. There was a positive relationship between grain yield and number of grains spike^{-1}. Boron had significant influence on N, P, K, S and B uptake by the crop which, in deed, was more influenced by crop yield and less by nutrient concentration, except N and B uptake where concentration had more influence than yield.

Singh and Yadav (2010) performed a research during the rabi season of 2008-09 under controlled glass house conditions to study the individual and interactive effects of zinc (0, 5 and 10 mg kg^{-1} soil) and boron (0, 0.75 and 1.5 mgkg^{-1} soil) on enzymatic activity and nutrient uptake in wheat (var. HD2285). Application of zinc (ZnSO4) @ 10 mgkg^{-1} soil and boron (borax) @0.75 mgkg^{-1} soil individually increased the plant height and total dry matter in maize. However, the maximum increase was obtained with the combined application of zinc and boron. The activities of enzymes per oxidase and starch phosphorylase showed a decrease in all the treatments as compared to untreated control. However, the activity of carbonic anhydrase increased, more prominently in the treatments containing zinc.

Khan *et al.* (2006) experimented on wheat and rice to study the response of boron application in wheat-rice system. Two levels of boron viz. 1 and 2 kg ha^{-1} with control were studied with the basal dose of N, P_2O_5 and K_2O as 120 – 90 - 60 kgha^{-1}. Wheat variety Naseer 2000 and rice variety IRRI- 6, both were planted in RCB design with three replications in a permanent layout. Boron application significantly affected wheat grain yield that ranged from 2.70 to 3.49 tha^{-1} giving highest increase of 19.9% over control from 1.0 kg ha^{-1}. The number of tillers m^{-2}, spike m^{-2}, spike length, plant height and 1000 grain weight of wheat were also significantly different from control for the same treatment. Paddy yield was also significantly affected by boron application, which ranged from 3.51 to 6.11 tha^{-1}. The highest yield was obtained from 2 $kgBha^{-1}$ (T7) when applied to both crops. The number of spikes m-^{2}, number of spikes $plant^{-1}$, spike length, plant height and 1000 grain weight paddy were significantly affected over control. The direct application of 1 and 2 $kgBha^{-1}$ gave an increase of 59.6 and 62.1%, cumulative application of 1 and 2 $kgBha^{-1}$ increased the paddy yield 61.1 and 74.1%, while residual application of 1 and 2 $kgBha^{-1}$ increased the yield by 36.8 and 48.8% over control. The direct application of 2 $kgBha^{-1}$ to each crop can be recommended for economical yield. Boron concentration in the leaves of wheat and rice was significantly affected by the application of boron that ranged from 10.37 - 14.91 and 3.52 - 5.81 $mgkg^{-1}$, respectively. Similarly the boron concentration in soil was also significantly affected by boron concentration in wheat and rice and ranged from 0.18 - 0.51 and 0.17 - 0.61 $mgkg^{-1}$, respectively. The highest concentration in leaf and soil in wheat was found from 2 $kgha^{-1}$, while cumulative application of 2 $kgha^{-1}$ proved to be the highest in both the crops.

Shukla and Warsi (2000) reported the growth characters (lAI, LAR, NAR, RGR and dry matter accumulation) were higher at high fertility (120, 60, 60 kgNPK/ha). Maximum lAI was observed at 75 DAS (5.36), LI\R at 30 DAS (16374 em/g), NAR at 60-75 DAS (8.31 g/m/day) and RGR at 30-45 (80.65 mg/g/day) crop growth periods. Among micronutrients, zinc application increased the different growth parametres and yield followed by sulphur and manganese. Iron and boron did not influence the growth and yield of wheat significantly. Zinc, manganese and boron content was higher in grain than straw whereas iron and sulphur content was higher in straw.

2.2 Effect of Boron (B) on growth stages of wheat varieties

Leghari *et al.* (2016) carried out an experiment at Student's Experimental Farm, Department of Agronomy, Sindh Agriculture University, Tandojam, during 2014-15. The trial was arranged on randomized complete block design, replicated thrice and treatments included: Control (untreated), NPK= 90:60:60 kg ha^{-1}, NPK = 90-30-30 kg ha^{-1} + B: 1% (tillering), NPK = 120:60:60 kg ha^{-1} + B: 1% (tillering), NPK = 90:30:30 kg ha^{-1} + B: 2% (tillering), NPK = 120:60:60 kg ha^{-1} + B: 2% (tillering).The statistical analysis of data proved that various combinations of NPK and boron application displayed significant ($P<0.05$) effects on nearly all the growth and yield components of wheat. Thus, maximum plant height 86.7cm, more tillers 418.0 m^2, increased spike length 11.6 cm, grains $spike^{-1}$ 51.0 and 49.0, grain weight $plant^{-1}$ 7.9 g, seed index (1000 grain weight) 41.7 g, biological yield 9131.7 $kgha^{-1}$, grain yield 3880.0 $kgha^{-1}$ and harvest index 42.5% were noted at NPK 120-60-60 $kgha^{-1}$ + B 2% at tillering phase, Whereas, all growth and yield parameters were measured poor under control (un-treated) plots. Hence, it was decided from the results that use of NPK = 120:60:60 kg ha^{-1} and 2% foliar application of boron at tillering stage proved better as compared to other treatments.

Rawashdeh and Sala (2014a) investigated the foliar fertilization or foliar feeding is one of the most important methods of fertilizer application. In agriculture practices fertilizer because foliar nutrients facilitate easy and quick consumption of nutrients by penetrating the stomata or leaf cuticle and enters the cells. Foliar application of Boron single or shared with other micronutrients had positive effect on growth, yield and yield parameters of wheat crop. In optimizing fertilization strategies, addition of foliar application develops fertilizer use efficiency and reduces soil pollution. Foliar application of Boron single or shared with other micronutrients at different growth stages have been shown to be effective in efficient consumption of boron by wheat and thus increase grain sitting and increase the grain yield, number of grains per spike, number of spiklets per spike and thousand grain weight. Preservation this in outlook, the literatures on foliar application of boron on the yield and yield components of wheat are reviewed in this paper.

Rawashdeh and Sala (2014b) carried out to study the effect of boron foliar application at different growth stages on morphological parameters of wheat Alex variety at Didactic Station, Timisoara, Romania during the year 2012-2013. The trial was laid out in a randomized complete block design (RCBD), consisted of three replications with the following treatments: T1 control (only received distilled water spray), T2 (B 0.3% at ZGS22), T3 (B 0.3% at ZGS41) and T4 (T2+T3) as form boric acid. Foliar solution of B was sprayed with a hand held pump sprayer at the rate of 400 L ha^{-1} on plant foliage. Experimental results revealed that the foliar application of 0.3% boron as a H_3BO_3 at different growth stages at ZGS22 and ZGS41 significantly increased plant height, spike length (cm), number of spikes m^{-2} and number of spikelets per spike which were over the control. Best results were obtained when B was applied at

0.3% at ZGS22 and ZGS41 (T4), which gave significant increase in plant height, spike length (cm), number of spikes m^{-2}, and number of spikelets per spike as compared with the control treatment. These parameters were increased by 11.11%, 15.38%, 12.81% and 17.30%, respectively.

Metwally *et al.* (2012) evaluated the fresh and dry matter yield of the test wheat cultivars showed marked decrease as the concentration of boron was increased. Elevated concentration of boron had a notable inhibitory effect on the biosynthesis of pigments fractions in the test wheat cultivars as severely as dry matter gain. The adverse concentration effects of boron on some metabolic responses were clearly displayed by shoot and root systems, exhibited in the elevated rates of proline, hydrogen peroxide and malondialdehyde formation. Potassium leakage was severely affected by boron-stress in some cultivars at all tested concentrations, while in some others a moderate damage was manifested only at the higher boron concentrations. Results concluded that the Sakha 93 out of all the different cultivars investigated was found to display the lowest sensitivity to boron-stress, while Gemmeza 9 was the most sensitive one.

Hwary and Yagoub (2011) conducted for two consecutive winter seasons (2008/09-2009/10) at the Demonstrated Farm, Sudan University of Science and Technology, Shambat, Sudan to study the effect of skipping one irrigation during different developmental stages on growth, yield, yield components and water use efficiency of wheat (*Triticum aestivum* L.). Condor cultivar was grown under six irrigation treatments at developmental growth stage, in which one-irrigation was skipped at some of growth stages (seedling W_1, tillering W_2, booting W_3, dough W_4 and repining stage W5) and irrigation without skipping with intervals of 10 days as control WS. The experimental design was randomized complete block design with four replications. The parameters studied were: plant height, dry matter accumulation, plant/m^2, tiller/plant, number of spike/m^2, spikelet/spike, grain/spike, 1000-grain weight, grain yield, straw yield, biomass, harvest index, water use efficiency. The results showed there were highly significant differences in all tested parameters due to skipping irrigation except plant/m^2 in both seasons, and plant height and dry matter accumulation in 45 days reading (booting stage) in the second seasons. Irrigation every 10 days throughout (control) gave higher values (few different with seedling and repining stages) than the other sensitive stages. Although, the resulted showed highly significant effect on the studied parameters biomass, straw and grain yield, harvest index, water use efficiency and protein content. In general irrigation every 10 days with slightly different at skipping on seedling and repining stages gave the highest protein content, grain and straw yield and field water use efficiency. Skipping irrigation during tillering and booting stage must be avoided.

Tahir *et al.* (2009) investigated the experiment in the University of Agriculture, Faisalabad, Pakistan during winter 2006-07, yield response of wheat (*Triticum aestivum* L.) to boron application at different growth stages. Foliar application of Boron in Wheat at four different growth stages i.e at tillering, jointing, booting and anthesis was practiced. Number of grains per spike, 1000 grain weight and grain yield was significantly increased where boron was applied. Significantly higher yield was obtained where Boron was applied at booting stage. So, boron application at booting stage was found to be the best time for obtaining higher grain yield of wheat. The results suggest that exogenous application of Boron (0.5 $kgha^{-1}$) at tillering stage influenced better yield and yield attributes of BARI Gom 24.

CHAPTER III

MATERIALS AND METHODS

The study was conducted at the experimental shed of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to March 2016 to evaluate the effect of boron (B) levels on the yield of wheat. The materials and methods used in performing this experiment are described in this chapter. A brief description of soil, crop, treatment, layout, statistical design, intercultural operations, data recording, data processing and chemical analysis are given below:

3.1 Experimental site

The experimental site was the experimental shed of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Geographically the experimental field is located at 23°46' N latitude and 90° 22' E longitude at an elevation of 8.2 m above the sea level belonging to the Agro-ecological Zone "AEZ-28" of Madhupur Tract (BBS, 2012).

3.2 Soil

The soil of the experimental pots is slightly acidic with low organic matter content collected from Agronomy Field Laboratory. The analyses were done from Soil Resources Development Institute (SRDI), Dhaka. The soil of the experimental pots is clay loam with a pH of 5.45-5.61. The physicochemical properties and nutrient status of soil of the experimental plots are given in Appendix VI.

3.3 Climate

The experimental site is situated under sub-tropical climate, characterized by heavy rainfall during Kharif season (April to September) and scanty rainfall in rabi season (October to March). In Rabi season temperature is generally low and there is plenty of sunshine. The atmospheric temperature tends to increase from February.

3.4 Description of the planting material

Wheat (*Triticum aestivum* L.) varieties (BARI Gom 23 & BARI Gom 24) were used as plant material. BARI developed these varieties and released in 2005. These are most popular varieties now due to its high yielding potentials and suitable for early and late planting (upto second week of December). These varieties attain a height of 95-100 cm and it takes 105-112 days to complete their life cycle and are resistant to leaf rust disease. The number of tillers plant^{-1} was 3-4 and the leaves were wide and deep green in color. It requires 64-66 days to heading. Grains are white, light and large in size. Its yield is 3-3.5 tha^{-1} and 1000 grain weight is 48-55 g and 3.5-4.15 tha^{-1} and 1000 grain weight is 50-58 g respectively. The seeds were collected from the Bangladesh Agricultural Research Institute (BARI).

3.5 Treatments

The experiment consisted of the following treatments:

A. Varieties

vi) V_1- BARI Gom 23

vii) V_2- BARI Gom 24

B. Boron level:

i) 0 kg ha^{-1} (B_0)

ii) 0.5 kg ha^{-1} (B_1)

iii) 1 kg ha^{-1} (B_2)

C. Growth Stages

iv) S_1- Seedling stage

v) S_2-Tillering stage

3.6 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications; each representing a block.

3.7 Pot preparation

For pot preparation the experimental soil was crushed and prepared suitable for the seed sowing. Weeds, stubbles and crop residues were removed from the pot. The fertilizers were applied to the experimental pots as per recommended dose. Each pot was filled with 14 kg soil. Then seeds had sown into the pot after 3 to 4 days.

3.8 Fertilizer application

The experimental pots were fertilized as per treatments with 180 kgNha $^{-1}$, 120 kg TSP ha^{-1}, 60 kg MOP ha^{-1}. Boron was applied as per treatments through boric acid (17% B) at 23 DAS and 43 DAS. The total amount of TSP, MOP, and one-third of the urea were applied at the time of final land preparation prior to sowing. The remaining two-thirds of urea were top-dressed in two equal splits on 20 and 55 days after sowing (DAS) of the seed. Boron doses are calculated considering weight of 1 ha soil is 2242000 kg and each pot containing 14 kg soil. All fertilizers are mixed with unit amount of water and applied to the pots.

3.8.1 Fertilizer application procedure in the experimental pot

1) B_0 = 0 kg Bha^{-1} (No boron was applied)

2) B_1 = 0.5 kg Bha^{-1} (0.0184 g Boric acid/pot)

3) B_2 = 1 kg Bha^{-1} (0.0367 g Boric acid/pot)

3.9 Sowing of seeds

The seeds were sown on 20 November 2016 at the rate of 10 seeds per pot.

3.10 Intercultural operations

Intercultural operations were done in order to ensure and maintain the normal growth of the crops. Manual weeding was done two times at 18 and 50 days after sowing (DAS). The pots were irrigated several times when necessary.

3.11 Harvesting and processing

The crop was harvested pot-wise at full maturity on 19 March 2016 and carried to the threshing floor for drying, threshing and cleaning. The grains and straw were then dried in the sun for four days.

3.12 Sampling and data recording

For collecting data on crop characters, 5 sample plants per pot were selected at random from 6 and uprooted prior to harvesting. The grain and straw yields were recorded pot-wise at 14% moisture level in tha^{-1}. The data on the following crop parameters were recorded from each pot.

i. Leaf length (cm) at (40 DAS, 60 DAS)
ii. Leaf breath (cm) at (40 DAS, 60 DAS)
iii. Plant height (cm) at (40 DAS, 60 DAS)
iv. Plant height during Harvest (cm)
v. No. of leaf $plant^{-1}$ (40 DAS, 60 DAS)
vi. Number of total tillers $plant^{-1}$ (40 DAS, 60 DAS)
vii. Length of spike (cm)
viii. Number of spikelets $spike^{-1}$
ix. Number of non fertile spikelets $spike^{-1}$
x. Number of grains $spike^{-1}$
xi. Number of sterile spikelets $spike^{-1}$
xii. Weight of 1000 grains (g)
xiii. Grain yield (tha^{-1})
xiv. Straw yield (tha^{-1})
xv. Biological yield (tha^{-1})
xvi. Harvest index (%)

3.13 Data collection techniques

A brief outline of the data recording procedure is as follows:

3.13.1 Growth, yield and yield contributing characters of wheat

3.13.1.1 Length of leaf (cm)

Length of the 3 leaves from each of 5 plants i.e. 15 leaves were measured from the bottom level to the tip and their average was calculated.

Breath of leaf (cm)

Breath of the 3 leaves from each of 5 plants i.e. 15 leaves were measured from the bottom, upper and middle level of the leaves and their average was calculated.

Plant height (cm)

Height of the plant was measured from the ground level to the tip of the uppermost spikelets of the panicle and their average was calculated.

Number of leaf plant^{-1}

Number of leaf per plant was counted during 40 DAS and 60 DAS and then their average values were calculated.

3.13.1.2 Leaf Area Index (LAI)

The Leaf Area Index was calculated as follows:

$$LAI = \frac{\text{Leaf length} \times \text{Leaf Breath}}{\text{Pot Area}} \times \text{Correction factor } (0.75)$$

3.13.1.2 Number of total tillers plant^{-1}

Number of total tillers plant^{-1} from each pot was counted during 40 DAS and 60 DAS and then their average values were calculated.

3.13.1.3 Number of effective tillers plant^{-1}

Number of effective tillers plant^{-1} from each pot was counted from 5 plants one week before harvest and their average values was taken.

3.13.1.4 Length of spike (cm)

Length of spike was measured from the sample plants and their average values were calculated.

3.13.1.5 Number of spikelets spike^{-1}

Number of spikelets spike^{-1} was counted taking five spikes from the five selected plants of each pot and the average numbers were recorded.

3.13.1.6 Number of grains spike^{-1}

Number of grains spike^{-1} was counted taking spikes from the marked 5 plants of each pot and the average numbers were recorded.

Number of sterile spikelets spike^{-1}

Number of sterile spikelets spike^{-1} was counted taking spikes from marked 5 selected plants of each pot and the average numbers were recorded.

Thousands grain weight (g)

The weight of 1000 seeds from each pot was measured in grain taking 5 plants marked from each unit pot.

Grain yield (tha^{-1})

Grains obtained from each unit pot were sun dried and weighed carefully. The dry weight of grains of selected plants was added to the respective unit pot to record the final yield pot^{-1}. The grain yield was finally converted to tha^{-1}.

3.13.1.10 Straw yield (tha^{-1})

Straw obtained from each unit pot including the straw of sample plants of respective unit pot was dried in sun and weighed to record the final straw yield pot^{-1} and finally converted to t ha^{-1}.

3.13.1.11 Biological yield (tha^{-1})

Total weight of aerial biomass (including the grain) at maturity was measured from each pot and expressed as tha^{-1}.

3.13.1.12 Harvest index (%)

The harvest index was calculated as follows:

Biological yield = Grain yield + Straw yield

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.14 Statistical analysis

The recorded data were compiled, tabulated and subject to statistical analysis. Analysis of variance was done with the help of computer package programme MSTAT-C. The difference among the treatment means was evaluated by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

A pot experiment was carried out at the Agronomy net house of the Dept. of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to study the effect of boron (B) levels on growth and yield components of wheat varieties (BARI Gom 23 and BARI Gom 24). The effects of different levels of boron on different plant characters, grain and straw yields of wheat has been presented and discussed in this chapter. The mean results of the experiment on the effect of B levels along with their different interactions, summaries of analysis of variance (ANOVA) on various characters and different matrix are presented in Tables 1 to 24, Figures 1 to 29 and Appendices I to VI, respectively. The results are discussed and interpreted under the following subheads.

4.1 Leaf Area Index (LAI)

The application of different levels of boron influenced the leaf area index significantly (Appendix-1). The higher leaf area index (1.08) was found in BARI Gom 24 and lower leaf area index (0.94) was observed from BARI Gom 23 at 40 days after sowing (Table 1). The higher leaf area index (2.91) was found in BARI Gom 24 and lower leaf area index (2.59) was observed from BARI Gom 23 at 60 days after sowing. When the pot was fertilized with 0.5 kg B ha^{-1} at 40 and 60 days after sowing in wheat varieties, the leaf area index was 1.49 and 3.74, respectively. In case of growth stage, the higher leaf area index (1.07 and 2.97) were observed with the boron application in tillering stage at 40 and 60 DAS, respectively. The higher leaf area index was found as 1.59 and 3.86 in V_2B_1 at 40 and 60 DAS, respectively (Table 2). The non significant but higher leaf area index were observed as 1.12 and 3.10 in V_2S_2 at 40 and 60 days after sowing (Table 3).

Application of B at different growth stages significantly affected the wheat leaf area index. The higher leaf area index at 40 DAS (1.68) with the application of 0.5kg Bha^{-1}at seedling stage, whereas the higher (3.95) leaf area index was found from the same level of boron application at 60 days after sowing (Table 4).

The higher leaf area index 1.81 and 4.10 at 40 and 60 DAS respectively were found from variety BARI Gom 24 with the 0.5 $kgBha^{-1}$ application at tillering stage (Table 5). The lower leaf area index 0.62 and 1.17 were found from variety BARI Gom 23 from the B_0 at 40 and 60 days after sowing, respectively. The application of boron in wheat was observed by Moghadam *et al.* (2012). The response of wheat leaf breath on the application of boron was evaluated by Halder *et al.* (2007). The leaf breath of wheat also observed in different varieties (Asad and Rafique, 2002). From the findings it was found that the leaf area index of wheat was significantly influenced and increased with the level of boron application.

Table 1. Effect of boron on leaf area index of wheat varieties with their growth stage at 40 and 60 days after sowing

Variety	Leaf area index at	
	40 DAS	60 DAS
V_1	0.94 b	2.59 b
V_2	1.08 a	2.91 a
LSD $_{(0.05)}$	0.038	0.054
Boron		
B_0	0.65 c	1.63 c
B_1	1.49 a	3.74 a
B_2	0.89 b	2.89 b
LSD $_{(0.05)}$	0.05	0.07
Growth stage		
S_1	0.96 b	2.54 b
S_2	1.07 a	2.97 a
LSD $_{(0.05)}$	0.04	0.05
CV (%)	5.58	2.82

V_1-BARI Gom 23; V_2-BARI Gom-24; B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 2. Interaction of varieties and boron on leaf area index of wheat at 40 and 60 days after sowing

Treatments	Leaf area index at	
	40 DAS	**60 DAS**
V_1B_0	0.63 e	1.49 f
V_1B_1	1.40 b	3.63 b
V_1B_2	0.80 d	2.66 d
V_2B_0	0.68 e	1.76 e
V_2B_1	1.59 a	3.86 a
V_2B_2	0.99 c	3.12 c
LSD $_{(0.05)}$	0.07	0.09
CV (%)	5.58	2.82

V_1-BARI Gom 23; V_2-BARI Gom-24; B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 3. Interaction of varieties and growth stages on leaf area index of wheat at 40 and 60 days after sowing

Treatments	LAI 40 DAS	LAI 60 DAS
V_1S_1	0.87	2.35
V_1S_2	1.02	2.83
V_2S_1	1.05	2.72
V_2S_2	1.12	3.10
LSD $_{(0.05)}$	NS	NS
CV (%)	5.58	2.82

V_1-BARI Gom 23; V_2-BARI Gom-24; S_1-Seedling stage; S_2-Tillering stage;
In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 4. Interaction of boron and growth stages on leaf area index of wheat at 40 and 60 days after sowing

Treatments	LAI 40 DAS	LAI 60 DAS
B_0S_1	0.66 d	1.28 f
B_0S_2	0.65 d	1.98 e
B_1S_1	1.30 b	3.53 b
B_1S_2	1.68 a	3.95 a
B_2S_1	0.91 c	2.80 d
B_2S_2	0.87 c	2.97 c
LSD $_{(0.05)}$	0.07	0.09
CV (%)	5.58	2.82

S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}
In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 5. Interaction of varieties, boron and growth stages on leaf area index of wheat at 40 and 60 days after sowing

Treatments	Leaf area index at	
	40 DAS	60 DAS
$V_1B_0S_1$	0.62 h	1.17 k
$V_1B_0S_2$	0.65 h	1.81 i
$V_1B_1S_1$	1.24 d	3.45 d
$V_1B_1S_2$	1.55 b	3.80 b
$V_1B_2S_1$	0.75 g	2.43 g
$V_1B_2S_2$	0.85 f	2.89 f
$V_2B_0S_1$	0.70 gh	1.38 j
$V_2B_0S_2$	0.65 h	2.14 h
$V_2B_1S_1$	1.36 c	3.61 c
$V_2B_1S_2$	1.81 a	4.10 a
$V_2B_2S_1$	1.08 e	3.17 e
$V_2B_2S_2$	0.90 f	3.06 e
LSD $_{(0.05)}$	0.09	0.13
CV (%)	5.58	2.82

V_1-BARI Gom 23; V_2-BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

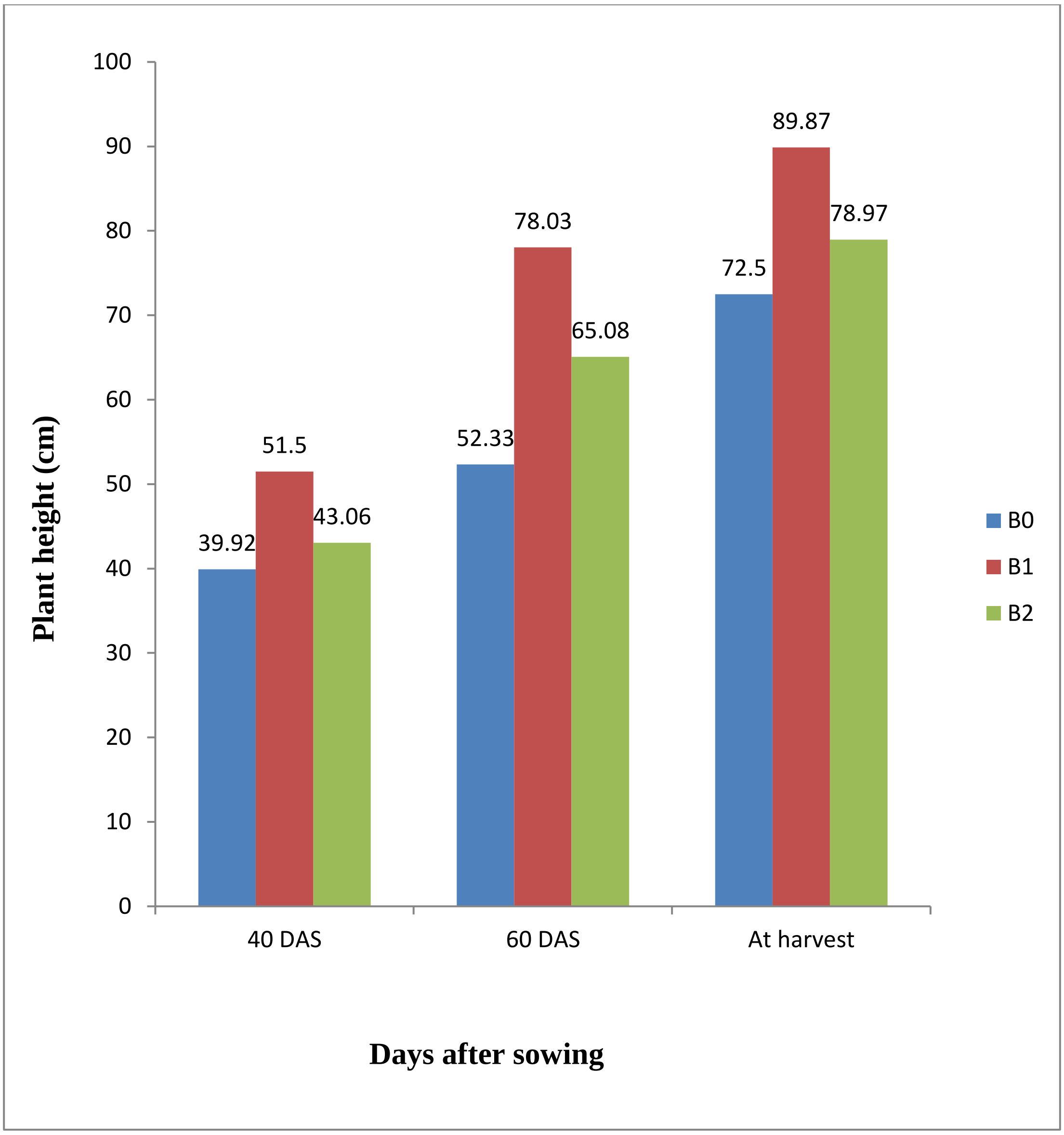
In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

4.2 Plant height (cm)

Application of B significantly affected the wheat plant height in respect to the varieties. The tallest plant (51.50 cm) was found with the treatment of 0.5 kgBha^{-1} and the smallest (39.92 cm) was found from control at 40 days after sowing and also the increased proportionally at 60 days after sowing and there time of harvesting. In case of seedling stage, the maximum plant height (66.31 cm) and (81.90 cm) were observed at 60 days after sowing and during harvesting, respectively. The minimum plant height 63.99 cm and 78.99 cm at 60 days after sowing and harvesting, accordingly. Above the findings shown that plant height was greatly affected and plant height increased with the level of B application (Fig. 1).

