GROWTH AND YIELD OF SOYBEAN AS INFLUENCED BY ADDED UREA AND BORON FOLIAR FERTILIZATION

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CERTIFICATE

This is to certify that thesis entitled, "Growth and Yield of Soybean as Influenced by Added Urea and Boron Foliar Fertilization" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) in AGRONOMY, embodies the result of a piece of bona fide research work carried out by MEHERUNNESA TAMANNA, Registration No. 11-04364 *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

Dated: June, 2017
Place: Dhaka, Bangladesh

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Supervisor

DEDICATED

TO

MY

BELOVED

PARENTS

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GROWTH AND YIELD OF SOYBEAN AS INFLUENCED BY ADDED UREA AND BORON FOLIAR FERTILIZATION

ABSTRACT

An experiment was carried out at the Agronomy research field, Sher–e- Bangla Agricultural University, Dhaka, during the period from 21 December, 2016 to 6 April, 2017 to investigate the effect of urea and boron application as foliar spray on growth and yield of soybean. The experiment conducted with two soybean varieties *viz.* V_1 = BARI soybean 5 and V_2 = BARI soybean 6 and five fertilizer application *viz.* T_1 = Recommended fertilizer (RF), T_2 = RF + Foliar spray (FS) of water at flower initiation (FI), T_3 = RF + Urea (2%) FS at FI, T_4 = RF + Boron (1%) FS at FI, T_5 = RF + Urea (2%) + Boron (1%) FS at FI. The experiment was laid out in split-plot design with three replications. Variety and fertilizer application were assigned in main and sub plots, respectively. Results showed that BARI Soybean-6 gave maximum dry weight plant^{-1} (11.55 g), pods plant^{-1} (57.47), pod length (3.74 cm), seeds pod^{-1} (2.87), 100- seed weight (13.41 g) and seed yield (2.13 t ha^{-1}). The highest dry weight plant^{-1} (12.18 g), pods plant^{-1} (59.67), pod length (3.80 cm), seeds pod^{-1} (2.89), 100 seed weight (13.45 g) and seed yield (2.17 t ha^{-1}) were obtained from treatment T_5 i. e, (RF+ Urea (2%) + Boron (1%) FS at FI. The highest dry weight plant^{-1} (12.86 g), pods plant^{-1} (63.67), pod length (3.91 cm), seeds pod^{-1} (3.05), and100- seed weight (14.03 g) was recorded from the treatment combination of V_2T_5. The highest yield was also produced by the treatment combination V_2T_5 (2.33 t ha^{-1}) as it was statistically identical with V_2T_2 (2.05 t ha^{-1}), V_2T_3 (2.23 t ha^{-1}) and V_2T_4 (2.12 t ha^{-1}) treatment combinations. Inclusion of urea (2%) + boron (1%) or urea (2%) or boron (1%) singly along with recommended fertilizer was efficient in improving yield by 27-44% over RF irrespective of varieties. The results revealed that BARI soybean 6 along with foliar treatment either T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) or T_3 (RF + Urea (2%) FS at FI) or T_4 (RF + Boron (1%) FS at FI) may be noted as better management for increased yield of Soybean.

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ABBREVIATIONS AND ACRONYMS

%	=	Percentage
AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
Ca	=	Calcium
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
e.g.	=	exempli gratia (L), for example
et al.,	=	And others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
GM	=	Geometric mean
i.e.	=	id est (L), that is
K	=	Potassium
kg	=	Kilogram (s)
L	=	Litre
LSD	=	Least Significant Difference
M.S.	=	Master of Science
m^2	=	Meter squares
mg	=	Miligram
ml	=	Mili Litre
NaOH	=	Sodium hydroxide
No.	=	Number
^{o}C	=	Degree Celceous
P	=	Phosphorus
SAU	=	Sher-e-Bangla Agricultural University
USA	=	United States of America
var.	=	Variety
WHO	=	World Health Organization
μg	=	Microgram

CHAPTER I

INTRODUCTION

Soybean (*Glycine max* L. Merrill) is one of the most important oilseed pulse crop in the world for humanbeing. Soybean holds a unique position in science and agriculture nowa-days for being a crop with enormous uses. It hasbecome the miracle crop of 20th century on account of having high protein and oil content and known as "Golden Bean". Soybean is now figure out as "Protein hope of future" for its nutritional value in Bangladesh. Soybean belongs to the family Fabaceae and sub-family Papilionaceae. It is the most important grain legume of the world and a new prospectivecrop for Bangladesh.Theplantis classed as an oilseed rather thana pulse. Soybean seed contains 40-45%protein, 20-22% oil,20-26%carbohydrate and a high amount of Ca, P and vitamins (Rahman*et al.*,2011).According toFAO(2007) the soybean oil is cholesterol free and spontaneous in diet. It contains 3% lesithine that helps in brain development. It accounts for approximately 50%of the total production of oil crops in the world. It has now become the leading source of edible oils and fats, composing of about 20% of the world supply and more than anyother single source of this essential food constituent (Singh *et al.*,1989).