Application of different levels of boron influenced plant height significantly (Appendix 1 & 2). The tallest plant height (53.17 cm) was found when the crop was fertilized with 0.5 kgBha^{-1} which was statistically identical with 1 kgBha^{-1} and the shortest plant height (39.56 cm) from control 40 days after sowing in tillering stage. Similarly, the plant height was proportionally in case of 60 days after sowing and in the time of harvesting (Fig. 2). Alam *et al.* (2000) described the enhancement of wheat growth on the application of boron fertilizer.

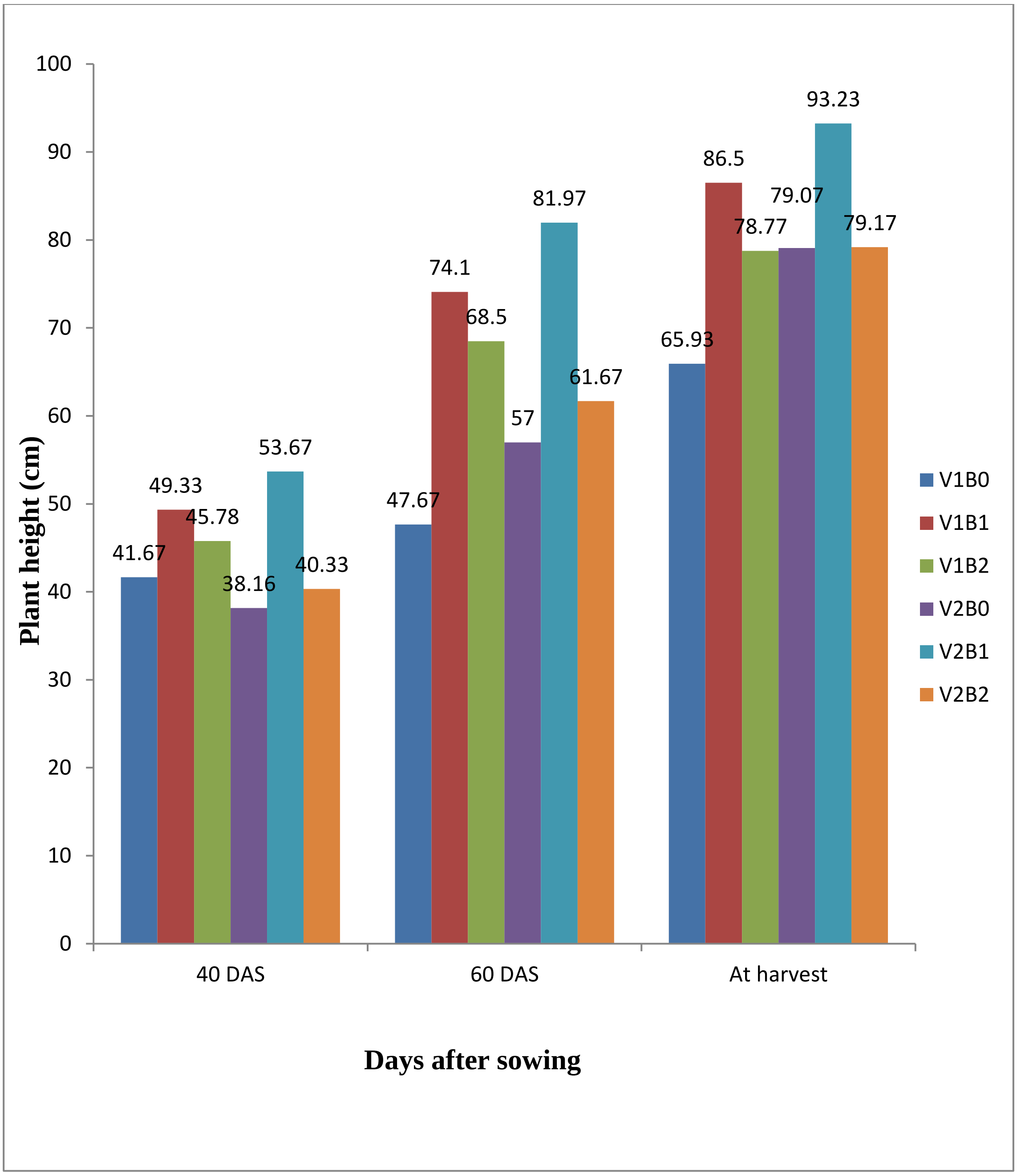
The highest plant height (67.88 cm) was observed variety at 60 days after sowing and also in the time of harvesting (85.44 cm) in BARI Gom 24 and BARI Gom 23, respectively. In case of variety and growth stages combination the plant height was not significantly difference. The minimum height 62.11 cm and 75.78 cm were found at 60 days after sowing and at harvesting time, respectively (Fig. 3 and Appendix 1 & 2). The maximum plant height (53.17 and 79.60 cm) was observed at 40 and 60 days after sowing with the application of 0.5 kgBha^{-1}(Fig. 4). In case of interaction, the maximum plant height (55.33 and83.33 cm) was observed with the application of 0.5 kgBha^{-1} in tillering stage of BARI Gom 24 (Fig. 5).The presented results are similar with the findings of Mete *et al.* (2005) who reported that plant height was obtained to increase by B application up to 3 kgBha^{-1} or 10 kg borax ha^{-1}. In contrast, BINA (1993) reported that plant height varied significantly by application of 1 kg Bha^{-1}.



B_0-Control; B=-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 1. Effect of boron levels on the plant height of wheat.

($LSD_{0.05}$ = 2.05, 1.12, and 2.56 at 40, 60 DAS and at harvest respectively)

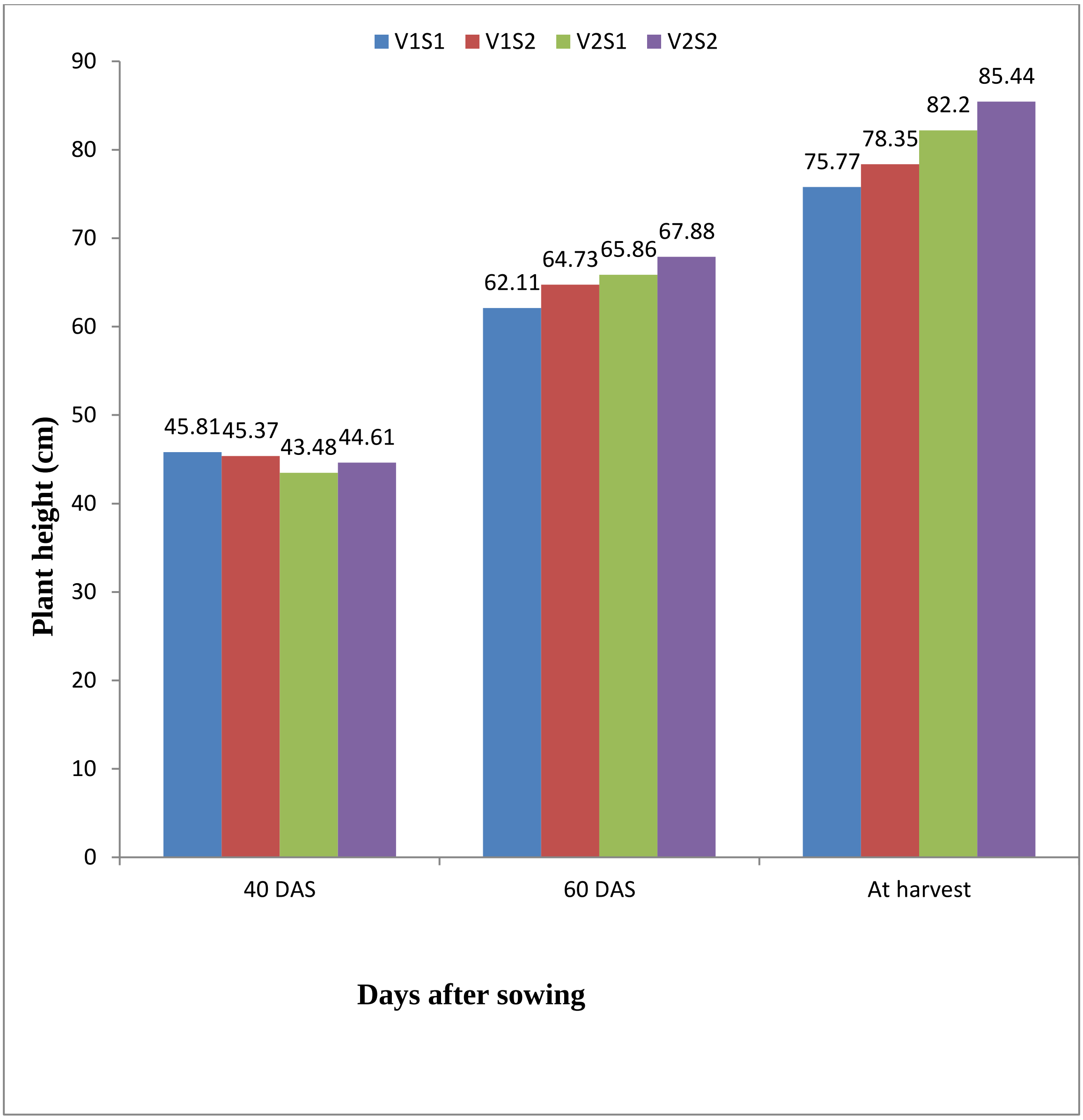


B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

V_1- BARI Gom 23; V_2-BARI Gom 24

Figure 2. Effect of boron levels on the plant height of two varieties of wheat.

($LSD_{0.05}$ = 2.89, 1.59, and 3.62 at 40, 60 DAS and at harvest respectively)

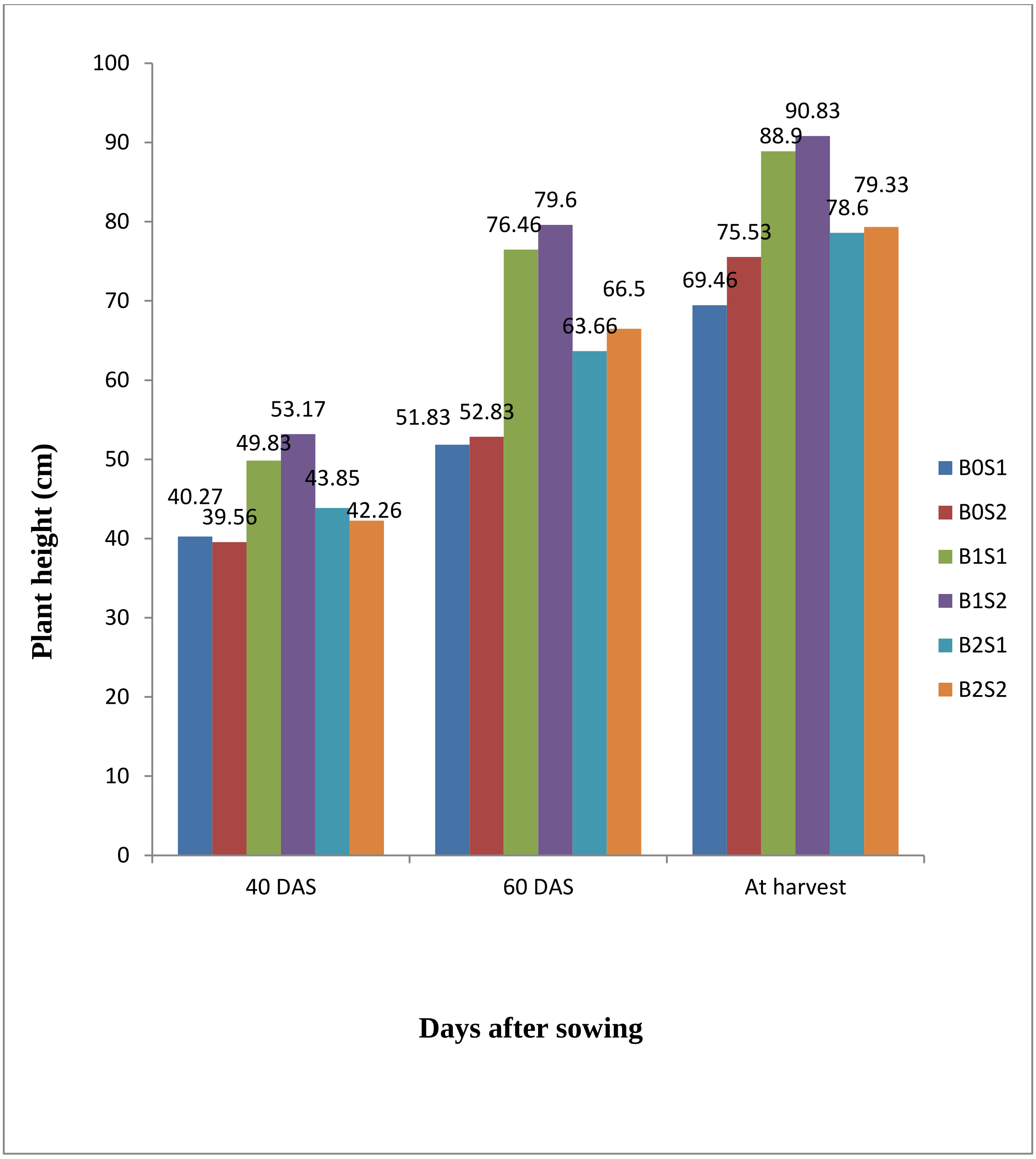


V_1- BARI Gom 23; V_2-BARI Gom 24

S_1-Seedling stage; S_2- Tillering Stage

Figure 3. Interaction of variety and growth stages on plant height of wheat.

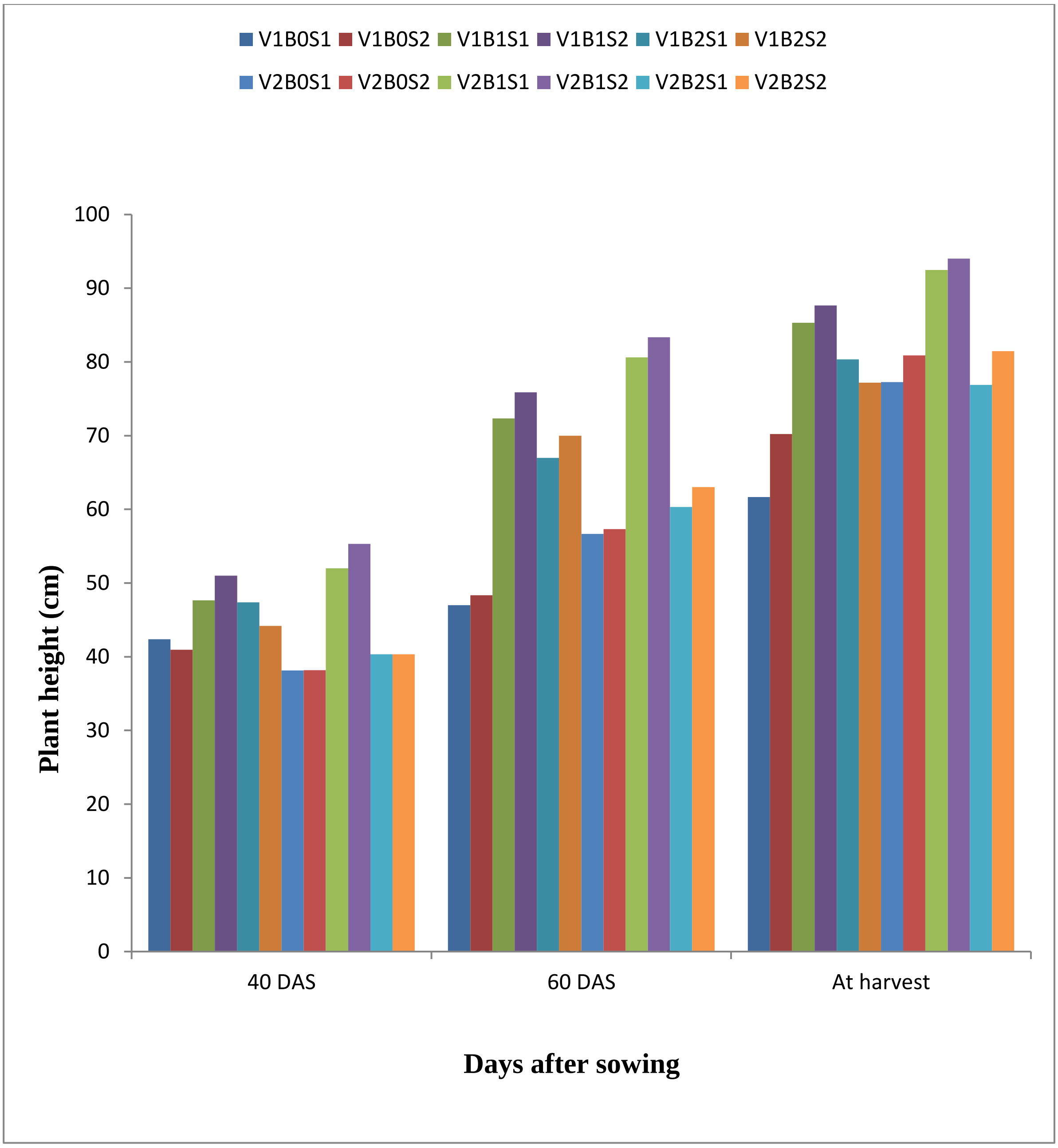
($LSD_{0.05}$ = 2.05, 1.12, and 2.56 at 40, 60 DAS and at harvest respectively)



B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

S_1-Seedling stage; S_2-Tillering stage

Figure 4. Effect of boron levels on seedling and tillering stage on plant height of wheat. ($LSD_{0.05}$ = 2.89, NS, and NS at 40, 60 DAS and at harvest respectively)



B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

S_1-Seedling stage; S_2-Tillering stage

V_1- BARI Gom 23; V_2-BARI Gom 24

Figure 5. Interaction effect of boron levels and growth stages on the plant height of wheat.

($LSD_{0.05}$ = NS at 40, 60 DAS and at harvest respectively)

4.3 Leaf number

Higher number of leaf (10.58) and the lower number (9.08) were observed the variety of BARI Gom 24 and BARI Gom 23 at 40 days after sowing, respectively (Table 6). The numbers of leaves were proportionally increased by 14.30 and 13.26, at 60 DAT. When the varieties were fertilized by boron then the numbers of leaves were increased. The numbers of leaves were also increased in both the varieties when boron was applied at tillering stage thn at seedling stage.

Application of B on leaf number per plant was about 40 DAS but was significant at 60 DAS. The highest numbers (14.37 & 12.5) of leaves were found in BARI Gom 24 and BARI Gom 23 with the application of 0.5 $kgBha^{-1}$ at 40 days after sowing (Table 7). And the increase continued till 60 days after sowing. The lowest numbers (6.57 & 7.40) of leaves were observed in both varieties from the control.

In case of seedling and tillering stage, the higher (14.23) and lower (7.03) number of leaves were calculated from tillering stage and also from seedling stage with the application of boron@0.5 $kgha^{-1}$ and from control, respectively (Table 8). And then the lowest numbers (9.23) of leaves were observed in application of boron @1 $kgha^{-1}$ in tillering stage at 40 days after sowing.

These results also found that the increase of leaf numbers was continued even till 60 days after sowing. The application of boron in leaf number was observed (Ziaeyan and Rajaie, 2009). Moreover, application of boron also influenced the combination of varieties, seedling and also tillering stage. The higher number (15.33) and lower (13.13) of leaves was observed in BARI Gom 24 and BARI Gom 23 with the same dose of Boron @0.50 kg ha^{-1} in tillering stage, respectively (Table 9). The number of leaves increased in different levels of Boron such as- 6.56 and 7.3 in both varieties from the control at 40 days after sowing.

Table 6. Effect of boron levels on no. of leaf plant^{-1} of wheat varieties with their growth stages at 40 and 60 days after sowing

Variety	Leaf no./plant at	
	40 DAS	60 DAS
V_1	9.08 b	13.26 b
V_2	10.58 a	14.30 a
LSD (0.05)	0.39	0.64
Boron		
B_0	6.98 c	10.09 c
B_1	13.44 a	17.89 a
B_2	9.08 b	13.35 b
LSD (0.05)	0.48	0.78
Growth Stages		
S_1	9.50 b	12.98 b
S_2	10.17 a	14.58 a
LSD (0.05)	0.39	0.64
CV	5.78	6.69

V_1-BARI Gom 23; V_2-BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1 kg Bha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 7. Interaction of variety and boron on no. of leaf plant^{-1} of wheat at 40 and 60 days after sowing

Variety × Boron levels	Leaf no./plant at 40 DAS	Leaf no./plant at 60 DAS
V_1B_0	6.567	8.517 e
V_1B_1	12.517	17.12 b
V_1B_2	8.167	14.13 c
V_2B_0	7.4	11.67 d
V_2B_1	14.367	18.67 a
V_2B_2	9.983	12.57 d
LSD $_{(0.05)}$	NS	1.1
CV (%)	5.78	6.69

V_1-BARI Gom 23; V_2-BARI Gom 24; B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}
In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 8. Interaction of boron levels and growth stages on no. of leaf plant^{-1} of wheat at 40 and 60 days after sowing

Boron levels × Growth stages	Leaf no./plant at	
	40 DAS	60 DAS
B_0S_1	6.93 d	8.83
B_0S_2	7.03 d	11.35
B_1S_1	12.65 b	17.13
B_1S_2	14.23 a	18.65
B_2S_1	8.92 c	12.97
B_2S_2	9.23 c	13.73
LSD $_{(0.05)}$	0.68	NS
CV (%)	5.78	6.69

S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kg Bha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 9. Interaction of variety, boron and growth stage on no. of leaf plant^{-1} of wheat 40 and 60 days after sowing

Variety × Boron levels × Growth stages	Leaf no./plant at	
	40 DAS	60 DAS
$V_1B_0S_1$	6.57	8.00 f
$V_1B_0S_2$	6.57	9.03 ef
$V_1B_1S_1$	11.90	16.43 b
$V_1B_1S_2$	13.13	17.80 b
$V_1B_2S_1$	8.03	14.80 c
$V_1B_2S_2$	8.30	13.47 c
$V_2B_0S_1$	7.30	9.67 de
$V_2B_0S_2$	7.50	13.67 c
$V_2B_1S_1$	13.40	17.83 b
$V_2B_1S_2$	15.33	19.50 a
$V_2B_2S_1$	9.80	11.13 d
$V_2B_2S_2$	10.17	14.00 c
LSD $_{(0.05)}$	NS	1.56
CV (%)	5.78	6.69

V_1-BARI Gom 23; V_2-BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

4.4 Tillering number

The maximum (2.08 and 2.06) average number of tillers were observed the variety of BARI Gom 23 and BARI Gom 24 at 40 days after sowing, respectively (Table 10). And the tillers numbers were proportionally increased at 60 days after sowing. But when the varieties were fertilized by boron then the numbers of tillers were increased at 40 and 60 days after sowing. In case of seedling and tillering stage, the numbers of tillers were also not significantly increased in both the varieties (Table 11).

Application of B significantly influenced the number of tillers at seedling and also tillering stage. The highest numbers (2.92 & 2.65) of tillers were found in BARI Gom 24 and BARI Gom 23 with the application of 0.5 $kgBha^{-1}$ at 40 days after sowing (Table 12). And the increase continued till 60 days after sowing. When 1 $kgha^{-1}$ Boron was applied in both varieties, the numbers of tillers were not increased considerably. The lowest numbers (1.66 & 1.27) of tillers were observed in both varieties from the control (Table 13). The growth and tillering number increased due to application of boron fertilizer (Zain *et al.*, 2015). Furthermore, application of boron also influenced the combination of varieties, seedling and also tillering stage. The maximum number of tillers ranged from 2.47 to 2.83 in seedling and tillering stage of BARI Gom 23 the dose of Boron @0.50kg ha^{-1}, respectively (Table 14). But the numbers of tillers were varied from 2.76 to 3.07 in both stage of BARI Gom 24 with the application of Boron @1$kgha^{-1}$ at 40 days after sowing. In case of control, the tillers number varied from 1.2 to 1.73 both seedling and tillering stage at 40 days after sowing in the selected varieties. These results are in agreement with the findings of Mishra *et al.* (1989).