Global production of soybeans is forecast to be 324 million tons in 2016,a 5% increase from the 2014 world total. The main producers of soybeans are the United States (35%), Brazil (27%), Argentina (19%), China (6%) and India (4%). Soybean is cultivated in the area of 0.15 million hectares in Bangladesh (DAE, 2015). In Bangladesh soybean is cultivated mainly as pulse crops occupying 60,893 ha with the production 112,024 tons (average yield 1.83 t/ha)(FAOSTAT, 2014).

Foliar fertilization is gaining more importance in recent years due to availability of soluble fertilizers and is of great significance in rainfed areas and under changing climatic condition. Many research reports indicated positive effect in enhancing crop yield and quality of oilseed/pulse crops. Foliar application of nutrients constitutes one of the important milestones in the progress of agricultural production. Fertilizer applied to thecrop at the time of sowing is not fully available to the plants as the crop approaches maturity so supplemental foliar application is one of the techniques to increase yield of the crop.

Foliar application of nutrients for increasing and exploiting genetic potential of the crop isconsidered as an efficient and economic method of supplementing the nutrient requirement.Application of inorganic nutrient spray will also enhance the nutrient availability, quick absorption and in turn increases the productivity. Nutrients applied through foliage play a pivotal role in increasing the seed yield in pulses and oilseeds (Chandrasekhar and Bangaruswamy, 2003).

Foliar application of major and micronutrients like NPKS and B is credited to be more advantageous than soil application and also avoiding the depletion of these nutrients in leaves, thereby resulting in an increased photosynthetic rate, better nutrient translocation to the developing seeds (Manonmani and Srimathi, 2009).

Most of the soil in Bangladesh is deficient in nitrogen. Nitrogen is responsible to increase the dry matter and protein percentage of grain as well as methionine and triptophen content in seed (Vidhate*et al.*,1986). Utilization of the majority of this N occurs during seed development. Nitrogen sources for the soybean include mineralization, soil organic matter,symbiotically fixed N, and N incorporated into plant tissue. Under certain soil, climatic,and yield conditions, N supply may limit soybean seed production. However, N applications made before reproductive growth stages are reported to decrease *Bradyrhizobia*activity, exhibited by reduced growth of nodules and lower N fixation,thus further increasing the difference between N supply and demand (Yoneyama*et al.*, 1985). The flower and pod abortion in pulse crop is higher as reported by Patel *et al.*(1984) while they studied the physiology of mungbean. They opined that pulse crops stop symbiosis during its onset of flowering and support the reproductive units but due to lack of nitrogen nutrient at this stage aggravated the situation. Foliar spray of urea at flowering stage could be an alternate option to support flowering and pod setting in Soybean.

Among the micronutrients, boron has a direct impact on productivity of oilseed crops. Boron significantly improves the vegetative growth and quantitative parameters of oilseed crops. Boron plays an important role in new cell development in meristemetic tissues, proper pollination and fruit or seed set. It is also involved in translocation of sugars, synthesis of amino acids, protein and carbohydrate metabolism. Boron is one of the most commonly deficient micronutrients in agriculture, with reports of deficiencies in 132 crops and in 80 countries (Shorrocks, 1997). These deficiencies typically result from boron leaching occurring in humid areas with coarse textured soils (Mortvedt and Woodruff, 1993). In plant physiological response of B deficiency include the loss of membrane integrity and cell wall stability, which result in the development of structural damage in generative and vegetative organs of crop such as blossom wilting and necrosis. Srivastava *et al.* (1997) found that boron deficiency is responsible to flower drop and poor podding.Boron plays a vital role in symbiosis process to fix nitrogen.

Among these factors, application of urea and boron as foliar spray on soybean can be easy adoptable and economic practice.Foliar spray of urea and boron plays a positive role for better growth and development of soybean without losing nutrient as experienced during soil application (Martens and Westermann, 1991).

The above observation created the scope of the present study with following objectives:

i. To compare the performance of varieties of Soybean.

ii. To study the effect of added foliar spray of urea and boron in soybean cultivation.

iii. To study the combined effect of variety and fertilizer application on growth and yield of soybean.

CHAPTER II

REVIEW OF LITERATURE

Soybean [Glycine max (L.)] is one of the most important and widely used pulse crops worldwide. The production level of soybean is very low compared to the other country which never meets the demand of Bangladesh. The reasons behind such low yield are poor fertilizer management, lack of high yielding varieties, poor crop management, soil type and improved technologies. Many researchers had done the research to find out the effect of foliar spray on soybean and on other crops. Foliar application of nutrients influences growth and yield of field crops. Foliar method of nutrient application can improve nutrient utilization and reduced environmental pollution by reducing the need of chemical fertilizers application in soils. (Abou El-Nour, 2002). Foliar application of nutrients constitutes one of the important milestones in the progress of agriculture production. Foliar applications are done for quick and efficient utilization of nutrients, elimination of losses through leaching and fixation and helps in regulating the uptake of nutrients by plants. In this review, an attempt has been made to present the effect of foliar application of urea (nitrogen) and boron on morpho-physiological characters and yield attributes in soybean and other field crops.

2.1 Effect of foliar spray nitrogen on plant growth, yield attributing characters and yield on soybean and other pulse crops.

Mallarino*et al.* (2005) reported that the foliar fertilization at early vegetative stages of soybean increased grain yield in 15 to 30% of the fields depending on the year.

Ashour and Thalooth (1983) studied the effect of soil fertilized with 35, 70 or 105 kg N ha^{-1} or foliar-sprayed with 0.5 or 1.0% urea at the R6 stage of plants development of soybean cv. Clark. Their results showed that foliar application of 1.0% urea increased fruit-set, weight of pods, and the yield of oil and protein in seed.

Garcia and Hanway (1976) evaluated various nutrient combinations for foliar application at the R2 to R7 growth stages and found that a 10-1-3-0.5 N-P-K-S ratio increased yieldsby 441 to 504 kg ha^{-1}. They concluded that the optimum time of foliar application was between growth stages R5 and R6.

Haq and Mallarino (2000) showed that N–P–K foliar fertilization of relatively small amounts sprayed at the V5 stage affected yields significantly at 6 or 27 sites. On the contrary,Schmitt *et al.* (2001) and Binford *et al.* (2004) reported that foliar applications of N-P-K showed decreases or no significant soybean grain yield differences. Kaiser *et al.* (2007) found that foliar fertilization with two fluid 3-8-15 and 28-0-0 (N-P-K) fertilizers at V5 or R2 growth stages, did not affect the grain yield of soybean cultivars.

El-Abady*et al.* (2008) conducted an experiment with foliar fertilizer treatment to observe the effect of foliar applications on soybean and reported that foliar applications treatment significantly increase plant height, number of nodes per plant, number of pods per plant, number of grain per plant, grain yield per plant and 1000-grain weight. Similar result was also reported by Yildirim *et al.* (2008), Odeleye*et al.* (2007), Schon and Blevins (1990), Reinbott and Blevins (1995) and Popovic *et al.* (2013) on thecontrary, Abdel-gawad*et al.* (1989) reported that foliar fertilization did not have any statistical effect on 1000-grain weight.

Woon and Porter (1986) reported that foliar fertilizers (FF) applied at the reproductive growthstage increased soybean yield but FF formulations 16N + 4P + 4K + 1 S giveshigher yield than formulation 12 N + 4 P + 4 K + 0.5 S.

Peele (1997) reported that the foliar dressing of macronutrients increased soybean grain yield by 30 to 400 kg ha^{-1}.

Sultan *et al.*(2003) reported that spraying with foliar fertilizers at 45 days after sowing increased grain yield of soybean. Haq and Mallarino (2005) found that foliar N fertilization increased protein and oil production because of soybean yield increases.

Popovic *et al.* (2013) reported that NS soybean varieties Galina (maturity group 0), Victoria and Tea (maturity group I) had higher yield and 1000- grain weight in the variant with foliar fertilization with fitofert (composition: 12% N, 4% P_2O_5, 6% K_2o, 0.013% Mn, 0.010% Fe, 0.008% B, 0.006% Cu, and 0.005% Zn) than in the control.