Table 10. Effect of boron on no. of tillers plant^{-1} of wheat varieties with their growth stage at 40 and 60 days after sowing

Variety	Tiller no./plant at	
	40 DAS	**60 DAS**
V_1	2.08	3.69 b
V_2	2.06	4.09 a
LSD (0.05)	NS	0.23
Boron		
B_0	1.47c	2.59 c
B_1	2.78 a	5.21 a
B_2	1.95 b	3.88 b
LSD (0.05)	0.15	0.28
Growth Stages		
S_1	2.03	3.65 b
S_2	2.11	4.14 a
LSD (0.05)	NS	0.23
CV (%)	15.2	8.58

V_1-BARI Gom 23; V_2- V_1-BARI Gom 23; V_2-BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 11. Interaction of variety and growth stages on no. of tillers plant^{-1} of wheat at 40 and 60 days after sowing

Variety × Growth stages	Tiller no./plant at	
	40 DAS	60 DAS
V_1S_1	2.04	3.54
V_1S_2	2.11	3.84
V_2S_1	2.01	3.76
V_2S_2	2.10	4.43
LSD $_{(0.05)}$	NS	NS
CV (%)	15.2	8.58

V_1-BARI Gom 23; V_2-BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 12. Interaction of variety and boron levels on no. of tillers plant^{-1} of wheat at 40 and 60 days after sowing

Variety × Boron levels	Tiller no./plant at	
	40 DAS	60 DAS
V_1B_0	1.53	2.27 e
V_1B_1	2.65	4.75 b
V_1B_2	2.05	4.07 c
V_2B_0	1.40	2.92 d
V_2B_1	2.92	5.67 a
V_2B_2	1.85	3.70 c
LSD (0.05)	NS	0.40
CV (%)	15.20	8.58

V_1-BARI Gom 23; V_2 V_1-BARI Gom 23; V_2-BARI Gom 24; B_0-Control; B_1-0.5 kg Bha^{-1}; B_2-1kgBha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 13. Interaction of boron levels and growth stages on no. of tillers plant^{-1} of wheat at 40 and 60 days after sowing

Boron levels × Growth stages	Tiller no./plant at	
	40 DAS	60 DAS
B_0S_1	1.66 c	2.45
B_0S_2	1.27 d	2.73
B_1S_1	2.62 b	4.80
B_1S_2	2.95 a	5.62
B_2S_1	1.8 0 c	3.70
B_2S_2	2.10 c	4.07
LSD (0.05)	0.32	NS
CV (%)	15.20	8.58

S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 14. Interaction of variety, boron and growth stage on no. of tillers plant^{-1} of wheat 40 and 60 days after sowing

Variety × Boron levels × Growth stages	Tillers no./plant at	
	40 DAS	60 DAS
$V_1B_0S_1$	1.73	2.27
$V_1B_0S_2$	1.33	2.27
$V_1B_1S_1$	2.47	4.50
$V_1B_1S_2$	2.83	5.00
$V_1B_2S_1$	1.93	3.87
$V_1B_2S_2$	2.17	4.27
$V_2B_0S_1$	1.60	2.63
$V_2B_0S_2$	1.20	3.20
$V_2B_1S_1$	2.77	5.10
$V_2B_1S_2$	3.07	6.23
$V_2B_2S_1$	1.67	3.53
$V_2B_2S_2$	2.03	3.87
$LSD_{(0.05)}$	NS	NS
CV (%)	15.20	8.58

V_1-BARI Gom 23; V_2-BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

4.5 Spike length (cm)

The spike length was ranged 13.92 to 13.27 cm in BARI Gom 24 and BARI Gom 23, respectively (Table 15). The dose of boron influenced the spike length and found 11.61, 13.69 and 15.48 at the rate of control (0), 1 $kgha^{-1}$ and also 0.5 $kgha^{-1}$, accordingly. In case of seedling and tillering stage, the spikes length was observed 13.19 and 14.03cm in BARI Gom 23 and BARI Gom 24, respectively (Table 16). The spike length increased 11.83 to 16.12 at the zero (0) and 0.5 $kgBha^{-1}$ in BARI Gom 24 (Table 17).

The lowest spike length was observed in BARI Gom 23 from the control. Application of B significantly influenced the spike length at seedling and also tillering stage in the selected varieties. The highest length (15.71 & 15.23 cm) of spikes was found in both stages with the application of 0.5 $kgBha^{-1}$ (Table 18). But when the boron was applied at 1$kgha^{-1}$ then the spike lengths were not increased and non-significant results were found. And the field was not fertilized by trace amount to boron, the spike lengths were observed as 11.71 and 11.5 in seedling and tillering stage.

The application of boron also influenced the spike length with the combination of varieties, seedling and also tillering stage. The maximum length of spikes ranged from 11.33to 13.58 in seedling and tillering stage of BARI Gom 23 with the dose of Boron @0, 0.50 and 1kg ha^{-1}, respectively (Table 19). But the numbers of spikes were varied from 11.66 to 16.33 in both stage of BARI Gom 24 with the application levels of Boron @0, 0.5 and 1$kgha^{-1}$. The results showed that B had positive effects to spike length. The results are in conformity with that of Mandal (1993).

4.6 Number of fertile spikelets spike^{-1}

The fertile spikes were ranged from 9.78 to 11.35 in BARI Gom 23 and BARI Gom 24, respectively (Table 15). The dose of boron influenced the fertile spike and found 9.59, 9.88 and 12.23 at the rate of control (0), 1 $kgha^{-1}$ and 0.5 $kgha^{-1}$, accordingly. In case of seedling and tillering stage, the fertile spikes were observed 10.34 and 10.79, respectively. The minimum fertile spike were found 9.77 at seedling and tillering stage in BARI Gom 23, whereas the maximum fertile spike 10.91 and 11.79 were observed at seedling and tillering stage in BARI Gom 24 (Table 16).

Application of B significantly influenced the fertile spike at different levels with the varieties. The highest numbers of fertile spikes 13.05 with the boron application @ 0.5 kgha^{-1} were found and then the nearest numbers (10.17 & 10.83) of fertile were observed in BARI Gom 24 with the rate of 1 kgha^{-1} and from control (Table 17). But the number of spikes ranged from 8.34 to 11.41with the control and application of boron@0.5kgha^{-1} . But when the boron was applied at 1kgha^{-1} then the fertile spikes were 9.82 to 9.93 at seedling and tillering stage, respectively. The number of spikes increased (11.66 to 12.80) with the application of boron @0.5 kgha^{-1} in both stage. And the fertile spikes were observed as 9.43 and 9.74 in seedling and tillering stage, when the field was not fertilized by trace amount to Boron (Table 18).

The application of boron also influenced the numbers of spike with the combination of varieties, seedling and also tillering stage. The maximum number of spikes ranged from 11.10 to 11.73 in seedling and tillering stage of BARI Gom 23 with the dose of Boron @ 0.50 kgha^{-1}, respectively (Table 19). But in case of BARI Gom 24, the maximum number of spikes ranged from 12.23 to 13.87 in seedling and tillering stage of with same dose of Boron. But the numbers of spikes were varied from 9.21 to 9.96 in both stage of BARI Gom 23 with the application levels of Boron @1kgha^{-1}. And it was increased in BARI Gom 24 with 9.91 to 10.43 numbers of spikes. At zero level of boron application the fertile spikes were observed 8.26 to 8.43 and 10.60 to 11.06 in the variety of BARI Gom 23 and BARI Gom 24 in both stages, respectively. Mitra and Jana (1991) reported that the number of fertile or effective tillers plant^{-1} was significantly increased up to 20 kg borax ha^{-1}.

4.7 No. of non fertile spikelets spike^{-1}

The non fertile spikes were ranged from 3.94 to 4.27 in BARI Gom 23 and BARI Gom 24, respectively (Table 15). The dose of boron influenced the non fertile spikes and found 3.47, 3.95 and 4.89 at the rate of 1kgha^{-1}, 0.5kgha^{-1} and control (0), accordingly. In case of seedling and tillering stage, the numbers of non fertile spikes were observed 3.60 and 4.60, respectively (Table 15). The average numbers of non fertile spikes were found 3.47 and 4.40 at tillering and seedling stage in BARI Gom 23, whereas the average number of non fertile spikes 3.73 and 4.80 were observed at tillering and seedling stage in BARI G 24 (Table 16).

The application of B significantly influenced the fertile spike at different levels with the varieties. The highest number of non fertile spikes 5.89 with control treatment and 3.0 to 3.90 were from the application of the boron @1kgha^{-1}, 0.5kgha^{-1} were found in BARI Gom 24, accordingly (Table 17). But the number of non fertile spikes ranged from 3.88, 3.92 and 3.99 with the control and application of boron@0.5 and 1kgha^{-1} . But when the boron was applied at 1kgha^{-1} then the non fertile spikes were 3.47 to 4.43 at tillering and seedling stage, respectively (Table 18). The numbers of non fertile spikes were increased 4.30 to 5.47 from the control treatment. And the non fertile spikes were decreased with the application of boron @1 kgha^{-1} in both stages. The application of boron also influenced the numbers of non fertile spikes with the combination of varieties, seedling and also tillering stage.

The maximum number of non fertile spikes ranged from 2.81 to 4.19 in tillering and seedling stage of BARI Gom 23 with the dose of Boron @0.50 kgha^{-1}, respectively (Table 19). But in case of BARI Gom 24, the maximum number of spikes ranged from 3.13 to 4.68 in tillering and seedling stage with same dose of Boron. The numbers of fertile spikes were varied from 3.79 to 4.07 in both stage of BARI Gom 23 with the application levels of Boron @1 kgha^{-1}. And it was decreased in BARI Gom 24 with 2.25 to 3.75 numbers of non fertile spikes with the same dose of boron. At zero level of boron application the non fertile spikes were observed 2.81 to 4.96 and 5.80 to 5.99 in the variety of BARI Gom 23 and BARI Gom 24 in both stages, respectively.

4.8 Number of grains spike^{-1}

There were also significant effects of different B levels on number of grains spike^{-1}. The results presented that the highest number of grains spike^{-1} (30.81) was produced by application of boron@0.5 kgha^{-1} and the lowest (21.74) was found at 1 kgha^{-1} of boron (Table 15). The highest number of grains spike^{-1} was probably attributed to reduction of sterility of wheat as B reduces male sterility of wheat. The seedling and tillering stage, the average number of grains spike^{-1} were observed as 22.45 and 25.43, respectively. Similar results were also reported by Mandal (1987), Mandal and Das (1988) and Rahman (1989). Guenis *et al.* (2003) who also reported marked increase in number of grains spike^{-1}of wheat for application of Boron. The highest number (27.76) of grains spike^{-1} was found in case of BARI Gom 24 at tillering stage and the lowest (22.16) was observed in BARI Gom 23 at seedling stage (Table 16). The grain numbers spike^{-1} was increased 27.25 to 34.38 with the application of boron@0.5 kgha^{-1} in BARI Gom 23 and BARI Gom 24, respectively (Table 17). In case of boron application in growth stage, the numbers of grains spike^{-1} were not increased statistically (Table 18). The highest number (41.00) of grains spike^{-1} was found BARI Gom 24 with the application of 0.5 kgha^{-1} at tillering stage and the lowest (18.53) was observed in BARI Gom 24 from the control at seedling stage (Table 19).

4.9 Spike straw weight

Spike straw weight showed significant variation due to B application. Numerically, the spike straw weight ranged 5.39g and 4.14g by applying B at the rate of 0.5 and 1 kgha^{-1} (Table 15). In case of growth stage, the highest spike straw wt. (4.90g) and the lowest (4.34g) were observed in BARI Gom 24 and BARI Gom 23, respectively (Table 16). But in case of BARI Gom 24, the spike straw weight (5.70g) was found with the B application@0.5 kgha^{-1} (Table 17). The second highest straw weight (5.08g) was observed in BARI Gom 23 with the same dose of boron application. When the boron was applied (@ 0.5kgha^{-1} in seedling and tillering stage of wheat, the range of straw weight from 5.18 to 5.60g, whereas the application of boron (@1 kgha^{-1} was found 4.20gm at tillering stage (Table 18).

The application of boron also influenced the spike straw weight with the combination of varieties, seedling and also tillering stage. The maximum spike straw wt. (6.00g) was found in BARI Gom 24 at tillering stage with the dose of Boron @0.50 kgha^{-1} (Table 19). The nearest maximum weight (5.40g) was observed at seedling stage with same dose of boron. The maximum spike straw weight (5.20g) was found in BARI Gom 23 at tillering stage with the dose of Boron @0.50 $kgha^{-1}$. The nearest maximum weight (4.96g) was observed at seedling stage with same dose of boron.

4.10 Seed weight plant^{-1}

The average seed weight plant^{-1} was found 7.01 and 7.31gm in BARI Gom 23 and BARI Gom 24, respectively. Seed weight plant^{-1} showed significant variation due to B application. Numerically, the seed weight plant^{-1}ranged 6.83g and 9.44g by applying B at the rate of 1$kgha^{-1}$ and 0.5 $kgha^{-1}$. But in case of BARI Gom 24, the seed weight plant^{-1} was found 7.39g and 7.76g were found in BARI Gom 23 and BARI Gom 24, respectively. The application of boron combination with the varieties influenced the seed weight. The highest seed weight (5.7g) plant^{-1} was observed in BARI Gom 24 with e application of boron@0.5 $kgha^{-1}$. The second nearest highest seed weight (5.08) was found in BARI Gom 23 with the same dose of boron. In case of seedling stage, the seed weight plant^{-1} was found 8.95g with the application of boron@0.5 $kgha^{-1}$. The highest seed weight plant^{-1} was found 9.93g with the application of boron@0.5 $kgha^{-1}$ at the tillering stage.

The application of boron also influenced the seed weight plant^{-1} with the combination of varieties, seedling and also tillering stage. The maximum seed weight plant^{-1} (10.67g) was found in BARI Gom 24 at tillering stage with the dose of Boron @ 0.50$kgha^{-1}$. The nearest maximum weight (9.20g) was observed at seedling stage with same dose of boron in BARI Gom 23 and BARI Gom 24. The lowest seed weight plant^{-1} 3.94 and 4.75g were found in BARI Gom 23 and BARI Gom 24 at seedling stage from the control treatment.

Table 15. Effect of boron on growth stages on yield and yield contributing characters of wheat

Variety	Spike length (cm)	No. of spikelets/spike	No. of Non fertile spikelets/spike	No. of grains /spike	Spike straw wt. (g)	Seed wt/ plant (g)
V_1	13.27 b	9.78 b	3.94	22.62 b	4.35 b	7.01 b
V_2	13.92 a	11.35 a	4.27	25.26 a	4.71 a	7.31 a
LSD (0.05)	0.63	0.41	NS	1.82	0.33	0.25
B_0	11.61 b	9.59 b	4.89 a	19.27 c	4.07 b	5.21 c
B_1	15.48 a	12.23 a	3.95 ab	30.81 a	5.39 a	9.44 a
B_2	13.69 b	9.88 b	3.47 b	21.74 b	4.14 b	6.83 b
LSD (0.05)	1.50	0.50	0.94	2.23	0.40	0.56
S_1	13.50	10.34 b	4.60 a	22.45 b	4.43	6.74 b
S_2	13.69	10.79 a	3.60 b	25.43 a	4.64	7.58 a
LSD (0.05)	NS	0.41	0.77	1.82	NS	0.45
CV (%)	5.27	5.55	27.09	10.99	10.53	9.19

V_1-BARI Gom 23; V_2-BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage;

B_0- Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 16. Interaction of variety and growth stages on yield and yield contributing characters of wheat

Variety × Growth stage	Spike length (cm)	No. Of fertile/spike	Non fertile spikelet	No. of grains /spike	Spike straw wt. (g)	Total seed wt/ plant (g)
V_1S_1	13.19	9.77 c	4.40	22.16 b	4.34	6.64
V_1S_2	13.34	9.79 c	3.47	23.09 b	4.37	7.39
V_2S_1	13.80	10.91 b	4.80	22.75 b	4.51	6.85
V_2S_2	14.03	11.79 a	3.73	27.76 a	4.90	7.77
LSD (0.05)	NS	0.57	NS	2.57	NS	NS
CV (%)	5.27	5.55	27.09	10.99	10.53	9.19

V_1-BARI Gom 23; V_2-BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 17. Interaction of variety and boron levels on yield and yield contributing characters of wheat

Variety× Boron levels	Spike length (cm)	No. of fertile spikelets /spike	No. of Non fertile spikelets /spike	No. of grains /spike	Spike straw wt. (g)	Total seed wt/ plant (g)
V_1B_0	11.38	8.35 e	3.89 b	19.27 c	3.89	5.63 d
V_1B_1	14.83	11.41 b	4.00 b	27.25 b	5.08	8.95 b
V_1B_2	13.58	9.58 d	3.93 b	21.34 c	4.09	6.46 c
V_2B_0	11.83	10.83 bc	5.89 a	19.27 c	4.24	4.80 e
V_2B_1	16.12	13.05 a	3.91 b	34.38 a	5.70	9.93 a
V_2B_2	13.80	10.17 cd	3.00 b	22.14 c	4.18	7.20 c
LSD (0.05)	NS	0.70	1.33	3.15	NS	0.79
CV (%)	5.27	5.55	27.09	10.99	10.53	9.19

V_1-BARI Gom 23; V_2-BARI Gom 24; B_0-Control; B_1-0.5 $kgBha^{-1}$; B_2- 1$kgBha^{-1}$

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 18. Interaction of boron levels and growth stage on yield and yield contributing characters of wheat

Variety × Growth stages	Spike length (cm)	No. of fertile spikelets /spike	No. of Non fertile spikelets /spike	No. of grains /spike	Spike straw wt. (g)	Total seed wt/ plant (g)
B_0S_1	11.72	9.43 c	5.47	18.87 d	4.03	4.35 e
B_0S_2	11.50	9.75 c	4.31	19.67 cd	4.10	6.08 d
B_1S_1	15.23	11.66 b	4.43	27.13 b	5.18	8.95 b
B_1S_2	15.72	12.80 a	3.47	34.50 a	5.60	9.93 a
B_2S_1	13.54	9.93 c	3.91	21.37 cd	4.07	6.94 c
B_2S_2	13.84	9.82 c	3.02	22.11 c	4.21	6.72 cd
LSD (0.05)	NS	0.70	NS	NS	NS	0.79
CV (%)	5.27	5.55	27.09	10.99	10.53	9.19

S_1- Seedling stage; S_2- Tillering stage; B_0- Control; B_1- 0.5 kgBha^{-1}; B_2- 1 kg Bha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 19. Interaction of variety, boron levels and growth stages on yield and yield contributing characters of wheat

Variety × Boron levels × Growth stages	Spike length (cm)	No. of fertile spikelets /spike	No.of non fertile spikelets /spike	No. of grains /spike	Spike straw wt. (g)	Total seed wt/ plant (g)
$V_1B_0S_1$	11.43	8.26	4.96	19.21 d	3.89	3.94 h
$V_1B_0S_2$	11.33	8.43	2.81	19.33 d	3.89	7.32 de
$V_1B_1S_1$	14.57	11.10	4.19	26.50 bc	4.97	8.70 bc
$V_1B_1S_2$	15.10	11.72	3.81	28.00 b	5.20	9.20 b
$V_1B_2S_1$	13.57	9.96	4.07	20.76 d	4.17	7.27 de
$V_1B_2S_2$	13.58	9.21	3.79	21.93 d	4.01	5.65 fg
$V_2B_0S_1$	12.00	10.60	5.99	18.53 d	4.18	4.75 gh
$V_2B_0S_2$	11.67	11.06	5.80	20.00 d	4.31	4.84 gh
$V_2B_1S_1$	15.90	12.23	4.68	27.75 b	5.40	9.20 b
$V_2B_1S_2$	16.33	13.87	3.13	41.00 a	6.00	10.67 a
$V_2B_2S_1$	13.50	9.91	3.75	21.98 d	3.96	6.60 ef
$V_2B_2S_2$	14.10	10.43	2.25	22.29 cd	4.40	7.80 cd
LSD $_{(0.05)}$	NS	NS	NS	4.46	NS	1.11
CV (%)	5.27	5.55	27.09	10.99	10.53	9.19

V_1- BARI Gom 23; V_2- BARI Gom 24; S_1- Seedling stage; S_2- Tillering stage; B_0- Control; B_1-0.5 kgBha^{-1}; B_2- 1 kgBha^{-1}

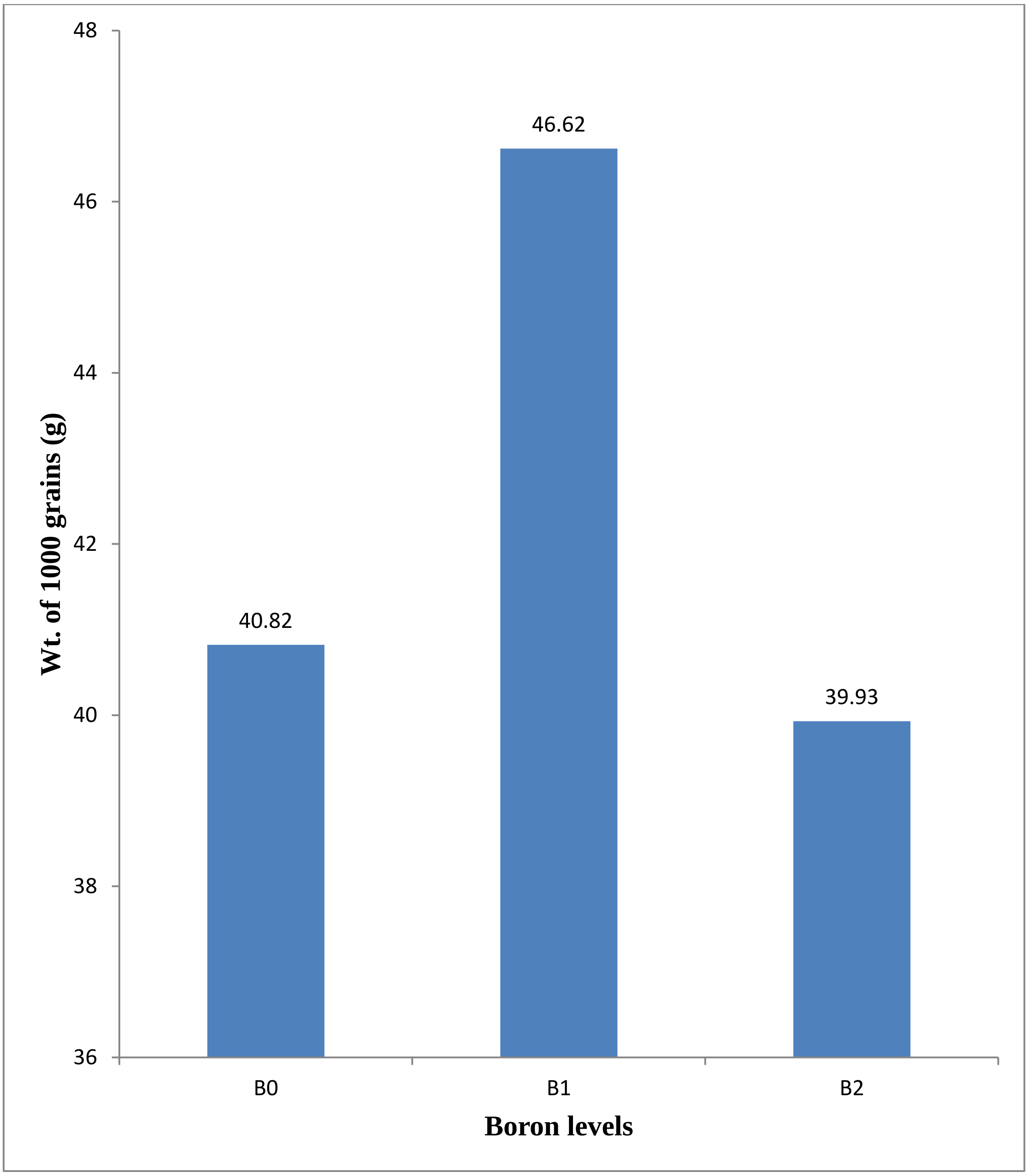
In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

4.11 Thousand grain weight (g)

Weight of 1000 grains showed significant variation due to boron application. Numerically, the highest 1000 grains weight (46.62 g) was found by applying B @0.5 $kgha^{-1}$ and the second highest 1000 grain weight (40.82 g) was found from control (Figure 6). In growth stage, the highest 1000 grains weight (43.05 g) and nearest wt. (41.87 g) were found (Table 7). But in case of $1kgha^{-1}$ B application, the 1000 grain weight was obtained 39.93g. In case of varieties, the maximum weight (48.23g) and nearest weight (40.17g) were found with the application of boron at the rate of $0.5kgha^{-1}$ in BARI Gom 24 (Figure 8).But the weight of 1000-grains was found 45.0g with the same dose of B application in BARI Gom 23. The 1000 grains weight ranged from 40.0 to 40.61g in both varieties from the control. Even at growth stage the 1000-grains weight were not increased proportionally with the varieties (Figure 9). This positive effect of Zn and B interaction on 1000 grains weight of wheat was also reported by Ali *et al.* (2009). Combination of the boron levels and growth stage, the highest wt. (43.18g) of 1000 grains and lowest wt. (41.31g) from tillering and seedling stage in BARI Gom 24 and BARI Gom 23, respectively (Figure 10).

The application of boron also influenced 1000 grains weight with the combination of varieties, seedling and also tillering stage. The maximum 1000 grains weight (49.2g) was found in BARI Gom 24 at tillering stage with the dose of Boron @ $0.50kgha^{-1}$ (Figure 11). The nearest maximum weight (47.26) was observed at seedling stage with same dose of boron. And 1000-grains weight (47g) was observed in BARI Gom 23 at tillering stage with application of boron @0.5 $kgha^{-1}$. Even the 1000 grains weights (42.2g & 41.06g) were found in BARI Gom 23 at seedling and tillering stage from the control.

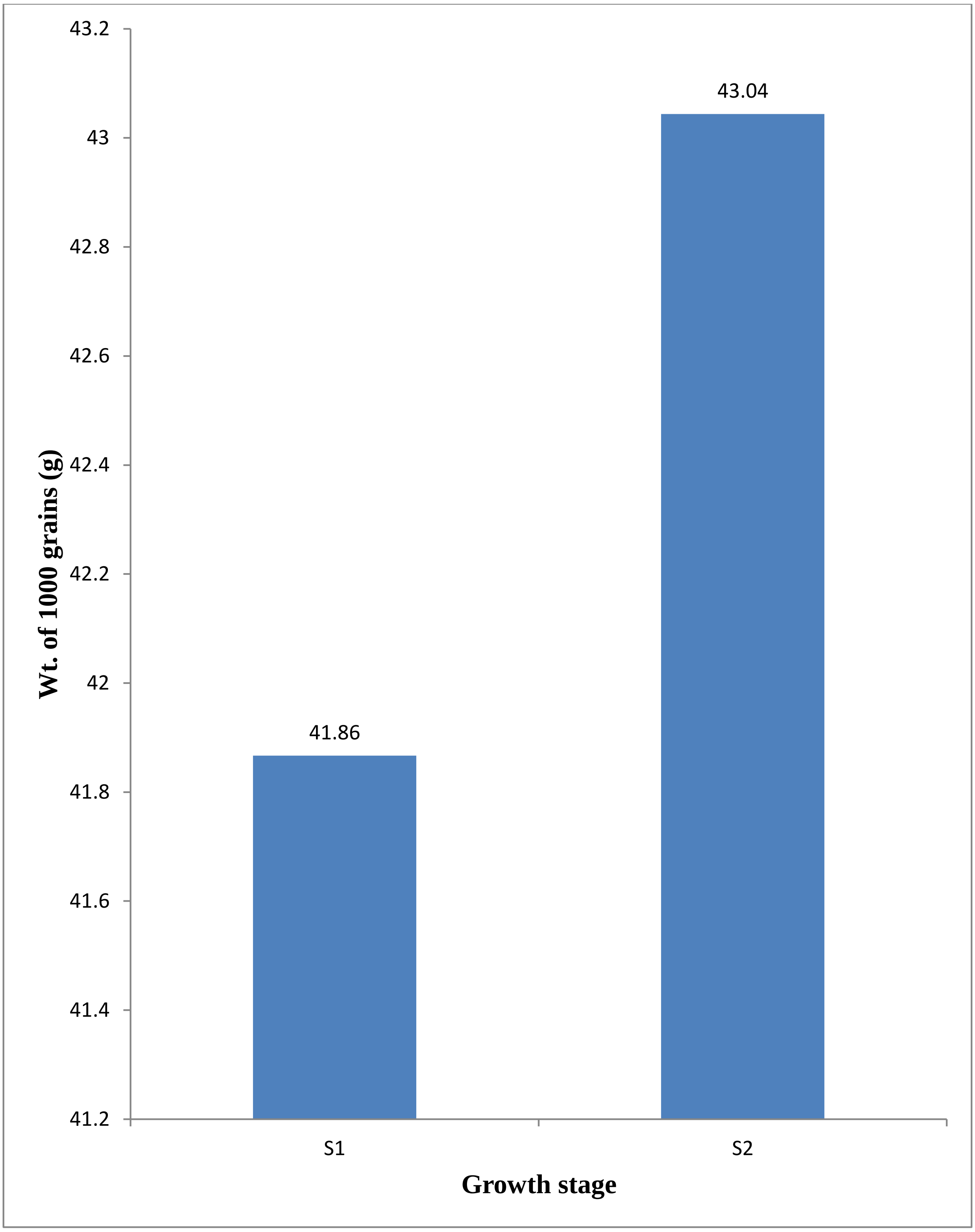
These results explain that the weight of 1000 grains dependents on the B fertilization. Such results are in conformity with the findings of Mete *et al.* (2005) and Soylu *et al.* (2005) who reported that the weight of 1000 grains increased significantly with the increased B fertilization. This positive effect of B on 1000-grain weight of wheat was also reported by Ali *et al.* (2009).



B_0-Control; B_1-0.5 $kgBha^{-1}$; B_2- 1 $kgBha^{-1}$

Figure 6. Effect of boron levels on the thousand grain weight of wheat.

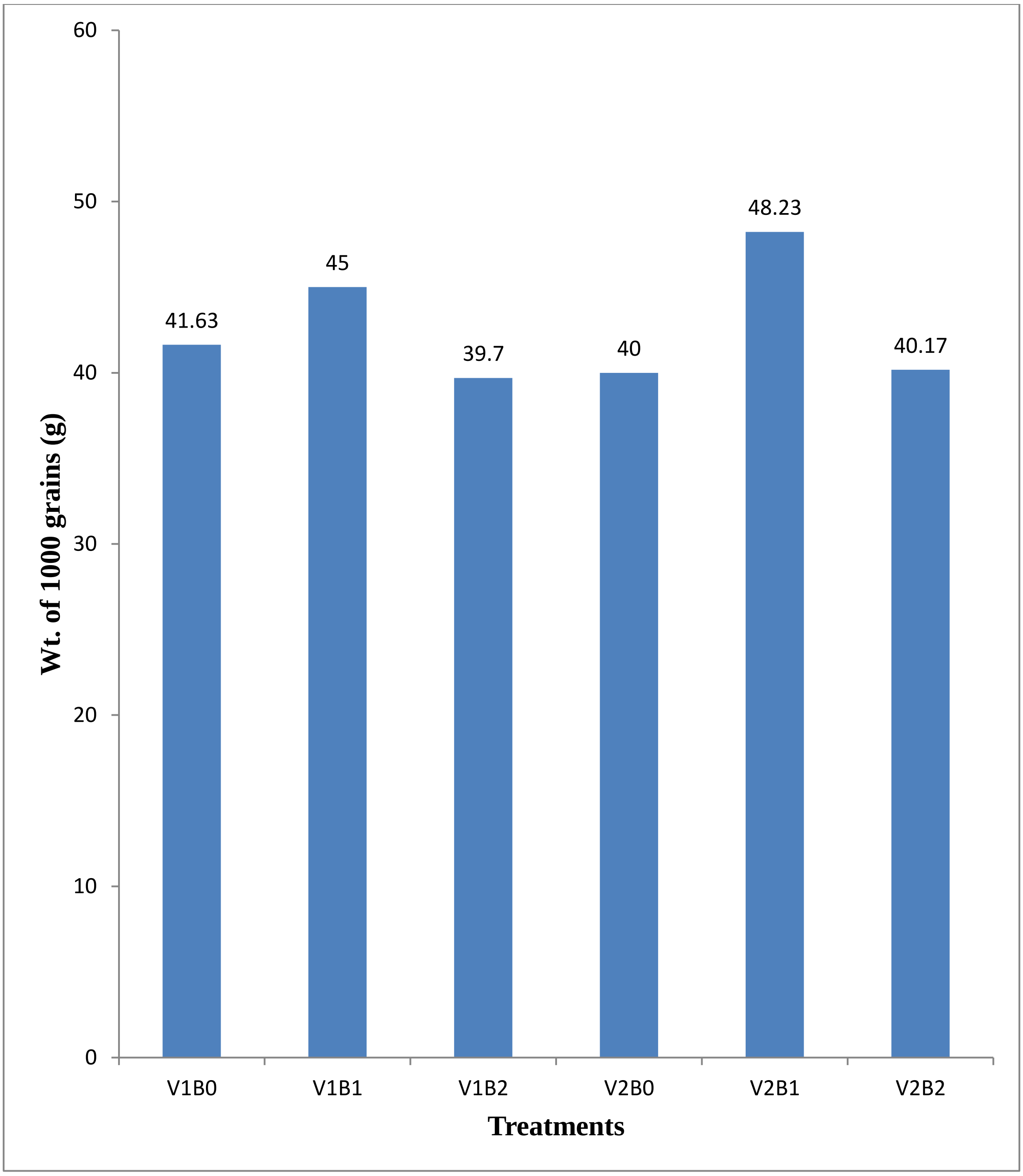
($LSD_{0.05}$ = 1.58)



S_1-Seedling stage; S_2-Tillering stage

Figure 7. Thousand grain weight of wheat for different growth stages.

($LSD_{0.05}$ = NS)

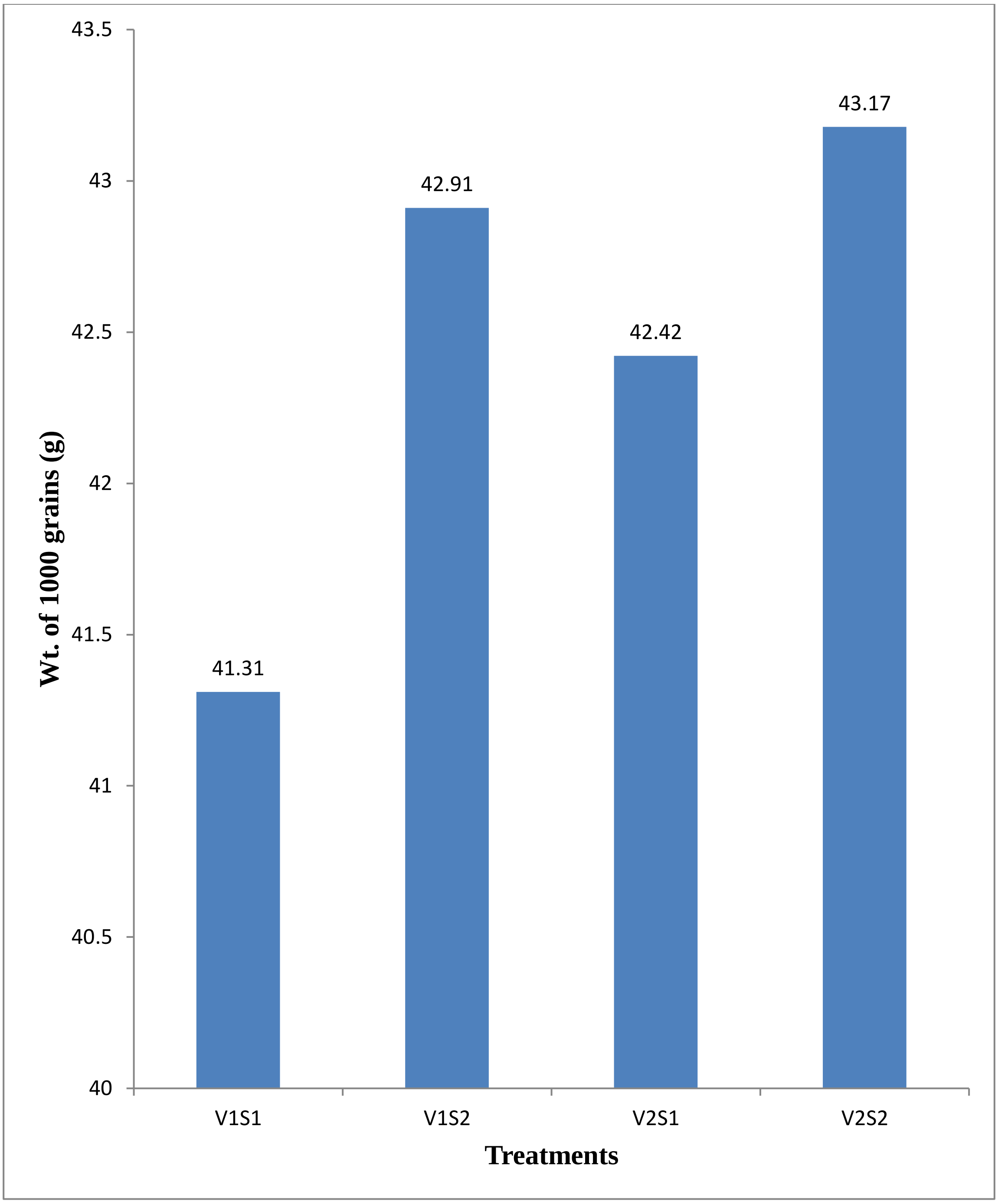


V_1-BARI Gom 23; V_2-BARI Gom 24

B_0-Control; B_1-0.5 $kgBha^{-1}$; B_2- 1$kgBha^{-1}$

Figure 8. Effect of boron levels on the grain wt. of wheat.

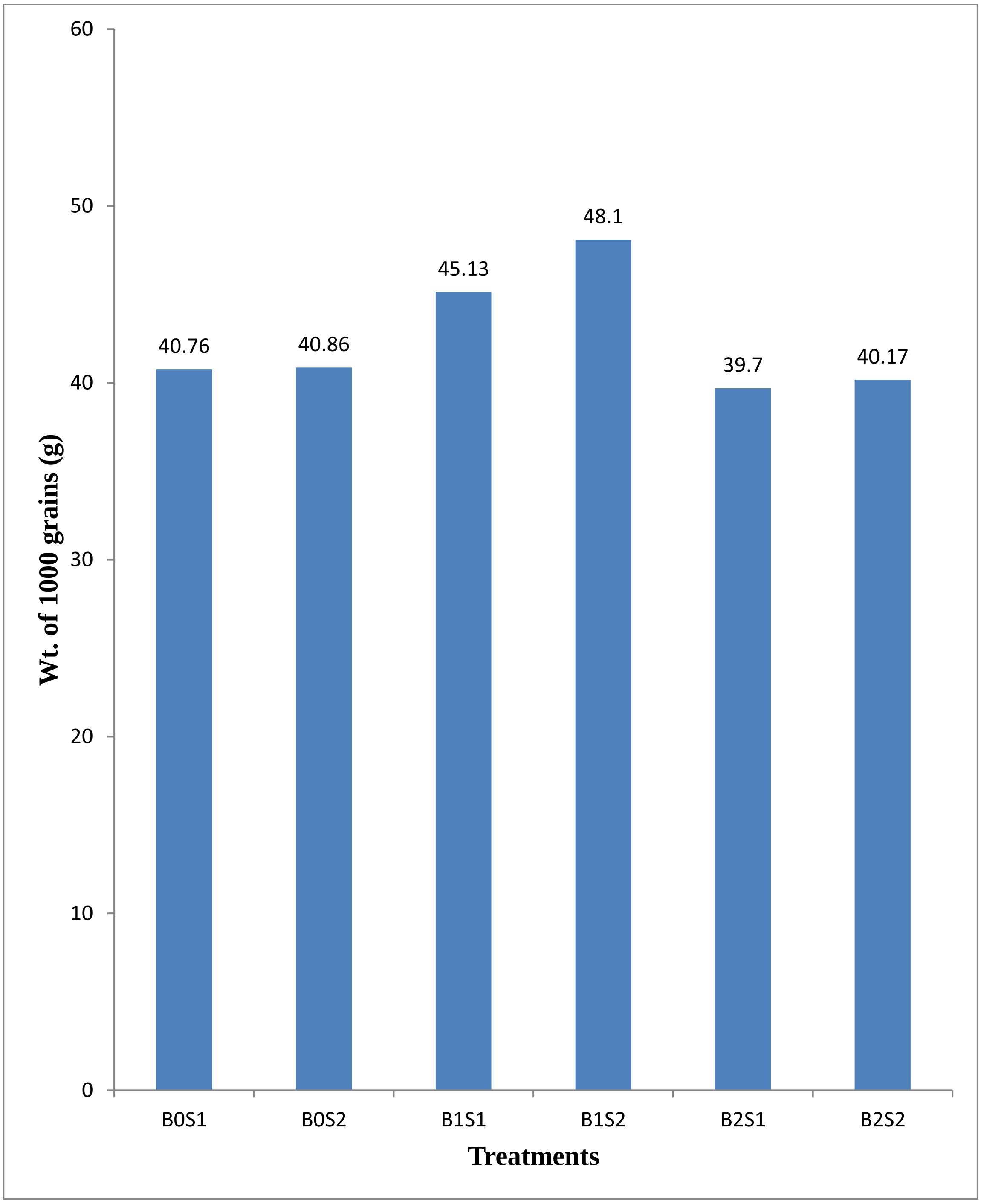
($LSD_{0.05}$ = 2.23)



V_1-BARI Gom 23; V_2-BARI Gom 24

S_1-Seedling stage; S_2-Tillering stage

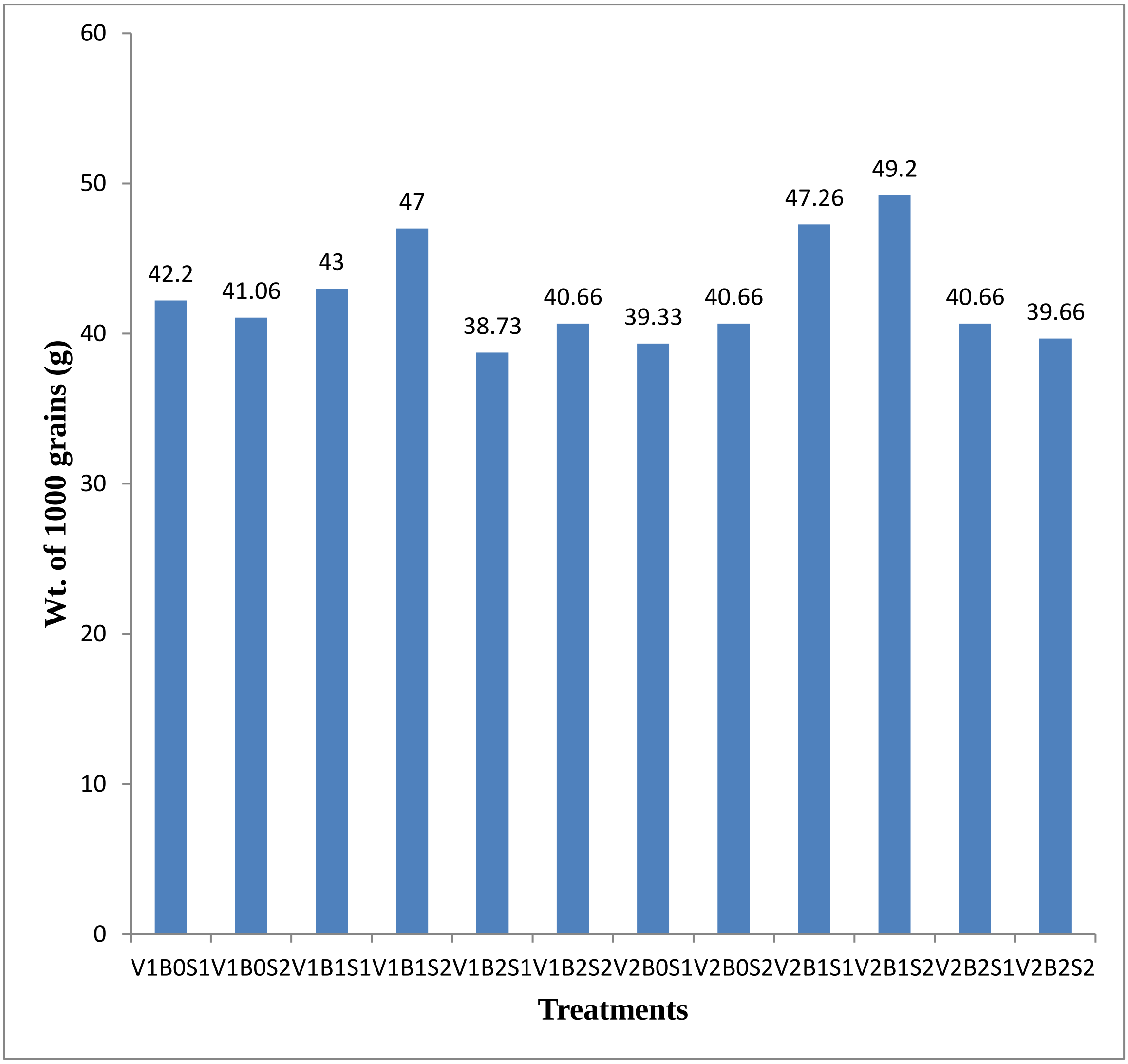
Figure 9. Interaction of variety and growth stages on thousand grain weight of wheat. ($LSD_{0.05}$ = NS)



S_1-Seedling stage; S_2-Tillering stage

B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 10. Interaction of boron levels and growth stages thousand grain wt. of wheat. ($LSD_{0.05}$ = NS)



V_1-BARI Gom 23; V_2-BARI Gom 24

S_1-Seedling stage; S_2-Tillering stage

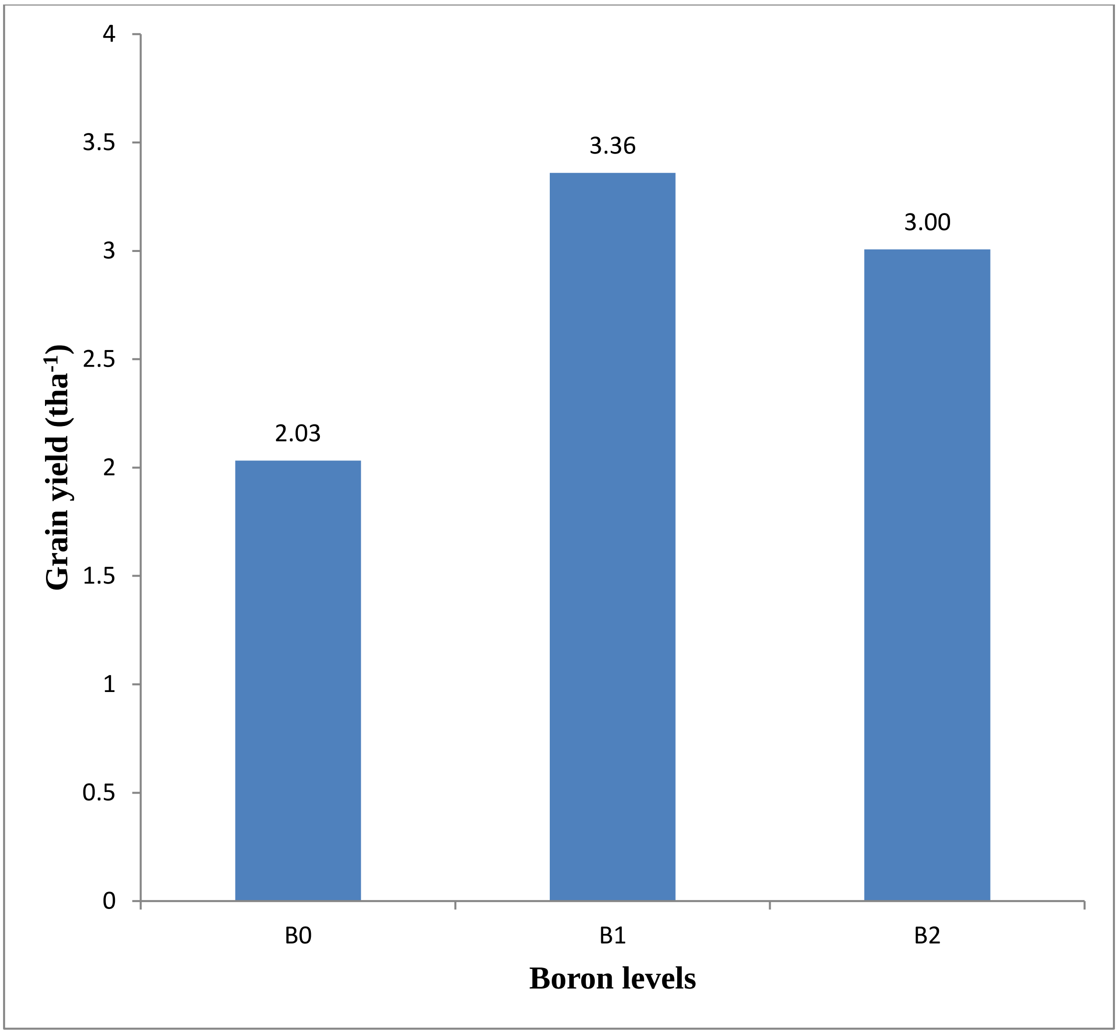
B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 11. Interaction of boron levels and growth stages on the thousand grain weight of wheat varieties. ($LSD_{0.05}$ = NS)

4.12 Grain Yield (tha^{-1})

Generally the five components influence the grain yield namely, number of effective tillers plant^{-1}, number of spike plant^{-1}, number of spikelets spike^{-1}, number of grains spike^{-1} and individual grain weight. Different B levels showed significant variations on grain yield of wheat (Appendix-4). Grain yield was influenced significantly due to the different levels of B application (Appendix- IV). Grain yield was observed 3.36 tha^{-1} when the application of 0.5 kgBha^{-1} (Figure 12). The highest grain yield (3.38 tha^{-1}) was observed at from the tillering stage (Figure 13). The boron application @0.5 kgha^{-1} showed the highest result (3.63 tha^{-1}) BARI Gom 24, whereas the lowest result was observed as 1.92 tha^{-1} from the control in BARI Gom 23 (Figure 14). The increased yield was mainly attributed to production of more number of grains spike^{-1} having higher 1000 grain weight. This result was in accordance with that of Singh and Singh (1984), Mandal (1987), Galrao *et al.* (1988), Rahman (1989), BINA (1993) and Jahiruddin *et al.* (1995). The highest grain yield (3.56 tha^{-1}) was observed from the tillering stage in BARI Gom 24 and the lowest result (2.73 tha^{-1}) from seedling stage in case of BARI Gom 23 (Figure 15).

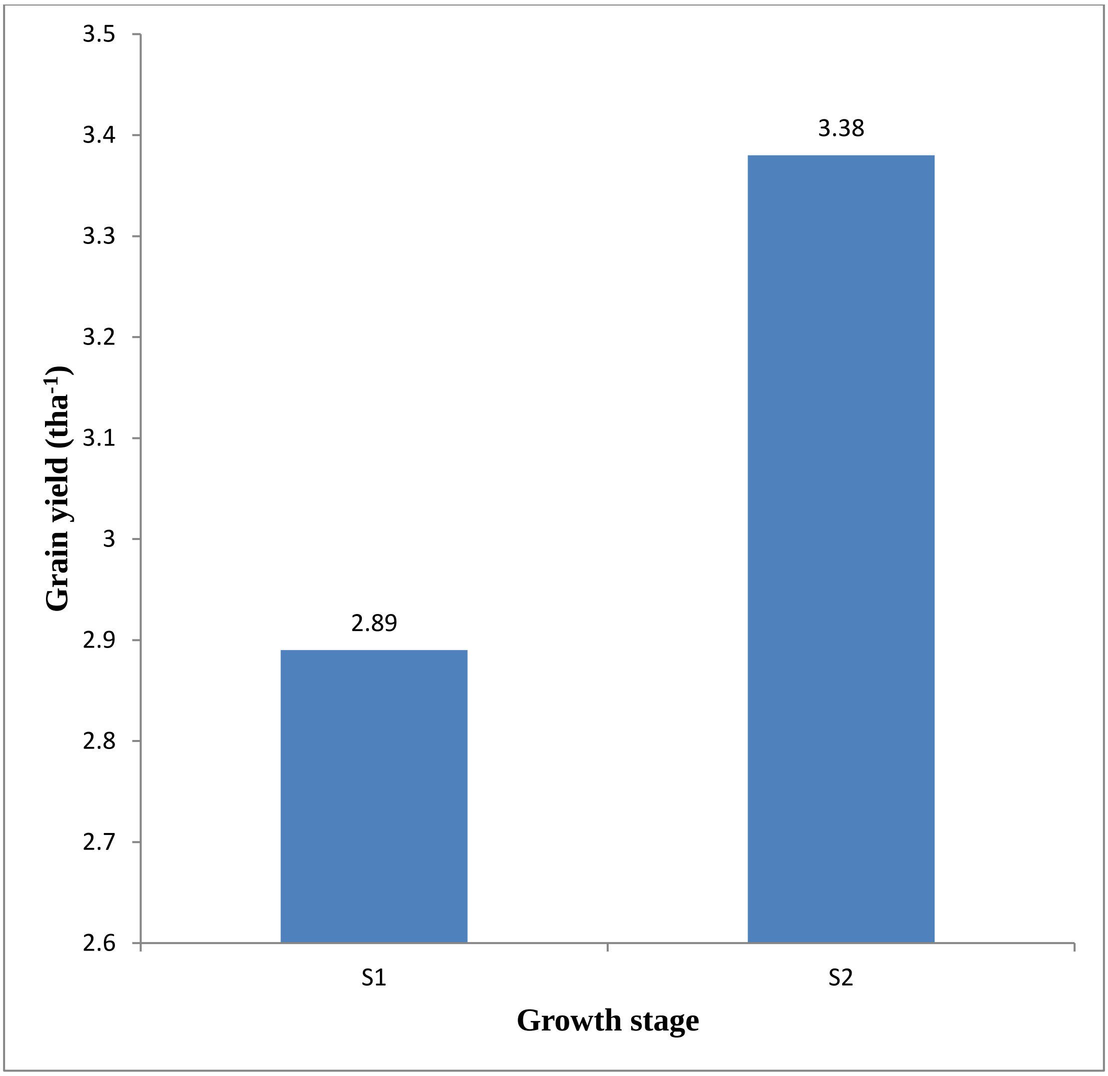
The highest grain yield (3.48 tha^{-1}) was found from the tillering stage with the application of 0.5 kgBha^{-1} and the lowest result (1.82 tha^{-1}) from the control in seedling stage (Figure 16). The interaction effect of different levels of B fertilizers was significant regarding grain yield (Appendix. V). The highest grain yield (3.62 tha^{-1}) was recorded at a combination from BARI Gom 24 at tillering stage with the application of boron @0.5 kgha^{-1} and the lowest (1.73 tha^{-1}) was recorded from control at seedling stage in BARI Gom 23 (Figure 17). Similar results were also published by Arif *et al.* (2006).