Chowdhury *et al.* (1985) obtained that the high level of foliar fertilization did not significantly effect on the grain yield in soybean cultivars Williams and Micthel.

Amany (2007) studied the effect of foliar application of urea on growth and yield components of chickpea with four foliar application treatments *viz.*,1 per cent urea sprayed at flowering, at pod set, pod filling and (control) unsprayed. Application of urea at 1 per cent during pod filling resulted in higher plant height, number of branches, total dry weight, pods and seeds/plant, 100-seed weight and harvest index.

Mondal *et al.*(2011) studied that, foliar application of N alone or combination of N and micronutrients recorded a higher leaf area (497 cm^2), specific leaf weight (10.72 mg cm^{-2}), chlorophyll content and total dry matter $plant^{-1}$ (10.2 g) over no foliar application of nutrients in different genotypes of mungbean.

Venkatesh and Basu (2011) studied that of foliar application of urea at 2 per cent concentration during 60, 75 and 90 DAS in chickpea recorded higher number of branches $plant^{-1}$ (5.9) which was at par with one or two sprays of urea over control and water spray.

Gupta *et al.*(2011) stated that foliar application of 2 per cent urea at flowering and 10 days after flowering along with biofertilizers (*Rhizobium*+ PSB+PGPR) resulted in higher dry weight due to enhanced biological nitrogen fixation and continuous supply of N through basal dose during initial stage and through foliar spray at later stages of crop growth in chickpea.

Nabih*et al.* (1982) observed that application of nitrogen at pod filling stage either to the soil or to the foliage increased the fruit set and weight of pods in soybean. Foliar spray of urea @ 1% was most effective in increasing the oil yield and protein content of seed.

Mohammad and Khan (1997) observed foliar spray of 30 kg N ha^{-1} on mustard grown with 60 kg N and 30 kg P ha^{-1} proved optimum for almost all growth and yield attributing parameters. This resulted in an increase in seed and oil yield of 11.18% and 12.13%, respectively over the control.

Manonmani and Srimathi (2009) concluded that, spraying with 2% DAP followed by urea one per cent recorded higher 100 seed weight (5.6 and 5.5 g), seed yield (1240 and 1040 kg ha^{-1}). Further, the seed germination per cent 92 and 88%, respectively in blackgram.

Gupta *et al.* (2010) reported that foliar application of DAP and urea at the rate of 2% in green gram has significantly increased plant height (64.5cm) steadily up to 60 DAS and leaf area index (5.0) than basal application of fertilizers and sprayed with distilled water.

Mandic*et al.* (2008) conducted a study to estimate the effects of foliar fertilization on yield attributes and grain yield on two soybean cultivars (Balkan and Becejka). Four treatments of fertilization vig:: control (no fertilization), Urea (46 kg N ha^{-1}), Urea (46 kg N ha^{-1})+ Wuxal super (5 l ha^{-1}) and Urea (46 kg N ha^{-1}) + Ferticare I (5 kg ha^{-1}) were tested. Wuxal super and Ferticare I was foliar applied two times at the R2-R3 growth stage. They reported that foliar fertilizers significantly increased the values for all quantitative traits.Balkan had higher values than Becejka. Ferticare I is more effective than Wuxal super in soybean because this fertilizer hashigher concentration of macronutrients.

Kamel*et al.* (2008) studied the effect of foliar application of N on growth and yield in soybean and reported that plant height, plant dry weight, leaf area, pod and seed number $plant^{1}$, seed weight $plant^{-1}$ and seed yield increased significantly with N foliar application of soybeans.

Sutoshi*et al.* (2006) reported that application of foliar urea increased 30% seed yield in soybean. Similar result was also reported by Gascho (2009) in soybean. Rehm (2003) and Sawyer (2008) showed no yield benefit when soybeans were sprayed with repeated of N-P-K-S at pod filling stage.

Oko*et al.* (2003) conducted an experiment to investigate the abscission levels of three soybean cultivars (TGX 536-02D. TGM 579 and Samsoy 11) as affected by foliar application of urea during the early reproductive stages they reported that flowering was not significantly increased by urea application, although all fertilized plants had fewer flower abortions than control. Percentage pod abortion was generally reduced (8%) when

N was applied at R1-R2-R3 stages while the proportion of aborted grains was highest in the unfertilized plants. The grain yield of foliar fertilized soybean was between 6 and 68% higher than control. These increases were attributed to higher number of pods and meaningful reductions in flower and pod abortions.