B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 12. Effect of boron levels on the grain yield of two wheat varieties.

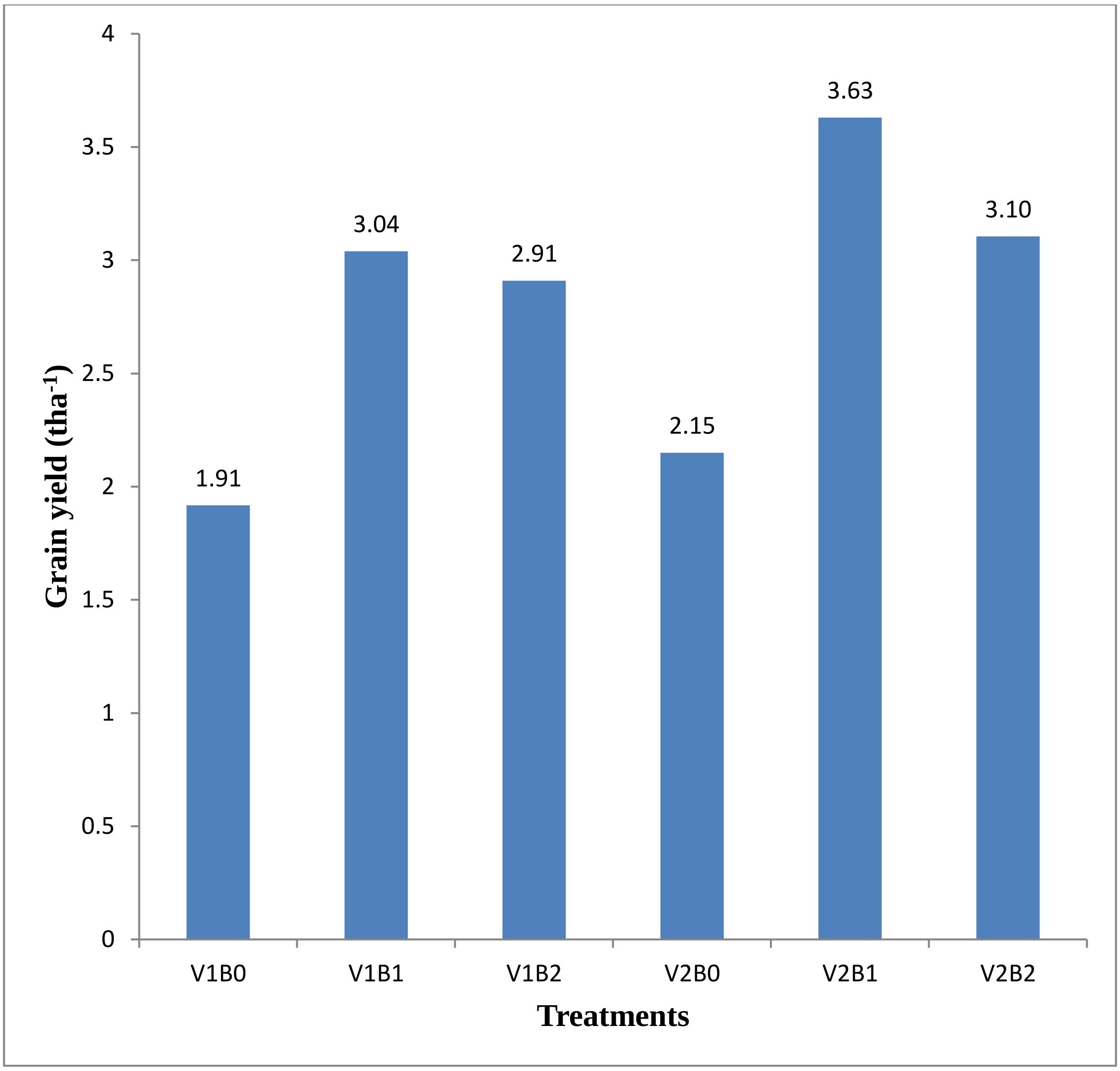
($LSD_{0.05}$ = 0.08)



S_1-Seedling stage; S_2-Tillering stage

Figure 13. Effect of growth stages on the grain yield of wheat.

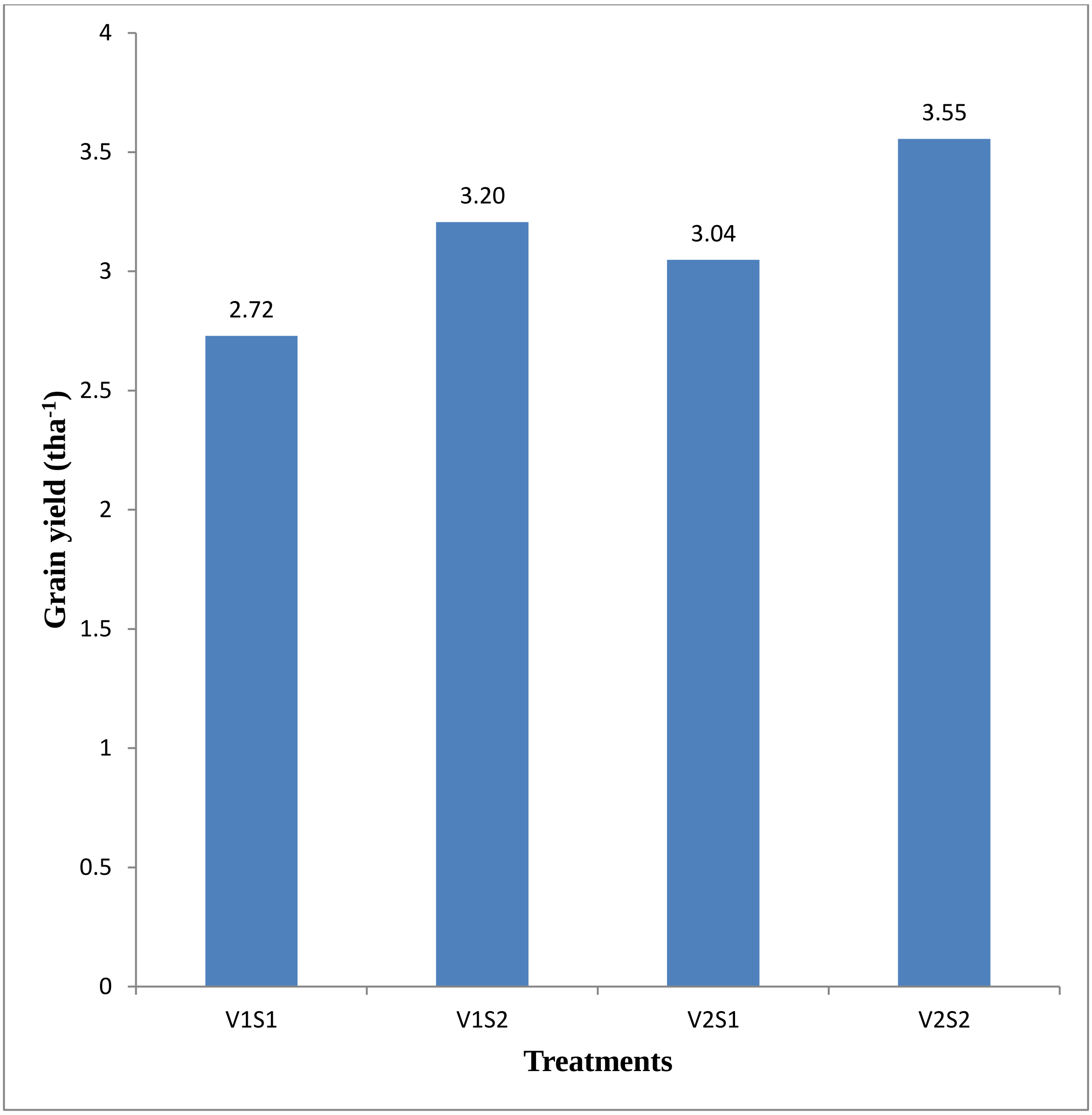
($LSD_{0.05}$ = 0.06)



V_1-BARI Gom 23; V_2-BARI Gom 24
B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 14. Effect of boron levels on the grain yield of wheat varieties.

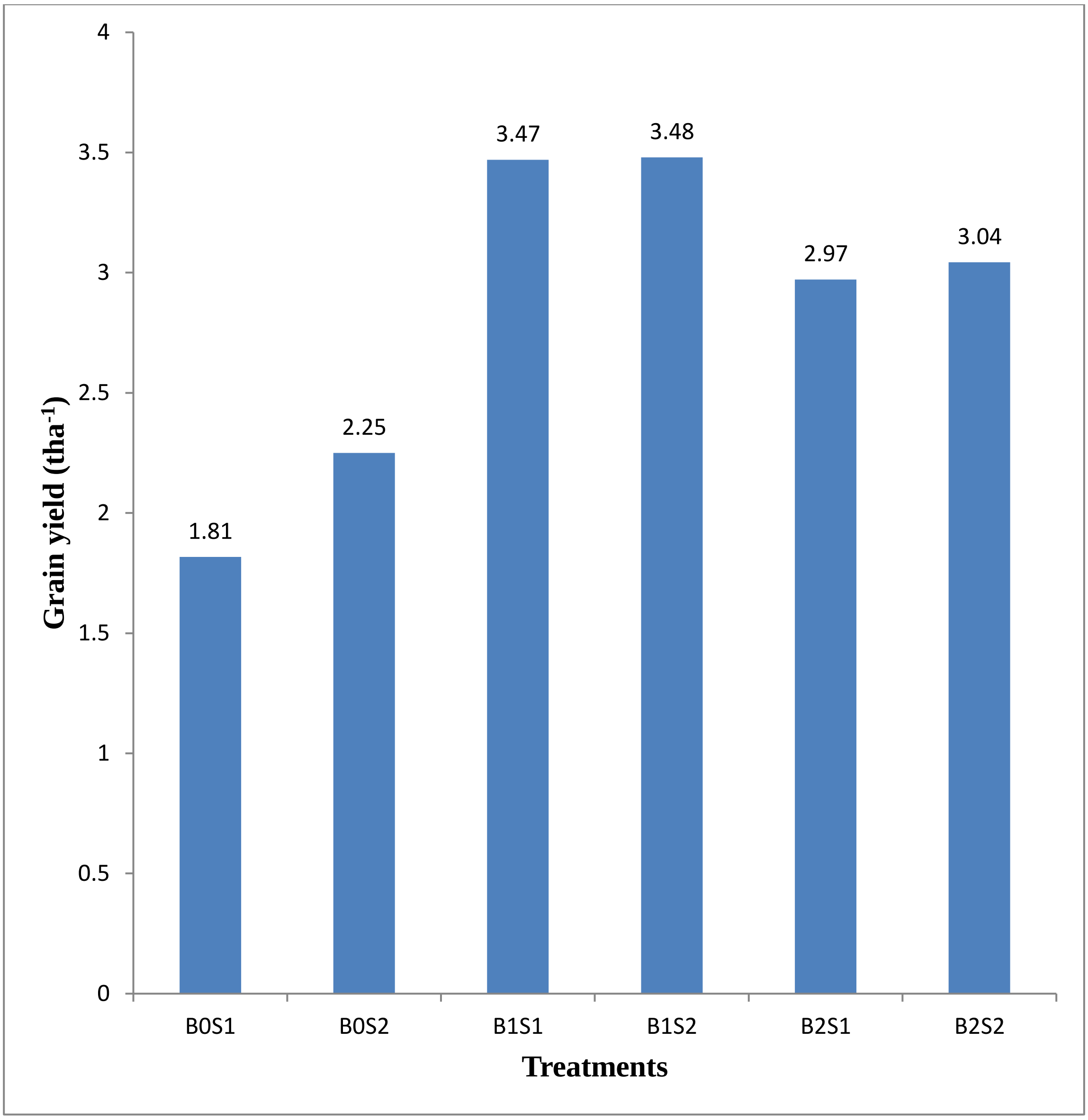
($LSD_{0.05}$ = 0.114)



V_1-BARI Gom 23; V_2-BARI Gom 24
S_1-Seedling stage; S_2-Tillering stage

Figure 15. Interaction of variety and growth stages on the grain yield of wheat.

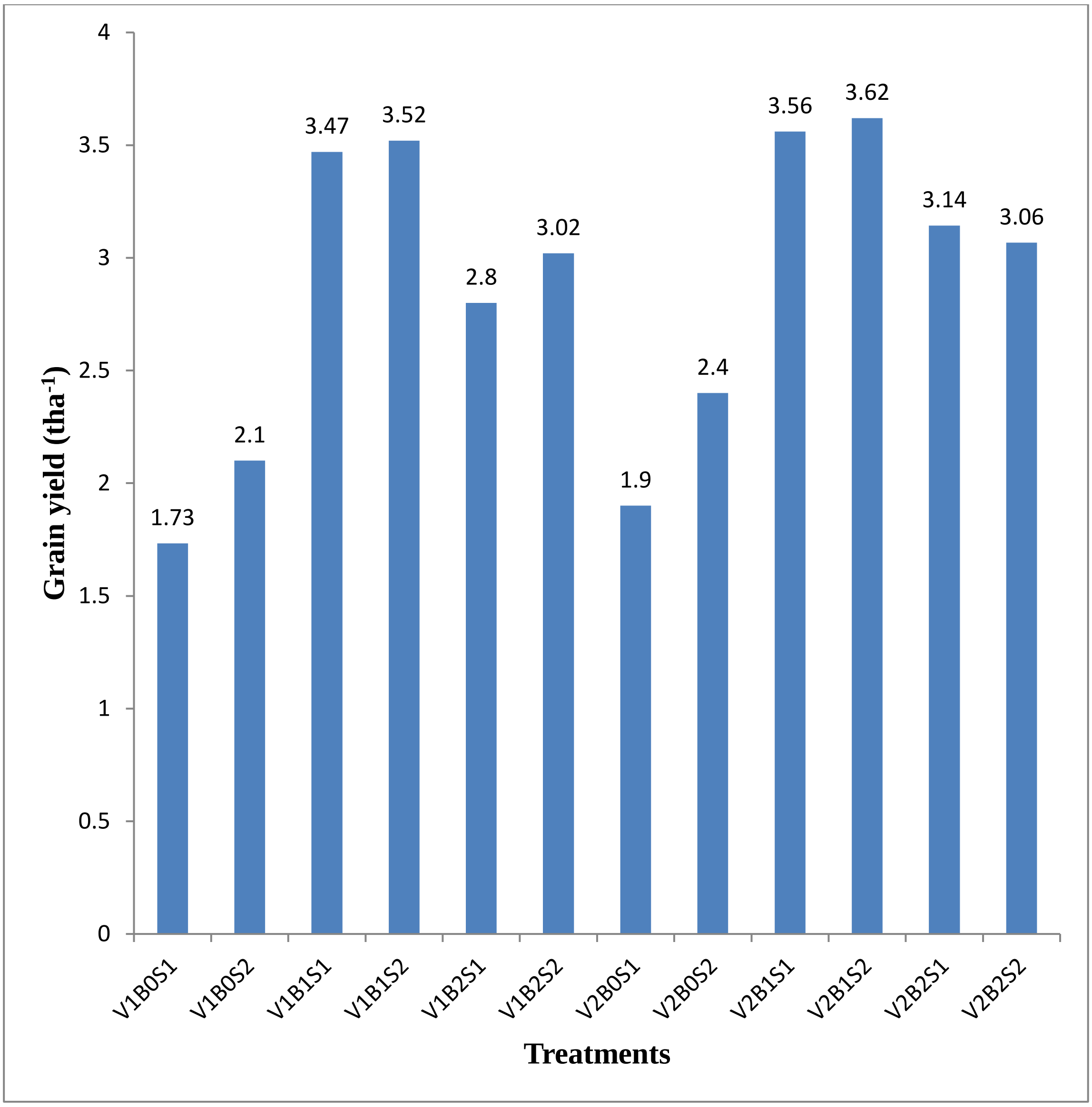
($LSD_{0.05}$ = 0.093)



S_1-Seedling stage; S_2-Tillering stage
B_0-Control; B_1-0.5 $kgBha^{-1}$, B_2- 1$kgBha^{-1}$

Figure 16. Effect of boron levels and growth stages on the grain yield of wheat.

($LSD_{0.05}$ = 0.114)



V_1-BARI Gom 23; V_2-BARI Gom 24

S_1-Seedling stage; S_2-Tillering stage

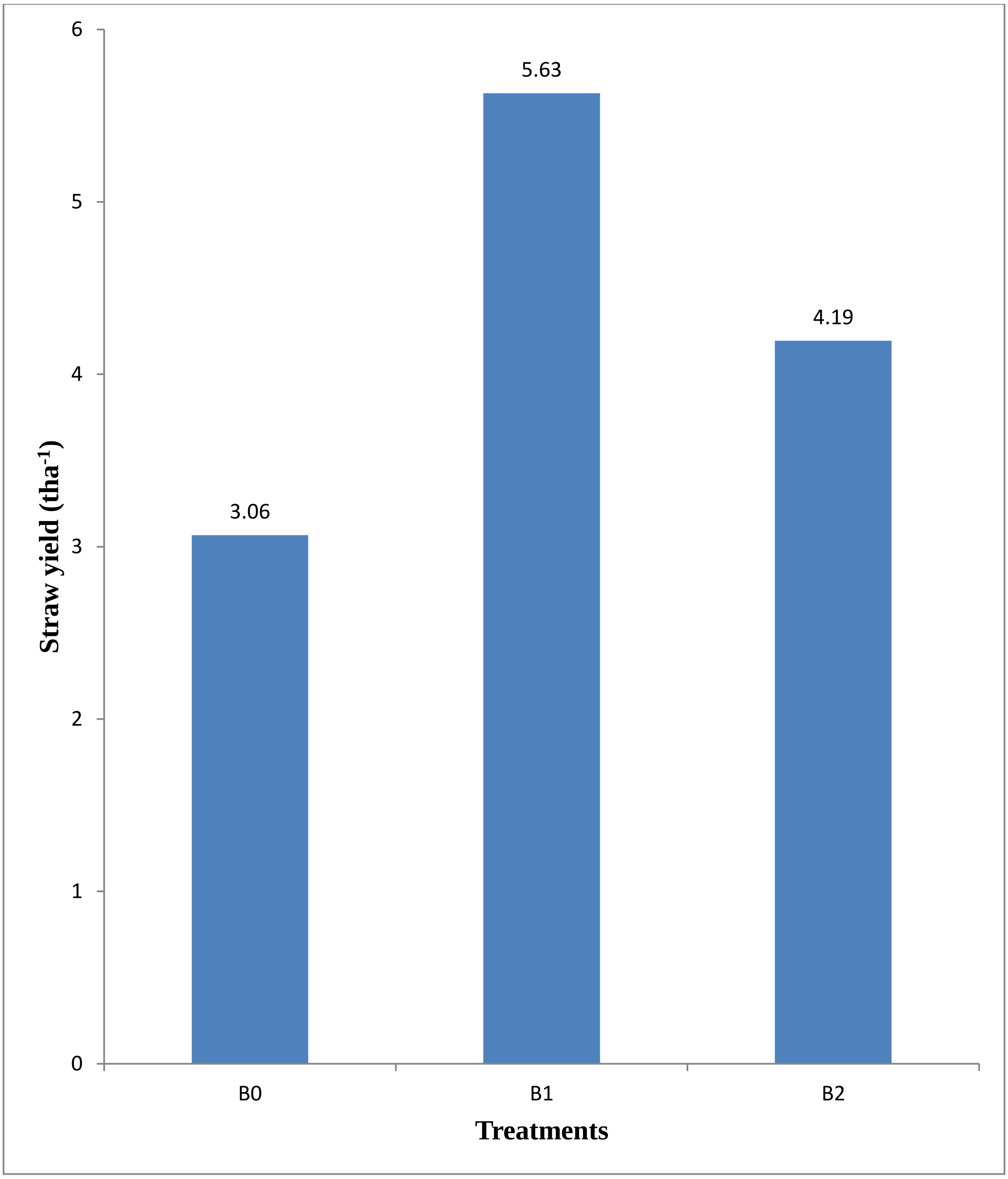
B_0-Control; B_1-0.5 kg Bha^{-1}; B_2- 1kg Bha^{-1}

Figure 17. Interaction effect of boron levels and growth stages on the grain yield of wheat varieties. ($LSD_{0.05}$ = 0.161)

4.13 Straw yield (tha^{-1})

Different levels of B application showed significant effects on the straw yield. The production of highest straw yield was (5.63 tha^{-1}) in 0.5 $kgBha^{-1}$ might be due to the fact that B tends primarily to encourage vegetative growth (Figure 18). The second highest result (4.19 tha^{-1}) was obtained from 0.5 $kgBha^{-1}$. In case of growth stage, the highest (4.54 tha^{-1}) and lowest (4.06 tha^{-1}) straw yield were observed from the tillering and seedling stage, respectively (Figure 19).The analysis of variance showed that the lowest straw yield (3.06 tha^{-1}) was obtained from control. BARI Gom 24 sowed the highest (5.88 tha^{-1}) straw yield with the application dose of boron 0.5 kg ha^{-1}, whereas BARI Gom 23 showed the lower straw yield (5.37 tha^{-1}) with the application of same dose of boron (Figure 20). The significant lowest straw yield was observed from the control. The combination of variety and growth stage, the maximum (4.67 tha^{-1}) and the minimum (3.81 tha^{-1}) straw yield were observed from the tillering and seedling stage in BARI Gom 24 and BARI Gom 23, respectively (Figure 21).

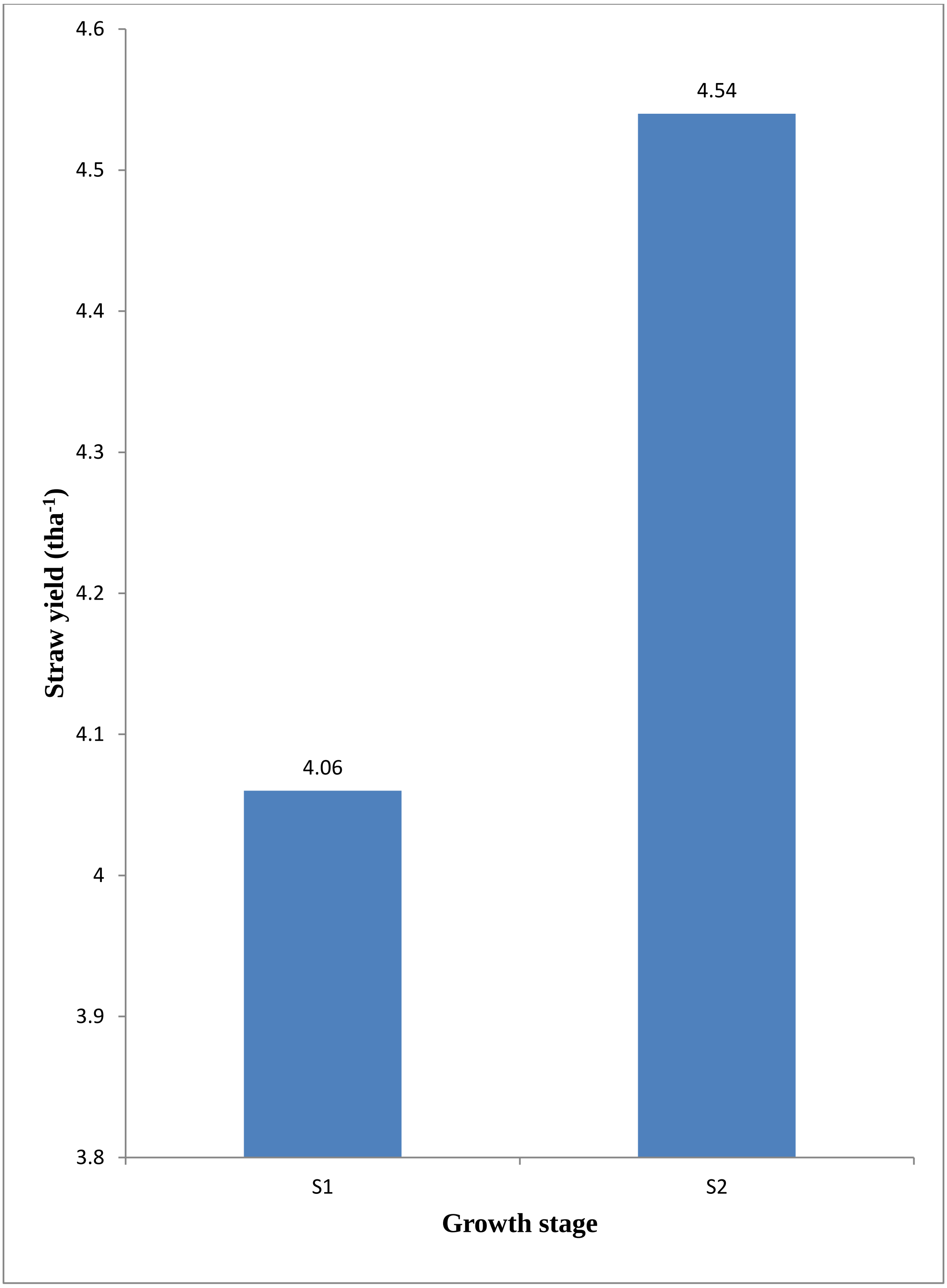
The findings for this character agree with the results observed by Rahman (1989). Malewar *et al.* (2001) also found similar findings. On the other, the results differ from that of Panwar *et al.* (1998) who reported that straw yield was less affected by high levels of B. The maximum (6.15 tha^{-1}) and the minimum (2.88 tha^{-1}) straw yield were observed with the application of boron at 0.5 $kgha^{-1}$ and from the control (Figure 22). From the interaction treatments, the highest (6.37 tha^{-1}) and the lowest (2.60 tha^{-1}) straw yield were observed with the application of boron at 0.5 $kgha^{-1}$ and from the control in seedling and tillering stage of BARI Gom 24 and BARI Gom 23, respectively (Figure 23).



B0-Control; B1-0.5 kgBha^{-1}; B2- 1kgBha^{-1}

Figure 18. Effect of boron levels on the straw yield of wheat.