Saravana (2012), conducted a field experiment during the kharif season in Main Agriculture Research Station, University of Agricultural Sciences, Dharwad, India with treatments containing control (no foliar spray), RPP + soil application of ZnSO4, sulphur spray @ 2%, boron spray @ 0.15%, starter NPK and booster NPK spray @ 2% with different combinations of sulphur and boron at full bloom and beginning of pod stages of crop. Foliar application of soluble starter NPK @ 2 per cent + sulphur spray @ 2 per cent at 45 DAS and soluble booster NPK @ 2 per cent + boron spray @ 0.15 per cent at 65 DAS (T8) recorded the highest seed yield (33.84 q ha^{-1}).

Kulsum (2009) conducted an experiment at Bangladesh Institute of Nuclear Agriculture, Mymensingh to investigate the effect of foliar application of urea on morpho-physiological characters, yield attributes and yield of soybean *cv.* BARl soybean 5. The experiment comprised of four levels of urea foliar application like i) T_1 = Control; ii) T_2 = Application of 1.5% urea once at 40 days after sowing at the beginning of flowering; iii) T_3 = Application of 1.5% urea twice from the beginning of flowering with an interval of 10 days; and iv) T4 = Application of 1.5% urea trice from the beginning of flowering to pod development stage with an interval of 10 days. Foliar application of urea had significant effect on morphological attributes (plant height, branch number, leaf area $plant^{-1}$), physiological characters (leaf area index, total dry mass $plant^{-1}$, absolute growth rate, chlorophyll and harvest index), yield attributes (number of pods $plant^{-1}$, number of seeds $plant^{-1}$ and 100-seed weight) and yield. Results showed that morphological, physiological, yield attributes and yield were increased in foliar urea applied plants over control but the increment was greater in T_4 than the others.

Sesay and Shibles (1990) studied the effect of N. P, K. foliar application on soybean during seed filling stage and observed that foliar nutrients application gave significant yield increase over control. They also observed that foliar application of nutrients caused delay in leaf senescence.

Peterson *et al.* (1990) and Atkins and Pigeaire (1993) reported that foliar application of cytokinin and nitrogen induced a longer period of flowering which resulted more flowers and pod developed and caused a increased seed yield in soybean and lupin. On the other hand, foliar spray of both macro (N, P, K and S) and micro (B, Mn and Mg) nutrients during flowering and podding of lupin did not increase grain yield (Seymour and Brennan, 1995).

Egli*et al*. (1988) concluded through a study that nutrients are translocated to the seed from vegetative parts of soybean which were not sufficient for proper seed growth and development and in that connection, the authors suggested foliar application of nutrient for increased grain yield in soybean. Similar opinion was given by Colvin *et al.* (1995).

De Mooy*et al.* (1983) and Welch *et al*. (1983) reported that foliar N fertilization had no effect on seed yield in soybean.on the contraryBrevedan*et al.* (1988) reported that an adequate supply of N to the plant during the period of flowering and pod set increased yield in soybean.

Schonbeck*et al.*(1986) studied the effect of pod number on dry matter and nitrogen accumulation and distribution in soybean and indicated that high levels of N during flowering were necessary for maximum yields. Similar result was reported by Schou*et al.* (1988), Alam*et al.* (1988) and Kumudini*et al*. (2002) in soybean.

Streeter (1988) estimated that during seed growth, daily N required was 5 kg N ha^{-1} must be translocated from vegetative organs, resulting in a depletion of the supply and in that situation foliar application of N might helpful for increased seed yield in soybean.

Takahashi *et al.* (2005) observed that during seed growth and development of soybean, the leaf N levels drastically reduced which resulted leaf senescence and foliar application of N may slow depletion of leaf N and enhanced pod set percentage thereby yield. Similar result was also reported by Maekawa and Kokubun (2005) in soybean.

Mitra*et al.* (1989) study the effect of foliar application of 1.5% urea solution one week before flowering and during the period of pod development in mungbean and observed that retarded the loss of chlorophyll and leaf nitrogen which enhance total dry matter production, pod production, 100-seed weight and seed yield. Similar result was reported by Pawar and Bhatia (1980) and Thakare*et al.* (1981) in mungbean and Nishioka and Okumura (2008) in soybean.

Boote*et al.* (1988) reported the importance of foliar application of N, P. K to photosynthesis and suggested that foliar fertilization must enhance the C balance of the plant to result in increased yield in soybean.

Extensive research conducted from 1980 to 1990s on foliar fertilization of soybean during reproductive stages showed inconsistent results of increased grain yield (Mallarino*el al*., 2001). Several researchers showed that foliar fertilization of soybean either did not influence or decrease yield (Parker and Boswell, 1990; Poole *et al*., 1993; Seasy and Shibles, 1990). But Wesley *et al*. (1998) reported that foliar fertilization had significant positive influence (yield increased > 12%) under irrigated condition of soybean.

Haq and Mallarino (1998, 2000) reported that early foliar application of N, P, and K increased plant growth and development which resulted increased TDM and yield but foliar application of N, P, and K at reproductive stage slightly increased seed yield due to increase pod number.

Barik and Rout (2000) showed in their experiment that foliar spray of macronutrients enhanced the yield, yield contributing characters, nitrogen content of plants and protein contcnt of grains of blackgram. Similar result was also reported by Kulkarim*et al*. (1999) in groundnut.

Gangwar and Singh (2001) observed the growth and development behavior of lentil in relation to foliar spray of urea in the field experiment increased plant height and dry matter production by such in treatment.

Gupta and Potalia (1997) stated that foliar application of N, Zn and Mo increased TDM as well as yield in groundnut.

Badaway and Tagoury (1987) studied the effect of different concentration of N, Co, Fe and Zn in broad bean and pea in a sandy loam soil and observed that the said microelements increased DM and fresh weight of nodules in pea but showed no response in broad bean.

Buneo (1995) found that when Fe, Zn and Mn were applied with urea as foliar spray at 30 days after sowing on soybean increased DM as compared to control. Hallock (1988) applied Mn both in broadcast and foliar spray and reported that foliar spray was better than broadcast in peanut.

Patil*et al*. (1993) worked on the effect of nitrogen and boron application on groundnut yield and observed that both soil and foliar application of N and B increased the pod yield significantly.

Hanbin*et al*. (2007) carried out experiment to study the effect of different levels and application method on morphological and physiological characters in soybean and reported that soil application of N along with foliar spray at reproductive stage was more effective than only soil application of N. Similarly, Alam*et al.* (1988) reported that soil application of urea normally increased plant height, leaves, branches, nodules, seeds, protein content and seed yield in soybean compared to that of control.

Manivannan*et al.* (2002) revealed that combined application of *Rhizobium* seed treatment + foliar application of N, P, K + chelated micronutrients (microsol) at 15, 30 and 45 DAS recorded markedly higher leaf area index ,dry matter production and crop growth rate in urd bean when compared to control (no application) .

2.2 Effect of foliar spray boron on plant growth, yield attributing characters and yield on soybean and other pulse crops

Ahmad *et al.* (2009) reported Boron (B) is considered as an essential element for plant growth and development. Sexual reproduction in plant is more sensitive to low B, than vegetative growth. Considerable research activities have been directed at accentuating the physiological and biochemical role of B in plant growth and development. This paper reviews of the literature (up to the year 2006) focusing on the role of boron in cell wall integrity, cell division, plasma membranes, phenol metabolism, and its requirement for the nitrogen fixation and in the reproductive growth of plants.

Bruns (2017) recently reported that with irrigation, a soybean yield of 3322 kg seed ha^{-1} in the lower Mississippi River Valley would remove about 153.9 g B ha^{-1} and that about 465.0 μg B $plant^{-1}$ would be returned to the soil in the crop residue.

Hemantaranjan*et al.* (2000) studied that effect of treatments included foliar application of boron (B) as boric acid at the rate of 50 and 100 ppm applied at 30 and 60 days after emergence and found that plant height, root length, chlorophyll B content, total dry matter production and seed yield of soybean were higher at 50 than 100 ppm B.

Rajni and Meitei (2004) determine the effect of foliar spraying of boron (0.5 and 1.0 ppm) and zinc (0.01 and 0.10 ppm) and their combinations with a control. They found that combined application of boron (1.0 ppm) and zinc (0.10 ppm) after 20 and 40 days of sowing of the seeds was found to be beneficial for growth in terms of plant height, leaf number, branch number and shoot weight, earliness, yield in terms of number, length, fresh weight, dry weight and percent dry matter of pod and number of seeds per pod on soybean.

Bellaloui*et al.* (2013) demonstrated foliar B-fertilization of soybean increased B accumulation in leaves and seed and altered seed protein and fatty acid content.