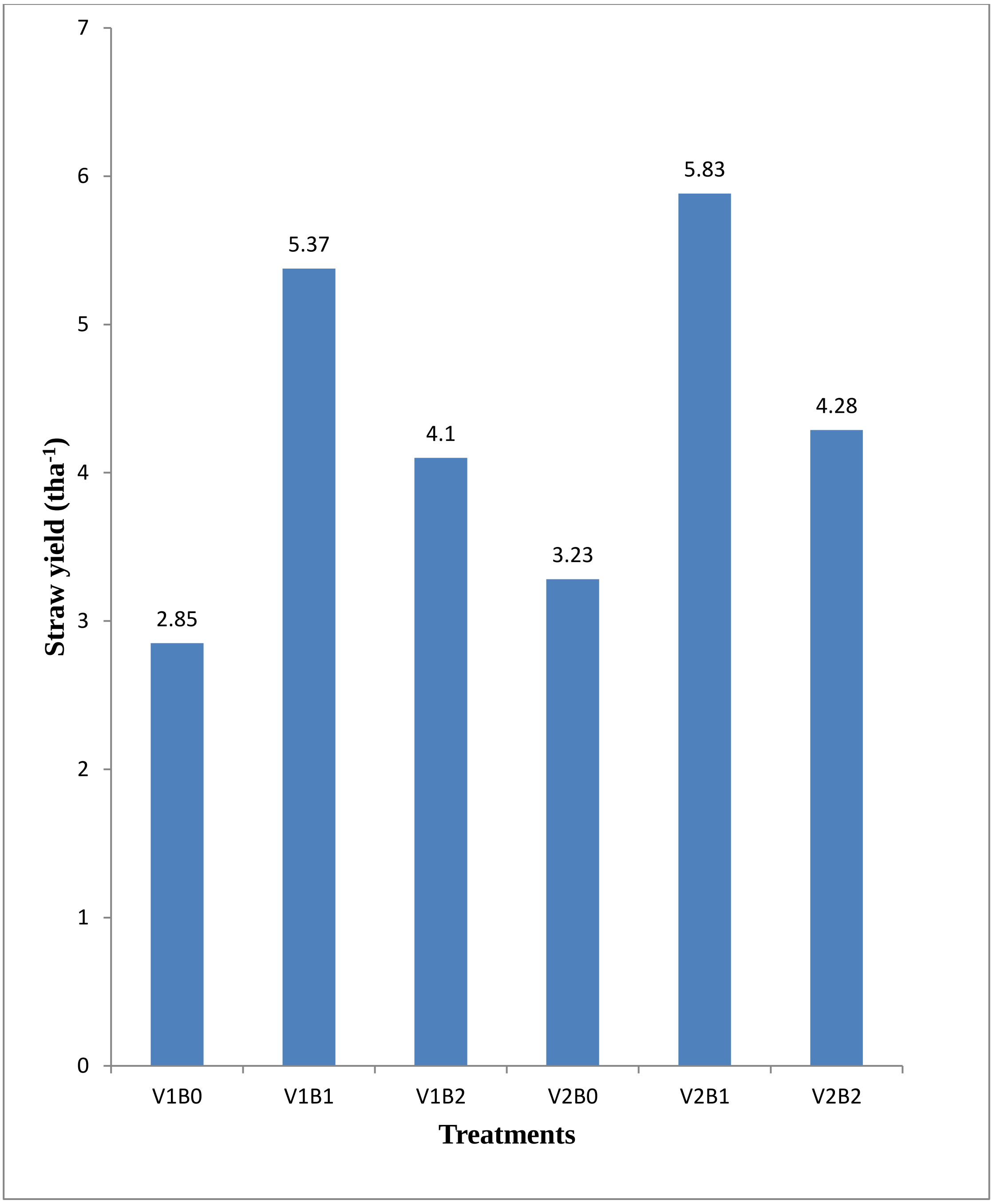
($LSD_{0.05}$ = 0.31)



S1-Seedling stage; S2-Tillering stage

Figure 19. Effect of growth stages on straw yield of wheat.

($LSD_{0.05}$ = 0.26)

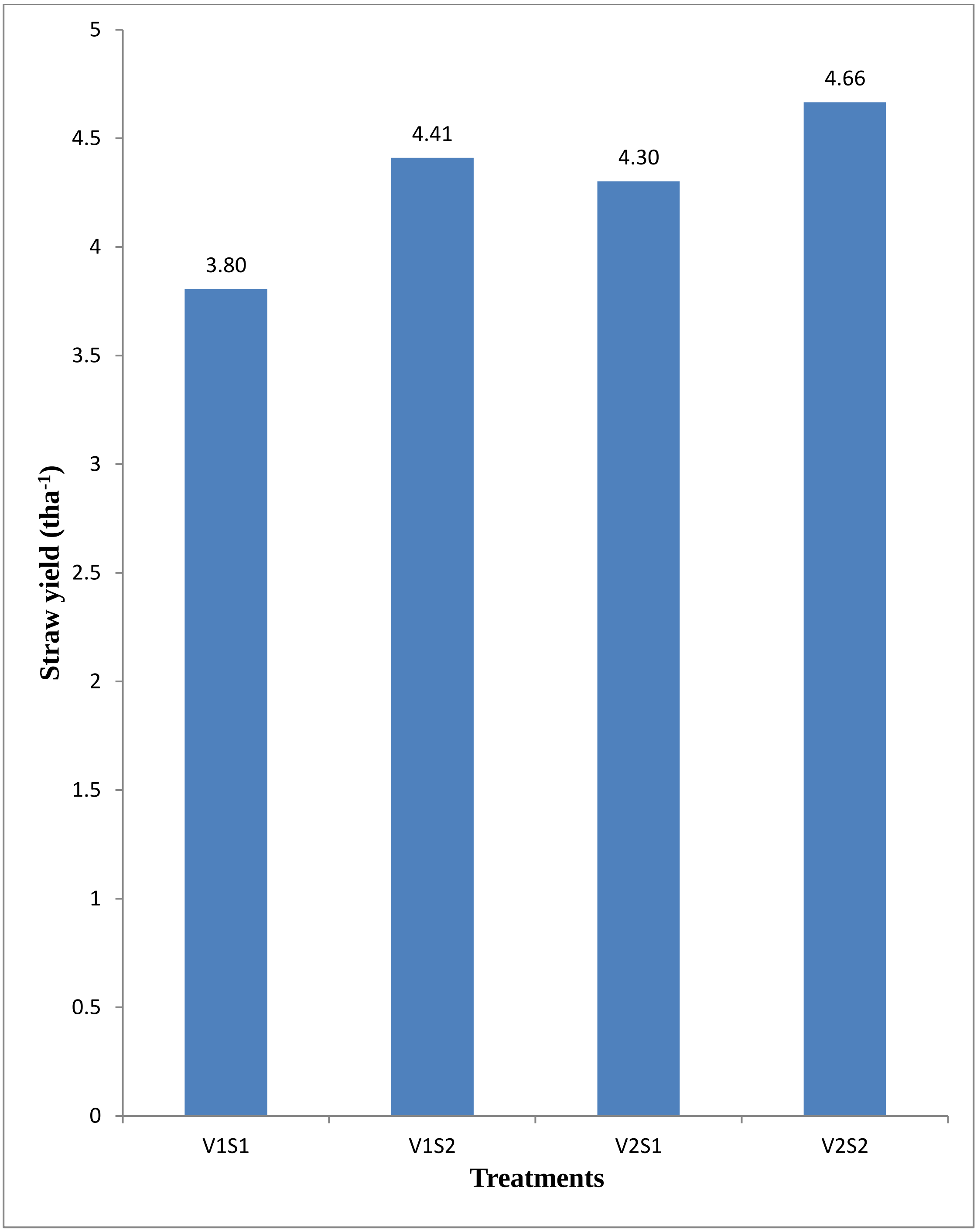


V_1-BARI Gom 23; V_2-BARI Gom 24

B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 20. Effect of boron levels on the straw yield of wheat varieties.

($LSD_{0.05}$ = 0.44)

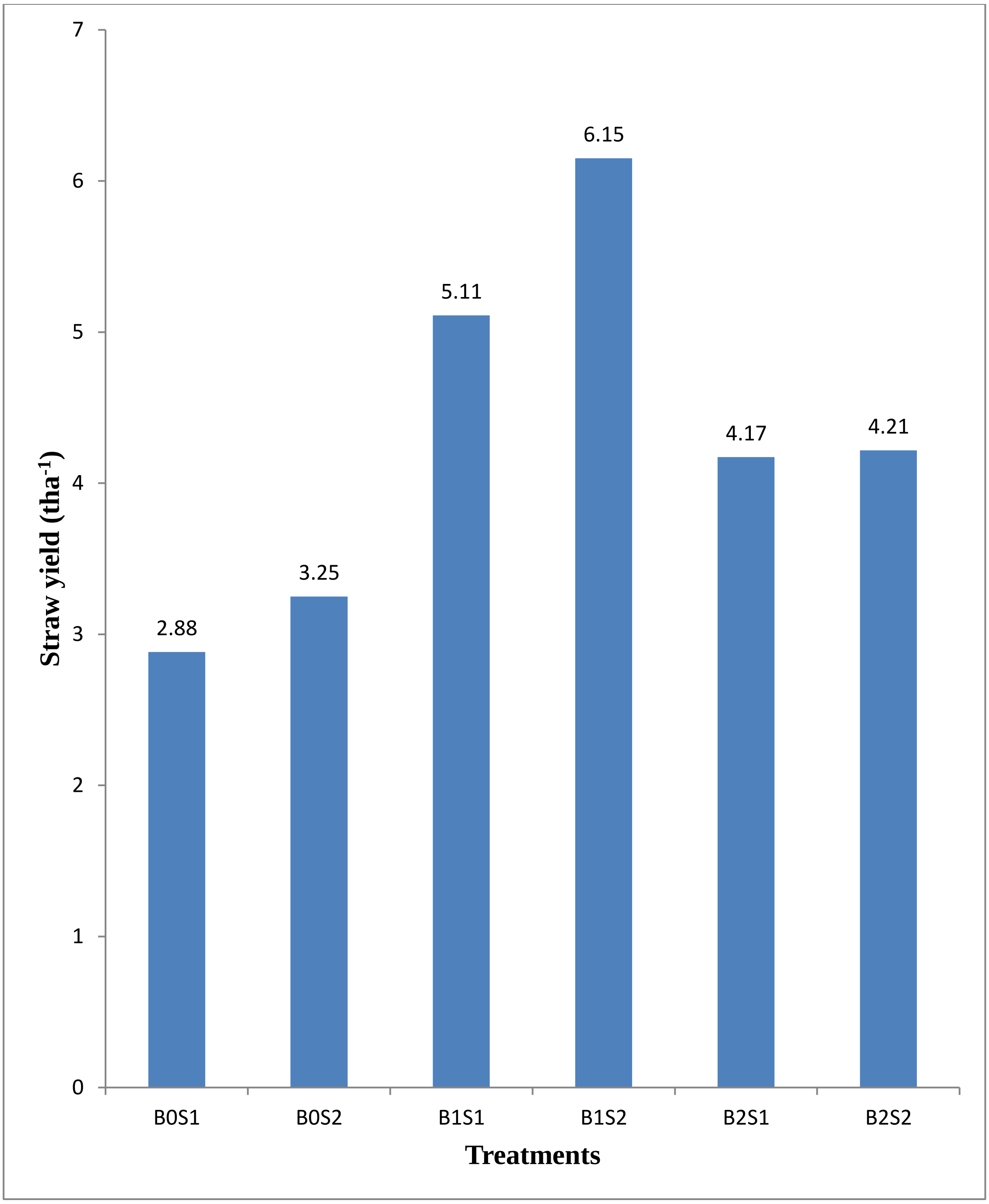


V_1-BARI Gom 23; V_2-BARI Gom 24

S_1-Seedling stage; S_2-Tillering stage

Figure 21. Effect of growth stages on the straw yield of wheat varieties.

($LSD_{0.05}$ = 0.36)



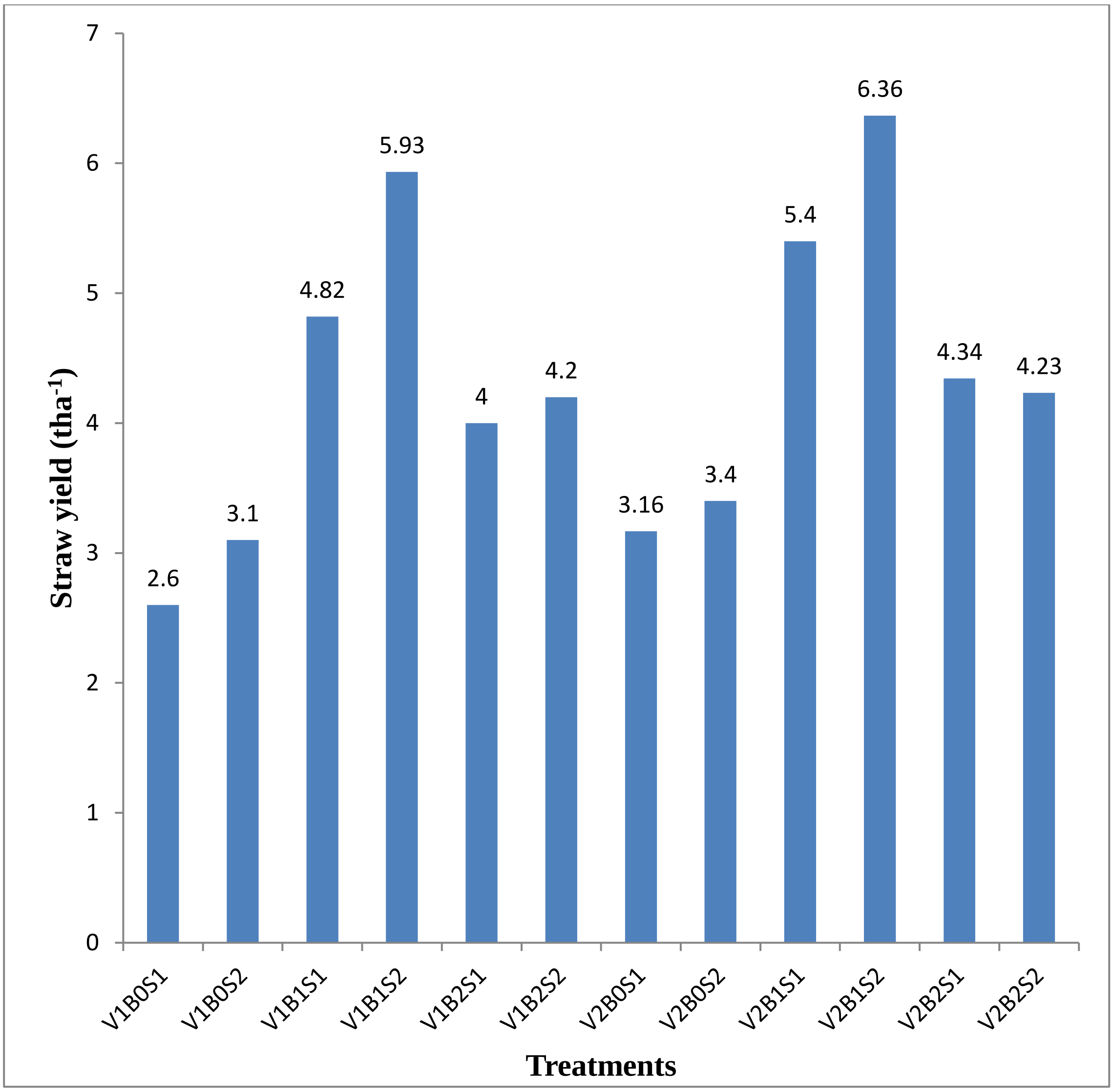
S_1-Seedling stage; S_2-Tillering stage

B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

1

Figure 22. Effect of boron levels and growth stages on straw yield of wheat.

($LSD_{0.05}$ = 0.44)



V_1-BARI Gom 23; V_2-BARI Gom 24

S_1-Seedling stage; S_2-Tillering stage

B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 23. Interaction effect of boron levels and growth stages on the straw yield of wheat varieties. ($LSD_{0.05}$ = 0.63)

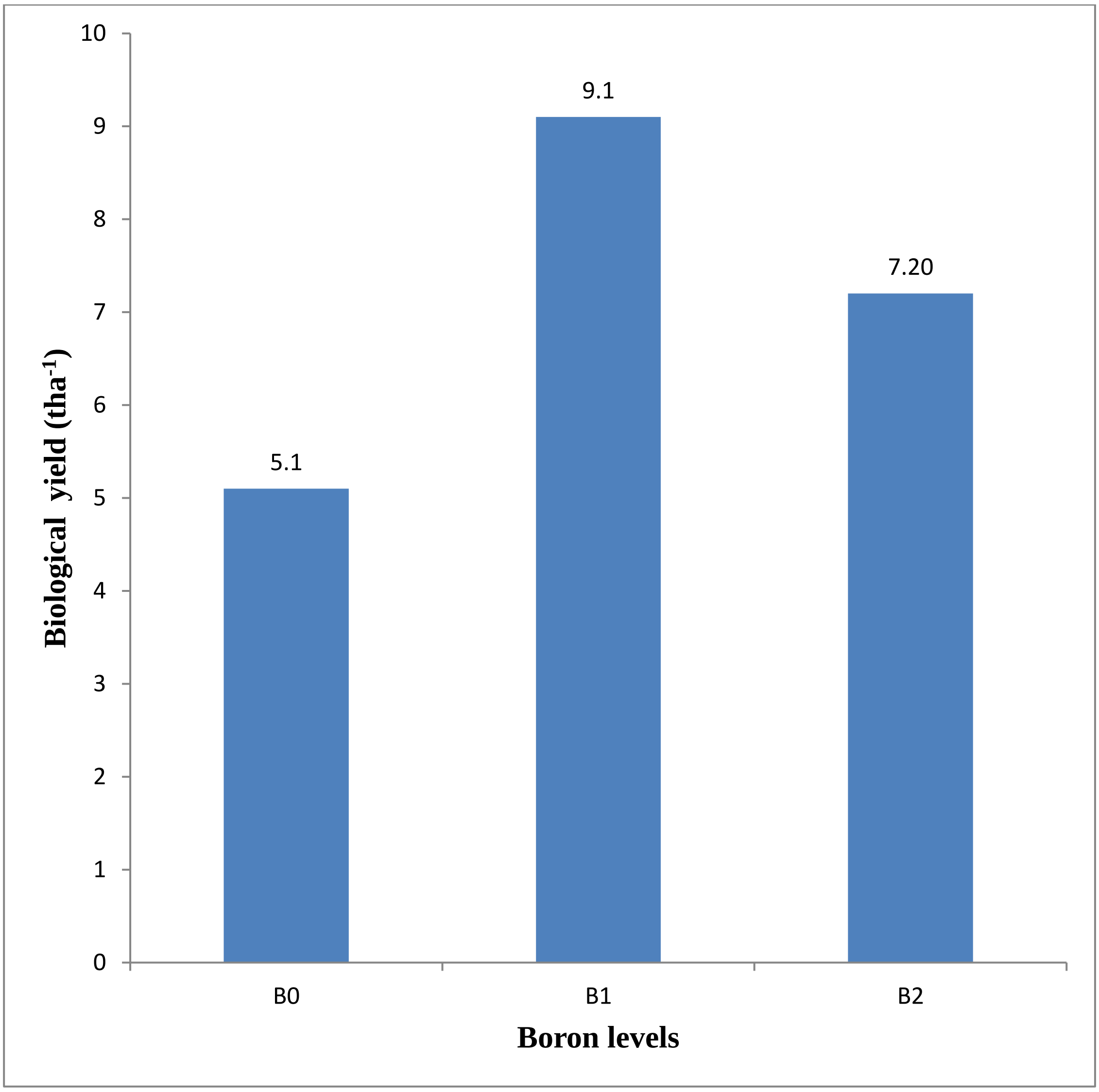
4.14 Biological yield (tha^{-1})

Different B levels significantly influenced the biological yield of wheat. It was noted that biological yield is calculated from the total of grain yield and straw yield. The highest biological yield (9.10 tha^{-1}) was obtained when the crop fertilized with 0.5 kgBha^{-1} and the lowest (5.10 tha^{-1}) with control (Figure 24). The highest biological (7.92 t ha^{-1}) and the lowest (6.94 tha^{-1}) were found in tillering and seedling stage, respectively (Figure 25).

When the varieties were fertilized by Boron, the highest result (10.12 tha^{-1}) was found in BARI Gom 24 with the dose of 0.5 kgha^{-1}, whereas the BARI Gom 23 showed 9.25 tha^{-1} (Figure 26). The variety with the seedling and tillering stage, the maximum weight (8.22 tha^{-1}) of biological yield was observed in BARI Gom 24 at tillering stage, whereas BARI Gom 23 showed 6.53 tha^{-1} at the seedling stage (Figure 27). But when the application of B in these stages, the highest biological yield was increased as 8.98 tha^{-1} with the 0.5 kgBha^{-1} and lowest was 6.54 tha^{-1} with the dose of 1 kgBha^{-1} (Figure 28). From the above results, it is clear that increase in B levels biological yield was increased. This is possibly due to significant effects of B in all vegetative and reproductive growth of wheat. Various authors reported that biological yield of wheat increased with increased rate of Zn application (Ali *et al.*, 2009 and Grewal *et al.*, 1997).

Biological yield of wheat showed significant effect due to interaction of B with the varieties with the seedling and tillering stage. The highest biological yield (10.45 tha^{-1}) was produced by 0.5 kgBha^{-1} in tillering stage with the BARI Gom 24 and lowest biological yield (4.33 tha^{-1}) was achieved by control treatment (Figure 29). The second highest result was found as 9.80 tha^{-1} in BARI Gom 23 with the same dose of boron. But in case of 1 kgBha^{-1} application of boron, the highest result was observed as 7.48 tha^{-1} in BARI Gom 24, whereas BARI Gom 23 showed 7.22 tha^{-1} in tillering stage. Even the highest result was found in BARI Gom 24 and lowest result (4.33 tha^{-1}) was observed in BARI Gom 23 from the control.

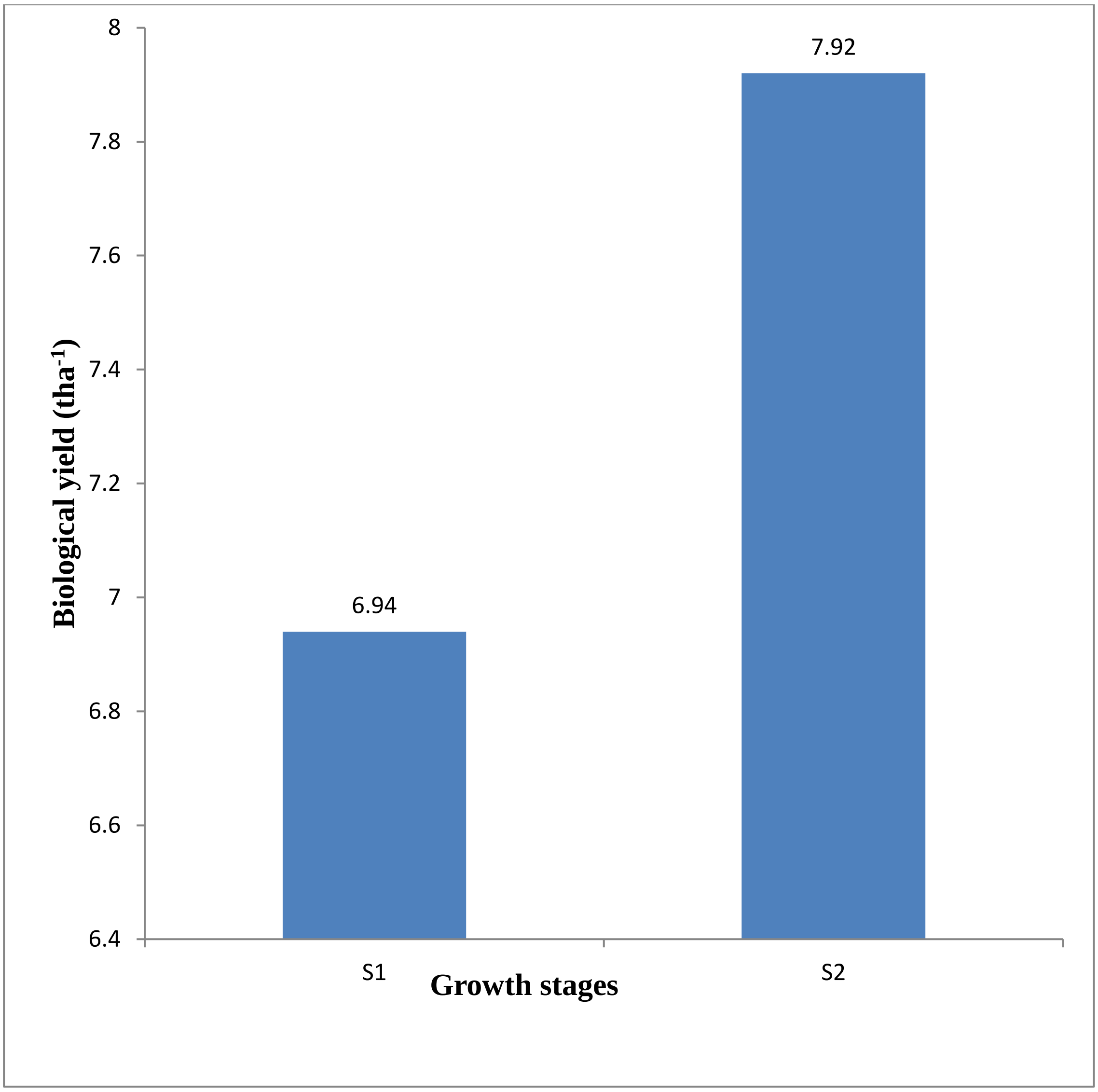
The result obtained in this regard is in accordance with the findings of Torun *et al.* (2001) and Grewal *et al.* (1997) who have reported increased dry matter production for application of zinc and boron over control.



B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 24. Effect of B levels on the Biological yield of wheat.

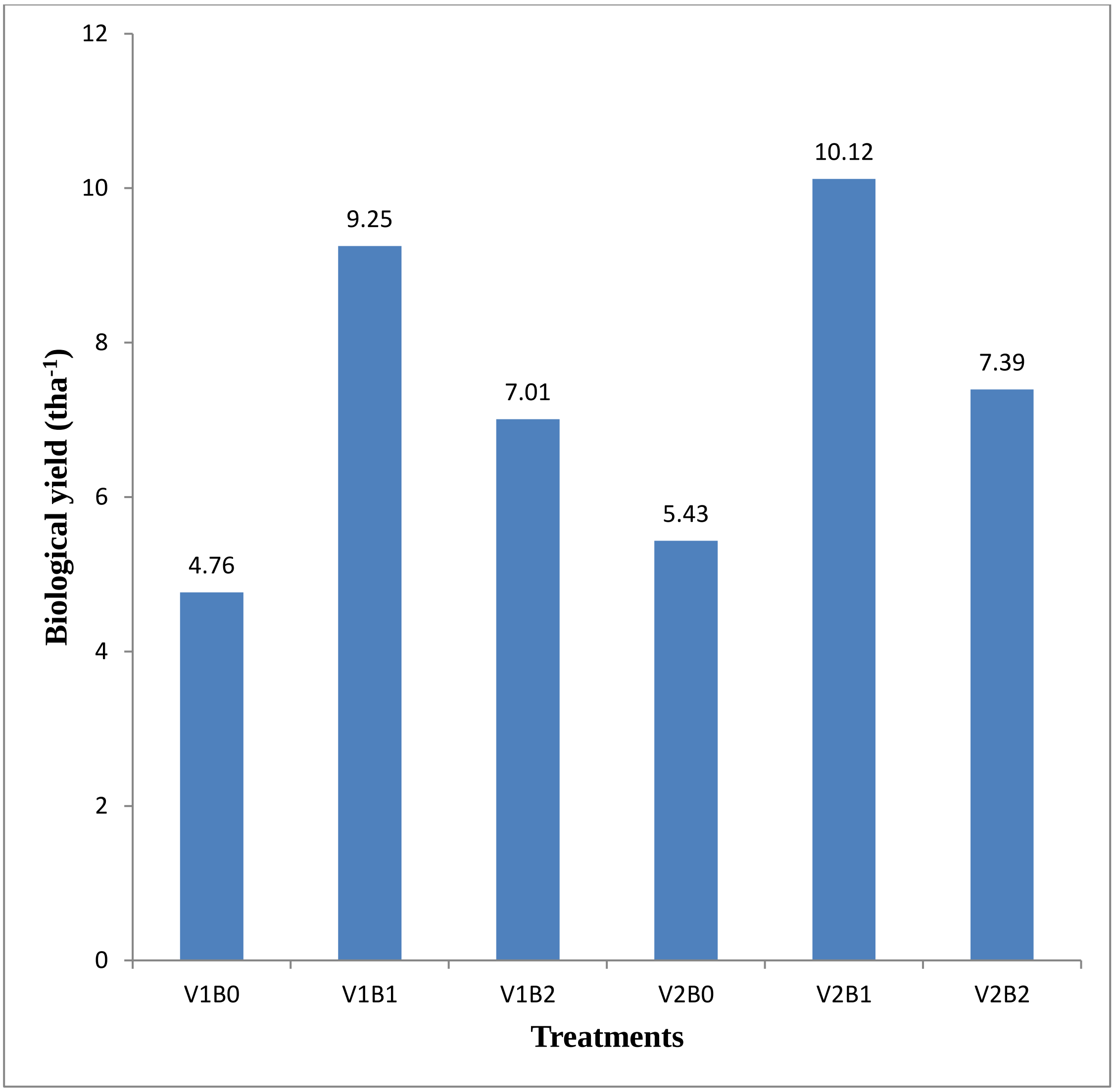
($LSD_{0.05}$ = 0.36)



S_1-Seedling stage; S_2-Tillering stage

Figure 25. Effect of growth stages on the biological yield of wheat.

($LSD_{0.05}$ = 0.29)

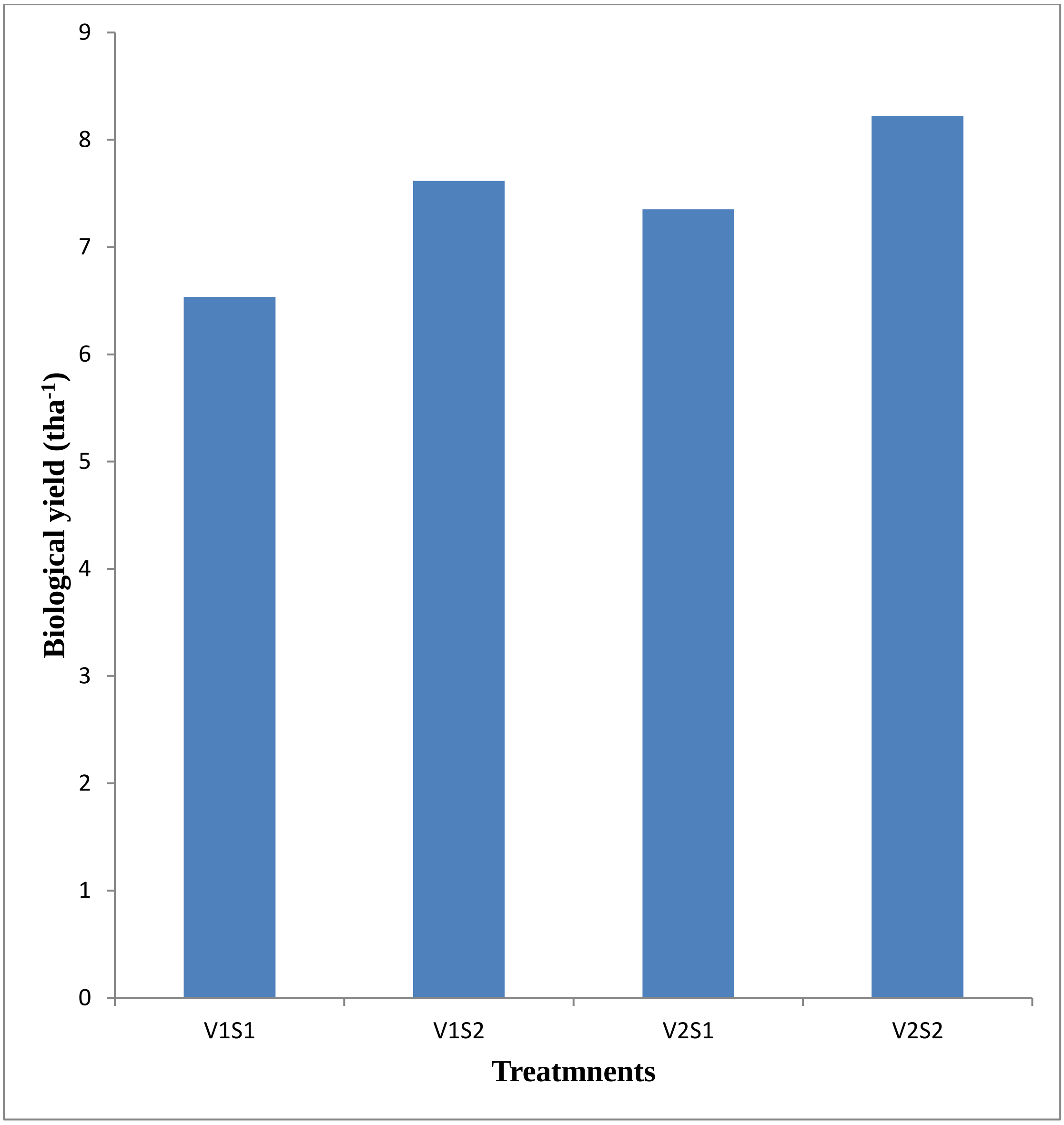


V_1-BARI Gom 23; V_2-BARI Gom 24

B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 26. Effect of boron levels on Biological yield of wheat varieties.

($LSD_{0.05}$ = NS)

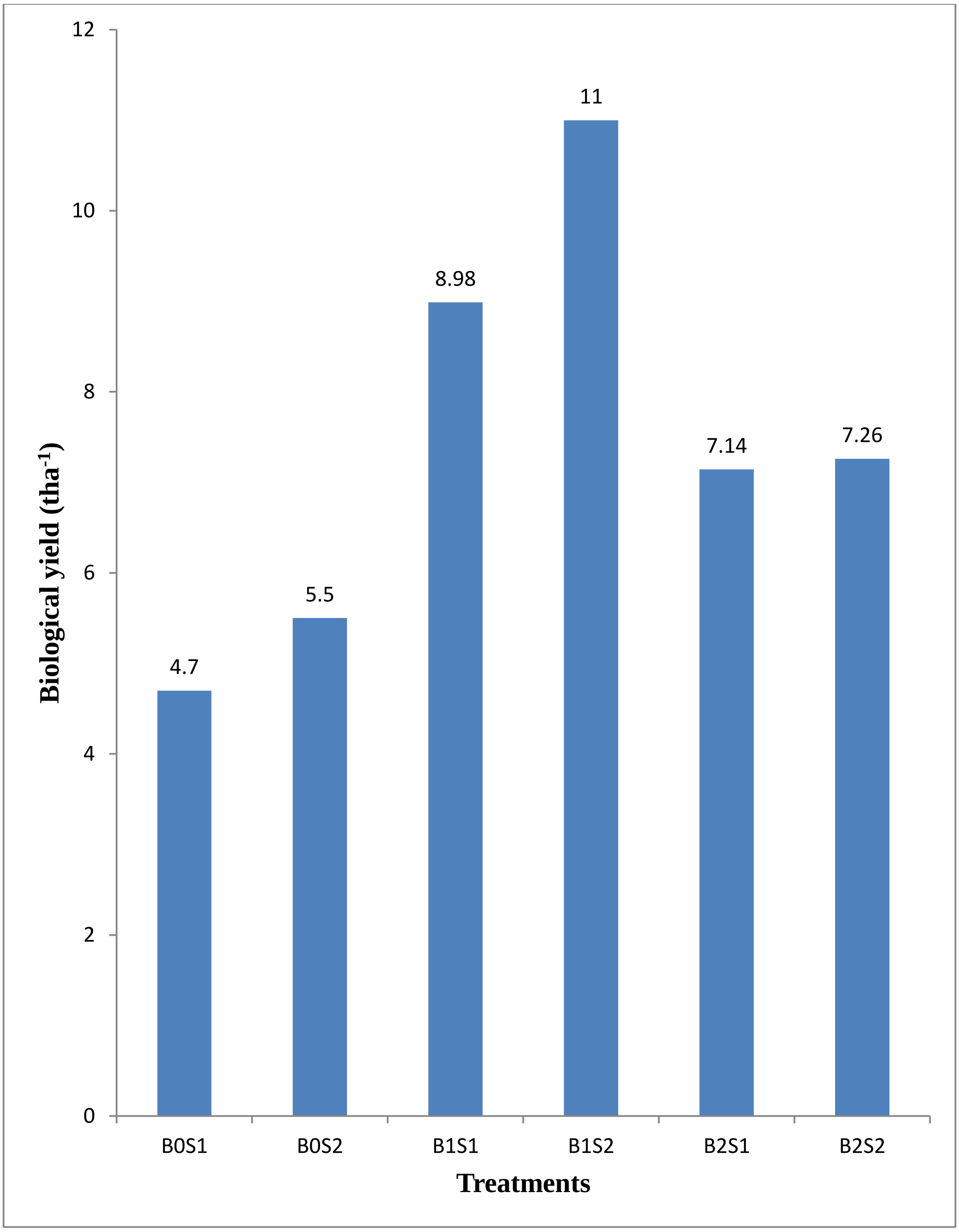


V_1-BARI Gom 23; V_2-BARI Gom 24

S_1-Seedling stage; S_2-Tillering stage

Figure 27. Effect of growth stages on the biological yield of wheat varieties.

($LSD_{0.05}$ = 0.42)

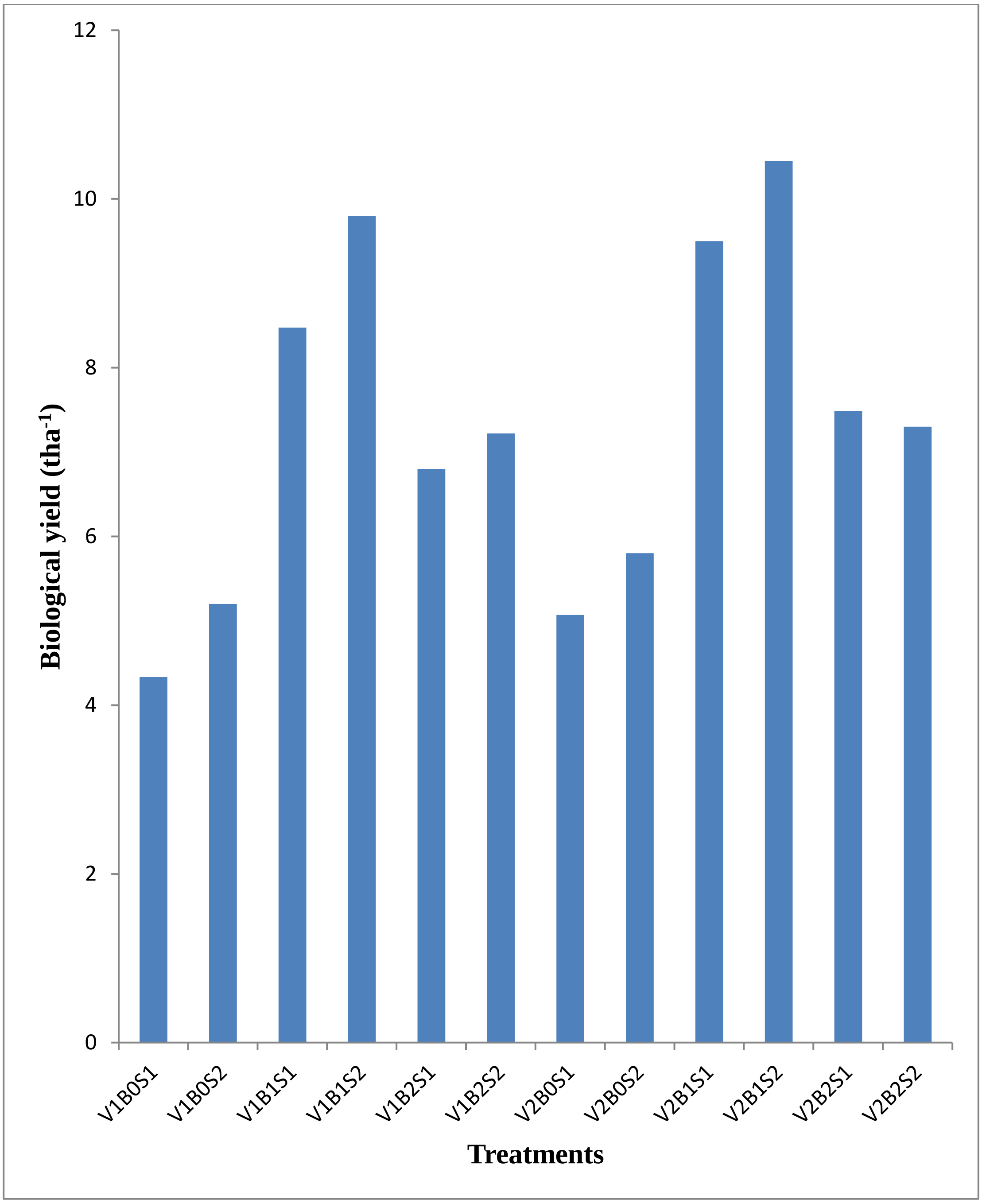


S_1-Seedling stage; S_2-Tillering stage

B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 28. Effect of boron levels and growth stages on biological yield of wheat.

($LSD_{0.05}$ = 0.51)



V_1-BARI Gom 23; V_2-BARI Gom 24

S_1-Seedling stage; S_2-Tillering stage

B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1kgBha^{-1}

Figure 29. Interaction effect of boron levels and growth stages on biological yield of wheat varieties. ($LSD_{0.05}$ = 0.72)

4.15 Harvest index (%)

The effects of B on harvest index showed significant variation. The highest harvest index (43.62%) was observed in 0.5 kg B ha^{-1} which was statistically similar (41.82%) with 1 $kgBha^{-1}$ and the lowest (39.94%) from the control (Table 20). Khan (2008) found that harvest index showed a significant variation due to the application of different levels of boron. The two varieties showed more or less similar harvest index (41.91 & & 41.68%). The highest harvest index (44.07%) was found in tillering stage with the application of 0.5 $kgBha^{-1}$, whereas the second highest harvest index (43.17%) was observed in seedling stage with the same dose of boron (Table 21). The lowest harvest index (38.95%) was found in seedling stage from the control. The BARI Gom 24 showed the maximum (44.10%) with the application of 0.5 $kgBha^{-1}$, whereas BARI Gom 23 showed the nearest result (43.14%) (Table 22). The lowest result found in BARI Gom 24 from the control. In case of seedling and tillering stage, the highest result (42.81%) was observed in BARI Gom 24 in tillering stage, whereas the lowest result (41%) was found from the seedling stage (Table 23). Statistically, the varieties with the seedling and tillering stage showed insignificant results.

The combination of two stages with the two varieties, the most highest result (44.98%) was observed in tillering stage with the application dose of boron@0.5 $kgha^{-1}$, where as the nearest results (43.22%) was found in seedling stage from the BARI Gom 24 (Table 24). The nearest results (43.16 & 43.13%) were observed in case of BARI Gom 23 from the tillering and seedling stage. The lowest result (37.73%) was found in case of BARI Gom 24 from the seedling stage in control.

The results indicate that harvest index was influenced by the B application might be due to the fact that it helps in fruit setting and grain formation. The development of wheat anthers and pollen is affected by B deficiency. Therefore, B has also the most pronounced effect on grain filling. These results are in agreement with those reported by Furlani *et al.* (2003).

Table 20. Effect of boron levels on harvest index in growth stages with the varieties

Variety	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
V_1	2.97 b	4.11 b	7.08 b	41.68
V_2	3.30 a	4.49 a	7.79 a	41.91
LSD (0.05)	0.07	0.26	0.29	NS
Boron				
B_0	2.03 c	3.07 c	5.10 c	39.94 c
B_1	4.36 a	5.63 a	9.99 a	43.62 a
B_2	3.01 b	4.19 b	7.20 b	41.82 b
LSD (0.05)	0.08	0.31	0.36	1.54
Growth Stages				
S_1	2.89 b	4.06 b	6.94 b	41.26
S_2	3.38 a	4.54 a	7.92 a	42.32
LSD (0.05)	0.07	0.26	0.29	1.26
CV (%)	3.05	8.61	5.73	4.36

V_1- BARI Gom 23; V_2- BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 $kgBha^{-1}$; B_2- 1 $kgBha^{-1}$.

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 21. Interaction of boron levels and growth stages on harvest index of wheat

Boron × Growth stage	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
B_0S_1	1.82 e	2.88 d	4.70 e	38.95 d
B_0S_2	2.25 d	3.25 d	5.50 d	40.93 cd
B_1S_1	3.88 b	5.11 b	8.99 b	43.17 ab
B_1S_2	4.85 a	6.15 a	11.00 a	44.07 a
B_2S_1	2.97 c	4.17 c	7.14 c	41.66 bc
B_2S_2	3.04 c	4.22 c	7.26 c	41.97 abc
LSD (0.05)	0.114	0.44	0.51	2.18
CV (%)	3.05	8.61	5.73	4.36

S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 $kgBha^{-1}$; B_2-1 $kgBha^{-1}$

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 22. Interaction of variety and boron levels on harvest index of wheat

Variety x Boron levels	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
V_1B_0	1.92 f	2.85 d	4.77	40.33 cd
V_1B_1	4.08 b	5.38 b	9.45	43.14 ab
V_1B_2	2.91 d	4.10 c	7.01	41.57 bcd
V_2B_0	2.15 e	3.28 d	5.43	39.55 d
V_2B_1	4.65 a	5.88 a	10.53	44.10 a
V_2B_2	3.12 c	4.29 c	7.39	42.07 abc
LSD (0.05)	0.11	0.44	NS	2.18
CV (%)	3.05	8.61	5.73	4.36

V_1-BARI Gom 23; V_2-BARI Gom 24; B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1 kgBha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 23. Interaction of variety and growth stages on harvest index of wheat

Variety × Growth stage	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
V_1S_1	2.73 d	3.81 c	6.54 c	41.52
V_1S_2	3.21 b	4.41 ab	7.62 b	41.84
V_2S_1	3.05 c	4.30 b	7.35 b	41
V_2S_2	3.56 a	4.67 a	8.22 a	42.81
$LSD_{(0.05)}$	0.09	0.36	0.42	NS
CV (%)	3.05	8.61	5.73	4.36

V_1-BARI Gom 23; V_2-BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Table 24. Interaction of variety, boron levels and growth stages on harvest index of wheat

Variety x Boron x Seedling	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
$V_1B_0S_1$	1.73 j	2.60 h	4.33 h	40.18 bc
$V_1B_0S_2$	2.10 h	3.10 gh	5.20 fg	40.48 bc
$V_1B_1S_1$	3.65 d	4.82 cd	8.47 d	43.13 ab
$V_1B_1S_2$	4.50 b	5.93 ab	10.43 b	43.16 ab
$V_1B_2S_1$	2.80 f	4.00 ef	6.80 e	41.27 b
$V_1B_2S_2$	3.02 e	4.20 de	7.22 e	41.87 b
$V_2B_0S_1$	1.90 i	3.17 gh	5.07 g	37.73 c
$V_2B_0S_2$	2.40 g	3.40 fg	5.80 f	41.37 b
$V_2B_1S_1$	4.10 c	5.40 bc	9.50 c	43.22 ab
$V_2B_1S_2$	5.20 a	6.37 a	11.57 a	44.98 a
$V_2B_2S_1$	3.14 e	4.34 de	7.49 e	42.06 ab
$V_2B_2S_2$	3.07 e	4.23 de	7.30 e	42.07 ab
LSD $_{(0.05)}$	0.16	0.63	0.72	3.09
CV (%)	3.05	8.61	5.73	4.36

V_1-BARI Gom 23; V_2-BARI Gom 24; S_1-Seedling stage; S_2-Tillering stage; B_0-Control; B_1-0.5 kgBha^{-1}; B_2- 1 kgBha^{-1}.

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

CHAPTER V

SUMMARY AND CONCLUSION

A pot experiment was carried out at the experimental shed of the Department of Agronomy, Sher-e- Bangla Agricultural University, Dhaka, during the period from November 2015 to March 2016 to evaluate the effect of three levels of boron viz., 0, 0.5, 1 kgBha^{-1} on grain yield and yield attributes of wheat (BARI Gom 23 and BARI Gom 24). The experiment was laid out in a randomized complete block design with three replications.

The experimental pots were fertilized as per treatments with 180 kgNha $^{-1}$, 120 kg TSP ha^{-1}, 60 kg MOP ha^{-1}. Boron was applied as per treatments through boric acid (17% B) at 23 DAS and 43 DAS. The total amount of TSP, MOP, and one-third of the urea were applied at the time of final land preparation prior to sowing. The remaining two-thirds of urea were top-dressed in two equal splits on 20 and 55 days after sowing (DAS) of the seed. Seeds were sown continuously by hand on 20 November 2015 at the rate of 120 kgha^{-1}. Weeding was done twice before urea application and irrigation was applied as per requirement. Data on different yield attributes and yield were recorded at maturity.

The highest leaf area index (1.68) with the application of 0.5 kg Bha^{-1}at 40 days after sowing in seedling stage, whereas the highest (3.95) leaf area index was found from the same level of boron application at 60 days after sowing. The highest leaf area index 1.81and 4.10 were found from variety BARI Gom 24 with the 0.5 kgBha^{-1} application of boron at 40 days after sowing, respectively. The lowest leaf area index 0.61 and 1.17 were found from variety BARI Gom 23 from the control at 40 and 60 days after sowing, respectively. The highest plant height (55.33 and 83.33 cm) was observed with the application of 0.50 kgha^{-1} in tillering stage of BARI Gom 24 in case of interaction. Application of B significantly influenced the number of leaves. The highest numbers (14.36 & 12.51) of leaves were found in BARI Gom 24 and BARI Gom 23 with the application of 0.5 kgBha^{-1} at 40 days after sowing and the increase continued till 60 days after sowing. The lowest number (6.5 & 7.4) of leaves were observed in both varieties from the control. The highest number (2.91 & 2.61) of tillers were found in BARI Gom 24 and BARI Gom 23 with the application of 0.5

kgBha^{-1} at 40 days after sowing and the increase continued till 60 days after sowing. When the 1kgha^{-1} Boron was applied in both varieties, the numbers of tillers were not increased considerably. The highest number of spikes ranged from 11.1 to 11.73cm in seedling and tillering stage of BARI Gom 23 with the dose of Boron @0.50 kgha^{-1}, respectively. In case of BARI Gom 24, the highest number of spikes ranged from 12.22 to 13.86cm in seedling and tillering stage of with same dose of Boron. The numbers of spikes were varied from 9.20 to 9.95cm in both stage of BARI Gom 23 with the application levels of Boron @1kgha^{-1}. The dose of boron influenced the non fertile spikes and found 3.46, 3.95 and 4.88 at the rate of 1kgha^{-1}, 0.5kgha^{-1} and control (0), accordingly. In case of seedling and tillering stage, the numbers of non fertile spikes were observed 3.6 and 4.6, respectively. The average numbers of non fertile spikes were found 3.47 and 4.40 at tillering and seedling stage in BARI Gom 23, whereas the average number of non fertile spikes 3.72 and 4.80 were observed at tillering and seedling stage in BARI Gom 24.

Numerically, the spike straw weight ranged 5.39g and 4.13g by applying B at the rate of 0.5 and 1kgha^{-1}. But in case of BARI Gom 24, the spike straw weight (5.7g) was found with the B application@0.5kgha^{-1}. The second highest straw weight (5.08g) was observed in BARI Gom 23 with the same dose of boron application. The results presented that the highest number of grains spike^{-1} 30.81) was produced by application of boron@0.5 kgha^{-1} and the lowest (21.74) was found at 1kgha^{-1} of boron. The highest number (41.00) of grains spike^{-1} was found BARI Gom 24 with the application of 0.5 kgha^{-1} at tillering stage and the lowest (18.53) was observed in BARI Gom 24 from the control at seedling stage.

The highest seed weight plant^{-1} (10.67g) was found in BARI Gom 24 at tillering stage with the dose of Boron @0.50 kgha^{-1}. The nearest highest weight (9.20g) was observed at seedling stage with same dose of boron in BARI Gom 23 and BARI Gom 24.

The highest 1000 grain weight (46.62 g) was found by applying B at the rate of 0.5 $kgha^{-1}$ and the second highest 1000-grain weight (40.82 g) was found from control. But in case of 1 $kgha^{-1}$ B application, the 1000 grain weight was obtained 39.93g. In case of varieties, the highest weight (48.23g) and nearest weight (40.17g) were found with the application of boron at the rate of 0.5$kgha^{-1}$ in BARI Gom 24. But the weight of 1000 grains was found 45.0g with the same dose of B application in BARI Gom 23. Grain yield was influenced significantly due to the different levels of B application (Appendix- IV). Grain yield was observed 3.36 tha^{-1} when the application of 0.5 kg B ha^{-1}(Figure 12). The highest grain yield (3.38 t ha^{-1}) was observed at from the tillering stage (Figure 13). The boron application @0.5 $kgha^{-1}$ showed the highest result (3.63 tha^{-1}) BARI Gom 24, whereas the lowest result was observed as 1.92 tha^{-1} from the control in BARI Gom 23 (Figure 14). The interaction effect of different levels of B fertilizers was significant regarding grain yield (Appendix. V). The highest grain yield (3.62 tha^{-1}) was recorded at a combination from BARI Gom 24 at tillering stage with the application of boron @0.5 $kgha^{-1}$ and the lowest (1.73 tha^{-1}) was recorded from control at seedling stage in BARI Gom 23 (Figure 17). The highest (6.15 tha^{-1}) and the lowest (2.88 tha^{-1}) straw yield were observed with the application of boron at 0.5 $kgha^{-1}$ and from the control (Figure 22). From the interaction treatments, the highest (6.37 tha^{-1}) and the lowest (2.60 tha^{-1}) straw yield were observed with the application of boron at 0.5 $kgha^{-1}$ and from the control in seedling and tillering stage of BARI Gom 24 and BARI Gom 23, respectively.