Sutradhar*et al.* (2016) reported only small yield responses in soybean to B fertilization. Which is agreed from earlier observations by both Touchton and Boswell (1995) and Woodruff (1979)?

Crak*et al.* (2006) examine the effect of soil and foliar application of boron (66.14% B_2O_3) at different rates (0, 0.5, 1, 1.5 and 2 kg ha-1) on plant height, first pod height, pod plant-1, boron content of seed, germination rate, 1000-seed weight of soybean during 2002-03. They reported that increasing boron rates applied either as soil or foliar improved yield (40%), first pod height (17%), boron content of seed (42%), germination rate (11%) and 1000- seed weight (5%) of soybean. For maximum yield, 1.09 kg ha^{-1} rate of boron was recommended.

Devi *et al.* (2012) evaluate the effects of foliar application of borax @ 0.1% solution on cabbage [*Bassicaoleracea*(L.) var. *capitata*]. The growth in terms of plant height, leaf numbers, leaf length and fresh biomass production was affected by the boron levels. The foliar spray was done twice at 25 and 50 days after transplanting showed significant increase in plant height, number of leaves, shoot fresh weight, dry weight, root fresh weight and dry weight and yield. The head diameter was increased with application of borax.

Basher *et al.* (2006) also concluded from his field experiment that the application of foliar B significantly increased the effective number of nodules per plant, fresh and dry weight of plant. The highest number of nodule was found at all growth stages by higher level of boron treatment.

Reinbott and Blevins (1995) observed four foliar applications of B + Mg increased soybean yield to 12 per cent at Mt. Vernon and 4 per cent at Columbia over a three-year period. Two foliar applications of B + Mg during the late reproductive stages increased soybean yield 18 per cent over a two-year period. The yield increase from foliar B + Mg treatment resulted from an increased number of pods on the main stem (18%) and branches (44%).

Kappes*et al.* (2008) also evaluate the effect of foliar application of boron on the agronomic characteristics, morphological characteristics and production components were determined.

Seidel and Basso (2012) evaluated the effects of boron (B) applied to leaf spraying at different stages of soybean, on yield components and productivity of soybean. Results showed that application of B did not influence soybean yield in any application stage and the yield components (pod number plant-^{1}, grain number pod-^{1}, grain weight did not differ significantly with application to leaf spraying of B, probably due to their adequate content in soil and water availability during the growing season.

Ahmad *et al.* (2009) investigated the effect of foliar application of boron on yield of rice. The treatments were comprised of boron i.e. no additive, 0.50%, 1.00%, 1.50% aqueous solutions for foliar application. Boric acid (11.17% B) was used as the source of boron. The results showed that application of 1% boron solution significantly affected 1000-grain weight, paddy yield, harvest index and all quality parameters.

Chattopadhay and Mukhopadhyay (2004) reported that the foliar application of boron in the form of borax 0.3% registered significant higher grain yield over control. Application of Zn, B and S in the combination recorded the highest grain yield over control. (Chitdeshwari and Poogathai, 2004).

Gulumser*et al.* (2005) works on the effects of the soil and (Solution; 66.14% B_2O_3) at various rates (0, 0.5, 1.0, 1.5 or 2.0 kg ha^{-1}) on the yield and yield components of *P. vulgaris.* The increase in the B rate enhanced the yield, quality and some of the morphological traits of *P. vulgaris*. The B rate had significant effects on the first pod height, B content of grains, germination rate, 1000-seed weight, and grain yield. The highest yield (247.88 kg ha^{-1}) was obtained with 1.11 kg B ha^{-1}.

Cirak*et al.* (2006) have reported the yield increase in response to applied boron either in soil or foliar application and there was a significant relationship between increasing boron rates and yield.

Rashidi and Gholami (2011) determine nitrogen (N) and boron (B) effects on yield of cotton. N was applied to the soil at rates of 0, 100, 200 and 300 kg ha^{-1} and B was applied as foliar at rates 0.5 and 1.0 kg ha-^{1}. Results showed that foliar application of B significantly increased boll number, boll weight, seed cotton yield and lint yield. In addition, leaf blade B concentration was affected by B application rate and increased significantly. Results also demonstrated that highest seed cotton yield was recorded in case of 1 kg ha^{-1} foliar application of B, and this foliar application rate resulted in 25% increased seed cotton yield.