Biological yield of wheat showed significant effect due to interaction of B with the varieties with the seedling and tillering stage. The highest biological yield (10.45 tha^{-1}) was produced by 0.5 $kgBha^{-1}$ in tillering stage with the BARI Gom 24 and lowest biological yield (4.33 tha^{-1}) was achieved by control treatment (Figure 29). The second highest result was found as 9.80 tha^{-1} in BARI Gom 23 with the same dose of boron. But in case of 1 $kgBha^{-1}$ application of boron, the highest result was observed as 7.48 tha^{-1} in BARI Gom 24, whereas BARI Gom 23 showed 7.22 tha^{-1} in tillering stage. Even the highest result was found in BARI Gom 24 and lowest result (4.33 tha^{-1}) was observed in BARI Gom 23 from the control.

The highest harvest index (44.07%) was found in tillering stage with the application of 0.5kg Bha^{-1}, whereas the second highest harvest index (43.17%) was observed in seedling stage with the same dose of boron. The lowest harvest index (38.95%) was found in seedling stage from the control. The BARI Gom 24 showed the highest (44.10%) with the application of 0.5kgBha^{-1}, whereas BARI Gom 23 showed the nearest result (43.14%).

REFERENCES

Alam, S. M., Iqbal, Z. and Latif, A. (2000). Effect of boron application with or without zinc on the yield of wheat. *Pakistan J. Soil. Sci.,* **18**: 95-98.

Ali, M. A., Tariq, N. H., Ahmed, N., Abid, M. and Rahim, A. (2013). Response of wheat (*Triticum aestivum* l.) to soil applied boron and zinc fertilizers under irrigated conditions. *Pakistan J. Agri., Agril. Engg.,* **29**(2): 114-125

Ali, S., Shah, A., Arif, M., Miraj, G., Ali, I., Sajjad, M., Farhatullah, M.Y. Khan and Khan, N.M. (2009). Enhancement of wheat grain yield and yield components through foliar application of Zinc and Boron. *Sarhad J. Agric.,* **25** (1): 15-19.

Arif, M., Chohan, M.A., Ali, S., Gul, R. and Khan, S. (2006). Response of wheat to foliar application of nutrients. *J. Agric. Biol. Sci.,* **1**: 30-34.

Asad, A. and Rafique, R. (2002). Identification of micronutrient deficiency of wheat in the Peshawar valley. *Comm.Soil Sci. Plant Analysis.* **33**:349-364.

Asad, A. and Rafique, R. (2000). Effect of zinc, copper, iron, manganese and boron on the yield and yield components of wheat crop in Tehsil Peshawar. *Pakistan. J. Biol. Sci.,* **3**: 1615-1620.

BINA (Bangladesh Institute of Nuclear Agriculture) (1993). Effect of different levels of boron application on the growth and yield of wheat. *Ann. Rep.* (1991-92). Bangladesh Inst. Nuclear Agric., Mymensingh. p. 159.

Biswas, A., Mukhopadhyay, D. and Biswas, A. (2015). Effect of Soil Zinc and Boron on the Yield and Uptake of Wheat in an Acid Soil of West Bengal, India. *Int. J. Plant and Soil Sci.,* **6**(4): 203-217

Debnath, C., Kader, M.A and Islam, N. (2014). Effect of Nitrogen and Boron on the Performance of Wheat. *J. Environ. Sci. Natural Res.,* 7(1): 105-110

Debnath, M.R., Jahiruddin, M., Rahman, M.M. and Haque, M.A. (2011). Determining optimum rate of boron application for higher yield of wheat in Old Brahmaputra Floodplain soil. *J. Bangladesh Agril. Univ.,* **9**(2): 205–210

Dell, B. and Haung, L.B. (1997). Physiological response of plants to low boron. *Plant Soil.*, **193**: 103-120.

FAO. (2013). World food and agriculture. Statistical yearbook. 2013. p. 289.

Furlani, A.M.C., Carvalho, C.P., Freitas, J.G. and Verdial, M.F. (2003). Wheat cultivar tolerance to boron deficiency and toxicity in nutrient solution. *ScientiaAgricola.,* **60** (2): 359-370.

Galrao, E.Z. and Sousa, D.M., De, G. (1988). Effect of boron on male sterility of wheat in an organic paddy soil. *Revista Brasileri de Ciencia do solo.,* **2** (2): 147-152.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research. 2nd edn. John Willy and Sons. New York. pp. 357-369.

Grewal, H.S., Zhonggu, L. and Graham, R.D. (1997). Influence of subsoil zinc on dry matter production, seed yield and distribution of zinc in oilseed rape genotypes differing in zinc efficiency. *Plant Soil.* **192** (2): 181 – 189.

Guenis, A., Alpaslan, M. and Unal, A. (2003) .Effects of boron fertilization on the yield and some yield components of bread and durum wheat. *Turkish J. Agric.* **27**: 329-335.

Gupta, U.C. (1979). Boron nutrition of Crops. *Adv. Agron*., **11**: 273-307.

Halder, N. K., Hossain, M. A., Siddiky, M. A., Nasreen, N. and Ullah, M. H. (2007). Response of wheat varieties to boron application in calcareous brown flood plain soil at southern region of Bangladesh. *J. Agron.* **6**(1): 21-24.

Hussain, M., Niaz, M., Iqbal, M., Iftikhar, T. and Ahmad, J. (2012). Emasculation techniques and detached tiller culture in wheat X maize crosses. *J. Agric. Res*., **50**(1): 11-19.

Hwary, A.T.B. A. and Yagoud, S.O. (2011). Effect of skipping irrigation on growth, yield, yield components and water use efficiency of wheat (*Triticum aestivum* L.) in semi arid Region of Sudan. *Agric. Biol. J. North America*, **2**(6): 1003-1009

Iftikhar,T., Babar, L.K., Zahoor, S. and Khan, N.G. (2010). Impact of land pattern and hydrological properties of soil on cotton yield. *Pakistan J. Bot*., **42**(5): 3023-3028

Jahiruddin, M., Ali, M.S., Hossain, M.A., Ahmed, M.U. and Hoque, M.M. (1995). Effect of boron on grain set, yield and some other parameters of wheat cultivars. *Bangladesh J. Agric. Sci.* **22**(1): 179-184.

Kapoor, S., Sharma, S.K., Rana, S.S. and Shankhyan, N. (2016). *International Journal of Advances in Agricultural Science and Technology* **3**(6):25-39

Khan, M.A., Fuller, M.P. and Baloch, F.S. (2008). Effect of soil applied zinc sulphate on wheat (*Triticum aestivum* L.) grown on a calcareous Soil in Pakistan., **36** (4), pp. 571–582.

Khan, R., Gurmani, A. H., Gurmani, A. R. and Zia, M. S. (2006). Effect of boron on rice yield under wheat-rice system. *Int. J. Agric. Bio*., **8**: 805-808.

Leghari, A.H., Laghari, G.M., Ansari, M.A., Mirjat, M.A., Laghari, U.A., Leghari, S.J., Laghari, A.H. and Abbasi, Z.A. (2016). Effect of NPK and boron on growth and yield of wheat variety TJ-83 at Tandojam Soil., **10**(10): 209-216

Makhdum. M. U., Suhog, S. and Memon, M. A. (1988). Influence of copper and zinc fertilization on the yield and quality of wheat Proc. Nat. Seminar on Micronutrient in Soils and Crop in Pakistan, December 13-15, 1987 NWFP Agri. Univ.

Malewar, G.V., Kate S.D., Waiker, S.L. and Islam, S. (2001). Interaction Effect of zinc and boron on yield, nutrient uptake and quality of mustard (*Brassica juncea* L.) on a Typic Haplustert. *J. Indian Soc. Soil Sci.,* **49** (4):763-765.

Mandal, A.B. (1987). Genetic Response of boron on bread wheat varieties Linder term soil. *J. Maharastra Agmc. Univ.***12** (2): 268-269.

Mandal, A.B. (1993). Effect of boron on different varieties of bread wheat (*Triticum aestivum* L.). *Crop Res.,* **6**: 330-334.

Mandal, A.B. and Das, A.D. (1988). Response of wheat (*Triticum aestivum* L.) to boron application. *Indian J. Agric. Sci.,* **58** (9): 681-683.

Marschner, H. (1995). Mineral Nutrition of Higher Plants. 2nd Ed. Academic Press.

Mete, P.K., Bhattachayay, P. and De, M. (2005). Effect of boron and lime on growth and yield of wheat (*Triticum aestivum* L.) in alluvial soils of west Bengal. *J. Interaca.,* **9** (4): 544-549.

Metwally, A., Rasha, E. and Hamada, A. (2012). Effect of boron on growth criteria of some wheat cultivars. *J. Biol Earth Sci.,* **2**(1): B1 -B9

Mishra, S.S., Guiati, J.M.L., Nanda, S.S., Charanayak, L.M. and Jena, S.N. (1989). Micronutrient Studies in Wheat. *J. Agric. Res*., **2** (2): 94- 96.

Mitra, A.K. and Jana, P.K. (1991). Effect of dose and methods of boron application on wheat in acid term soils of North Bengal. *Indian J. Agron.,* **36** (1): 72-74.

Moghadam, M.J., Sharifabad, H.H., Noormohamadi, G., Sadeghian, M.Y., Siadat, S.A. (2012). The Effect of zinc, boron and copper foliar application, on yield and yield components in wheat (Triticum aestivum L.). *Ann. Biolo. Res.,* **3**:3875-3884

Muhammad, Z.H., Kashif, M., Maqshoof, A. and Imran, M. (2016). Influence of boron fertilization on growth and yield of wheat crop under salt stress environment. *Soil Environ.,* **35**(2): 181-186

Nadim, M.A., Inayat U.A., Baloch, M.S., Khan, N. and Khalid, N. (2013). Micronutrient use efficiency in wheat as affected by different boron application methods. *Pakistan. J. Bot*., **45**(3): 887-892, 2013.

Nawab, K., Amanullah, Arif, M., Shah, P., Rab, A., Khan, M.A. and Khan, K. (2011). Effect of FYM, potassium and zinc on phenology and grain yield of wheat in rainfed cropping systems. *Pakistan J. Bot.,* **43**(5): 2391-2396.

Panwar, B.S., Gupta, S.P. and Kala, P. (1998). Response to boron in pearl millet and chickpea in a pot experitnent with a non calcareotts soil in India. *Acta Agron. Hung*., **46** (4): 335-340.

Rahman, S. (1989). Influence of different nutrients on grain formation in wheat. Thesis M.Sc. (Ag). in Soil Sci. Bangladesh Argil. Univ. Mymensingh. pp. 33-34.

Rashid, A. (1989). Cooperative research programme on micronutrient status of Pakistan. soils and their role in crop production. Annual Report, 1988-89. Land Resources Section NARC, Islamabad.

Rawashdeh, H.M. and Sala, F. (2014). Foliar application of boron on some yield components and grain yield of wheat. *Academic Research Journal of Agric Sci. Res.,* **2**(7):97-101

Rawashdeh, H.M. and Sala, F. (2013a). The effect of foliar application of iron and boron on early growth parameters of wheat (*Triticum aestivum* L.). *Res. J. Agric. Sci.,* **45**(1): 21- 26.

Rawashdeh, H.M. and Sala, F. (2014b). Influence of iron foliar fertilization on some growth and physiological parameters of wheat at two growth stages. Scientific Papers. Series A. Agron., 57: 306-309.

Rerkasem, B. and Loneragan, J.F. (1994). Boron deficiency in two wheat genotypes in a warm, subtropical region. *Agron. J.,* **6:**887–890.

Shukla, S.K., and Warsi, A.S. (2000). Effect of sulphur and micro-nutrients on growth, nutrient content and yield of wheat *(Triticum aestivum* L.). *Indian J. Agric. Res***.,** **34** (3): 203-205

Singh, D. and Yadav, S. (2010). Growth of wheat in response to zinc and boron application to soil deficient in available zinc and boron. Multidisciplinary Adv. Res. Department of Botany, Lucknow University, Lucknow-226007

Singh, V and Singh, S.P. (1984). Effect of applied boron on nutrient uptake by barley crop. *Curr. Agric.* **8**: 89-90.

Soylu, S., Sade, B., Topal, A., Akgun, N. and Gezgin, S. (2005). Responses of irrigated durum and bread wheat cultivars to boron application in low boron calcareous soil. *Turk J. Agric. For.* **29**: 275-286.

Tahir, M. (1981). Availability status of micronutrient in the soils of West Pakistan and the role and behaviour of soils of West Pakistan and the role and behavior of selected micronutrients in nutrition of crops Final Technical Report. PL-480.

Tahir, M., Tanveer, A., Shah, T.H., Fiaz, N. and Wasaya, A. (2009). Yield response of wheat (*triticum aestivum* l.) to boron application at different growth stages. *Pakistan J. Life Soc. Sci.,* **7**(1):39-42

Torun, A., Itekin, I.G.A., Kalayci, M., Yilmaz, A., Eker, S. and Cakmak, I. (2001). Effects of zinc fertilization on grain yield and shoot concentrations of zinc, boron, and phosphorus of 25 wheat cultivars grown on a zinc-deficient and boron-toxic soil. *J. Plant Nutr.,* **24** (11): 1817-1829.

Yilmaz, A., Ekiz, H., Torun, B., Gulekin, I., Karanlink, S., Bagci, S. A. and Cakmak I. (1997). Effect of different zinc application methods on grain yield and zinc concentration in wheat cultivars grown on zinc-deficient calcareous soils. *J. Plant Nutr.,* **20** (4-5), 461-471.

Yoshida, S. and Tanaka, A. (1969). Zinc deficiency of the rice plant in calcareous soils. *Soil Sci. Plant Nut.,* **15**: 75-80.

Zain, M., Khan, I., Qadri, R.W.K., Ashraf, U., Hussain, S., Minhas, S., Siddique, A., Jahangir, M.M. and Bashir, M. (2015). Foliar application of micronutrients enhances wheat growth, yield and related attributes. *American J. Plant Sci.,* **6**(7):864-869.

Ziaeyan, A.H. and Rajaie, M. (2009). Combined effect of Zinc and Boron on yield and nutrients accumulation in corn. *Int. J. Plant Prod.,* **3** (3): 23-33.

APPENDICES

Appendix-I: Mean square value (MSV) of LAI of wheat at different boron levels and growth stages at 40 DAS and 60 DAS

Source of variation	Degree of freedom	Mean square value (MSV) of LAI at	
		40 DAS	60 DAS
Replication	2	0.02	0.01
Variety (V)	1	0.18**	0.91**
Boron (B)	2	2.22**	13.60**
V X B	2	0.02**	0.04**
Seedling (S)	1	0.11**	1.68**
V X S	1	0.01	0.02
B X S	2	0.17**	0.21**
V X B X S	2	0.03**	0.13**
Error	22	0.003	0.006

Appendix-II: Mean square value (MSV) of leaf length, leaf breath and plant height of wheat at different boron levels and growth stages at 40 DAS and 60 DAS

Source of variation	Degrees of freedom	Leaf length at		Leaf breath at		Plant height at	
		40 DAS	60 DAS	40 DAS	60 DAS	40 DAS	60 DAS
Replication	2	1.96	1.29	0.32	0.03	4.17	2.77
Variety (V)	1	7.91*	9.41*	3.09**	0.97	21.39	107.47**
Boron (B)	2	35.80**	35.67**	35.87**	34.40**	430.63**	1981.51**
V x B	2	1.67	0.25	0.79*	0.29**	1.08	48.53**
Seedling (S)	1	0.47	1.66	0.46*	2.75**	80.49**	239.80**
V x S	1	0.09	0.002	0.24	0.0001	5.52	0.81
B x S	2	5.05*	7.05*	2.01**	1.60*	20.66*	4.001
V x B x S	2	0.32	1.31	1.17**	0.73	1.95	0.04
Error	22	1.28	1.62	0.14	0.46	5.84	1.76

Appendix-III: Mean square value (MSV) of leaf no./plant and tiller no./plant of wheat at different boron levels and growth stages at 40 DAS and 60 DAS and plant height at harvest

Source of variation	Degrees of freedom	Plant height at	Leaf no./plant at		Tiller no./plant at		Plant height at
		Harvest	40 DAS	60 DAS	40 DAS	60 DAS	Harvest
Replication	2	10.22	0.68	0.80	0.10	0.03	10.22
Variety (V)	1	410.74**	20.25**	9.82**	0.04	1.44**	410.73**
Boron (B)	2	924.46**	130.31**	184.17**	5.32**	20.54**	924.45**
V x B	2	76.27**	4**	23.04**	0.05	2.15**	76.27 **
Seedling (S)	1	121.60**	1.001	17.26**	0.19	1.38**	121.61**
V x S	1	1	0.25	13.94**	0.01	0.32	1
B x S	2	23.48	1.93**	2.31	0.51	0.25	23.48
V x B x S	2	31.29	0.08	2.98**	0.01*	0.11	31.29
Error	22	9.14	0.32	0.85	0.10	0.11	9.14

Appendix-IV: Mean square value (MSV) of spike length, no. of fertile spikelets /spike, no. of non fertile spikelets/spike, no. of grains /spike and 1000 grain wt. of wheat at different boron levels

Source of variation	Degrees of freedom	Spike length	No. of fertile spikelets /spike	No. of non fertile spikelets/spike	No. of grains /spike	1000 grain wt.
Replication	2	1.72	1.27	1.26	1.76	3.00
Variety (V)	1	3.82*	22.17**	0.98	62.54**	4.27
Boron (B)	2	44.94**	25.18**	6.29*	443.28**	158.17**
V x B	2	0.33	1.78*	9.09*	79.48**	12.48
Seedling (S)	1	0.94	2.70*	6.86*	45.81**	17.87*
V x S	1	0.02	1.66*	0.05	37.43*	1.60
B x S	2	0.40	1.20	0.06	43.63**	7.30
V x B x S	2	0.15	0.20	2.48	34.01*	6.31
Error	22	0.51	0.34	1.23	6.92	3.46

Appendix-V: Mean square value (MSV) of spike straw wt., seed wt/ plant, grain yield, straw yield, biological yield and harvest Index of wheat at different boron levels

Source of variation	Degrees of freedom	Spike straw wt.	Seed wt/ plant	Grain yield	Straw yield	Biological yield	Harvest Index
Replication	2	0.25	0.66	0.01	0.11	0.07	9.54
Variety (V)	1	1.13*	0.77	1.00**	1.27**	4.54**	0.47
Boron (B)	2	6.68**	54.63**	16.43**	19.81**	72.31**	40.67**
V x B	2	0.39	6.27**	0.13**	0.08**	0.37	2.44
Seedling (S)	1	0.21	2.93**	2.18**	2.11**	8.58**	10.10*
V x S	1	0.30	0.06	0.02**	0.13**	0.1**	5.03
B x S	2	0.10	2.89**	0.62**	0.77*	2.77**	2.14**
V x B x S	2	0.04	7.4**	0.06**	0.01**	0.10**	2.91**
Error	22	0.23	0.43	0.01	0.14	0.18	3.32

Appendix-VI. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Particle size constitution:

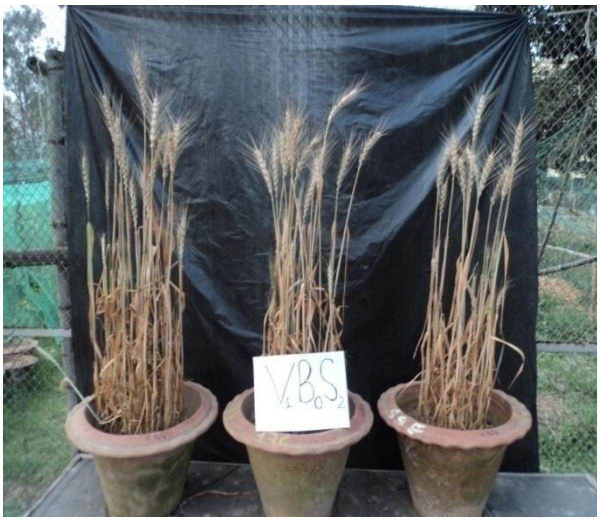
Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

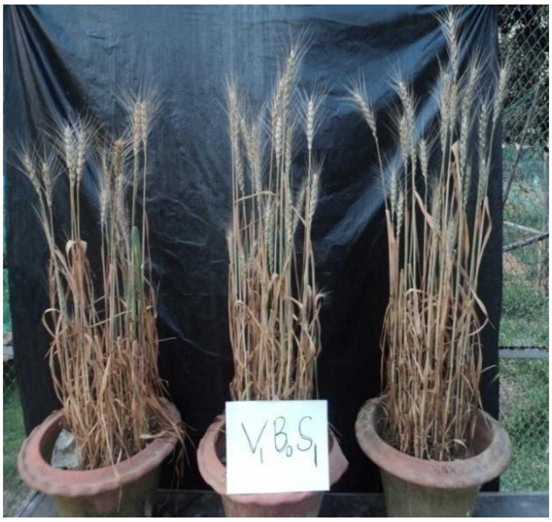
Chemical composition:

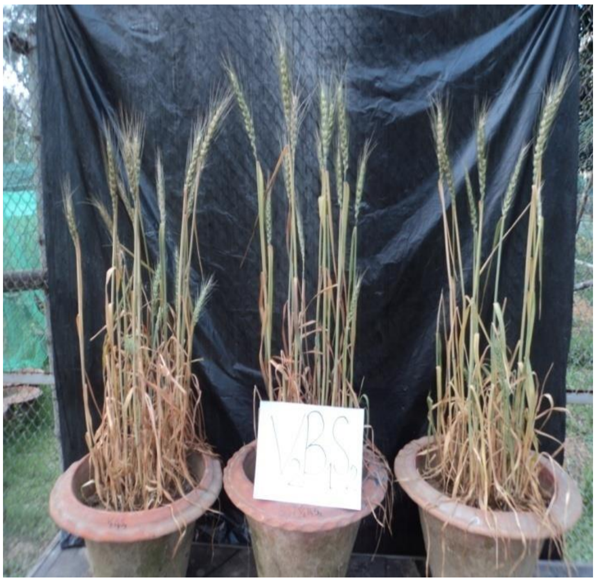
Constituents	:	0-15 cm depth
P^H	:	5.45-5.61
Total N (%)	:	0.07
Available P (µ g/g)	:	18.49
Exchangeable K (µ g/g)	:	0.07
Available S (µ g/g)	:	20.82
Available Fe (µ g/g)	:	229
Available Zn (µ g/g)	:	4.48
Available Mg (µ g/g)	:	0.825
Available Na (µ g/g)	:	0.32
Available B (µ g/g)	:	0.94
Organic matter (%)	:	0.83

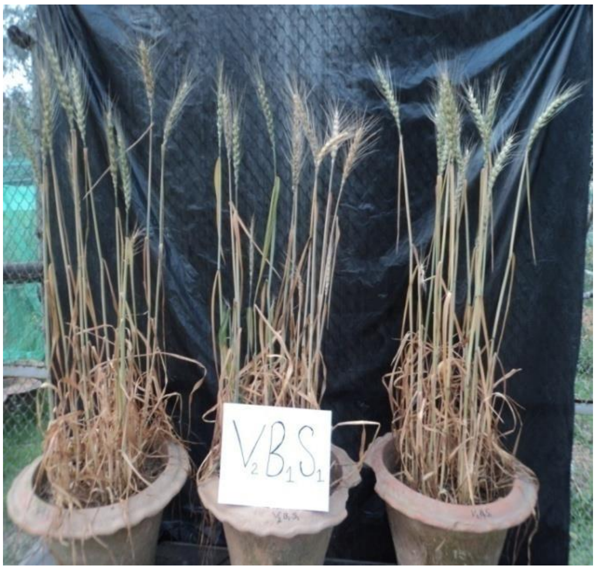
Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

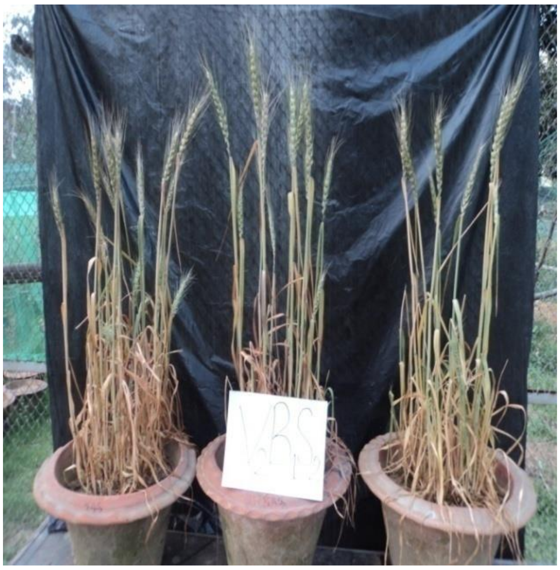
LIST OF PLATES

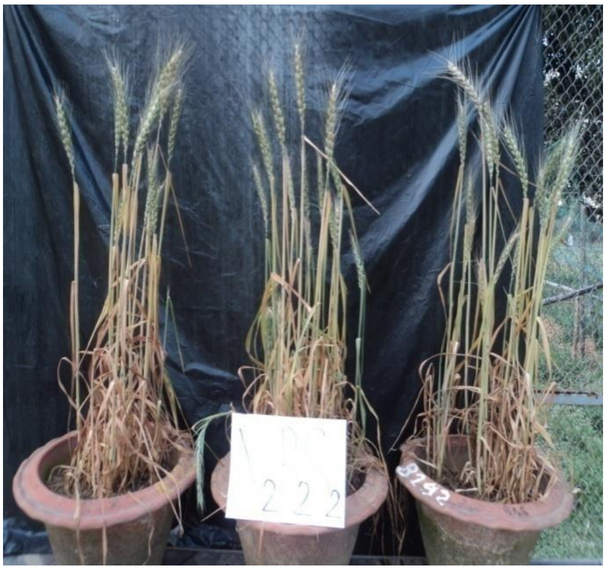


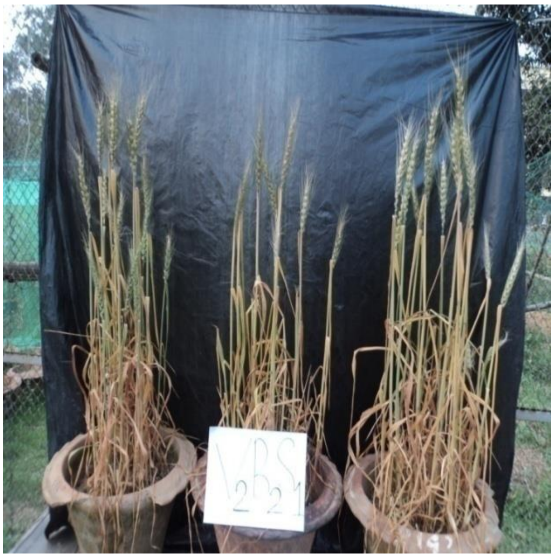





V2B1S1








V1B2S1