Coelho *et al.* (2011) evaluate the agronomic effectiveness of different doses of foliar applications of B in soybean. It was observed that the treatment (17% B) had a higher efficiency in fresh weight, dry weight and height of soybean, as compared to the productive treatment (17% B) was what gave the best performance among the treatments.

El-Yazied and Mady (2012) study the effect of separate and combined foliar applications of boron (0, 25 and 50 ppm) and yeast extracts (0, 2.5 and 5 ml/L) on growth, yield and some biochemical constituents of broad bean. The results revealed that, foliar application with boron and yeast extract either individually or in a mixture, significantly stimulate many growth aspects as number of leaves per plant, dry weights of both stems and leaves per plant, total leaf area and absolute growth rate as compared with the control treatment. Foliar spraying with boron at 50 ppm and yeast extract at 5 ml L-1 can be used to increase the final green pods and seed yield as well as seed quality of broad bean.

Jamami*et al*. (2006), opined that the application of boron and zinc in corn did not result in increased productivity. The explanation is that the initial concentration of the B element and Zn were in the appropriate concentration for culture.

Ross *et al*. (2006) works on fertilization with Boron promoted increase in production in three of four experiments from 4 to 130% in soybean, when compared to treatments without Boron, although the concentration of Boron present in the soil was deficient.

Seidel *et. al*. (2011) conducted two experiments were carried out during two successive seasons 2009-2010 and 2010-2011. The treatments consisted of applying commercial fertilizer on the basis of Calcium and Boron (10% Ca2+ and 0.5% of B). Foliar fertilizer containing Ca_2+ and B was applied 30 days after germination, when the plants were at the R3 stage. The reported that the application of the foliar fertilizer with Calcium and Boron, applied 30 days after germination did not affect yield components and soybean yield during successive seasons 2009-2010 and 2010-2011.

Uikey (2012) examined the effect of different levels of Boron on soybean in a Vertisol in the field of the Research Farm of J.N.K.V.V., College of Agriculture, Jabalpur during Kharif season. He concluded with the findings that, All the growth parameters viz., plant height, plant dry weight, root dry weight, number of root nodules plant^{-1} of soybean were significantly influenced by various dose of boron at crop growth stages. Different levels of Boron supply strategies exhibited a variable response in influencing the yield attributes like number of pods, seed pod^{-1} and harvest index remain unchanged due to treatments.

Espinoza *e. al*.,(2002) established series of studies on three farmer fields to assess the yield response of soybean to various soil- and foliar-applied B rates. The results revealed that the yield response to foliar-applied B during the 2002 season was significant in one out of three studies, but there was a trend for yields to increase with increasing B rates at the other locations.

Arnold (2016) conducted an experiment with three commercial cultivars available for use in the ESPS (Early Soybean Production System) were selected and foliar fertilized with a B solution at concentrations of 280 g B ha^{-1}, 560 g B ha^{-1}, or a split application at both R3 and R5 of 280 g B ha^{-1}. Yields of cultivar AG4632 were unaffected by B fertilization. Boron fertilization of P47T36 at R5 generally improved yields (>4000.0 kg ha^{-1}) over the control (3668.6 kg ha^{-1}) and applications at R3 (<3900.0 kg ha^{-1}). The 560 g B ha^{-1} treatment at R3 for $P_{50}T_{64}$ produced less seed (3742.5 kg ha-1) than all other treatments.

Studies by Schon and Blevins (1987; 1990) at the University of Missouri, Columbia demonstrated that foliar applied B could stimulate soybean yield by increasing pods on lateral branches, seed number, and overall seed yield. Boron treatments caused a significant 84.8% increase in the number of lateral pods per plant and a 17.6% increase in total seed weight per plant. However, the B application caused leaf burn damage on young soybean seedlings, a reduction in plant stand, and a decrease in plant height. In other research conducted in 1987 and 1988, Schon and Blevins (1990) found a significantincrease in leaf N content as well as increase in leaf P, K, and S content with foliar B applications. In an attempt to more broadly assess the need for foliar B, Oplinger*et al*. (1993) evaluated the influence of supplemental soil and foliar-applied B across a broad range of Midwestern growing conditions and soils.

Mary Schon and Blevins (1990) reported that foliar application of B @ 1.12 kg ha^{-1} and 2.24 kg ha^{-1} increased the number of branches $plant^{-1}$ at the end of the season and significantly stimulated the formation of groundnut pods on branches. This rate also further tended to increase the number of seeds $plant^{-1}$ and seed yield $plant^{-1}$.

Asad*et al.* (2003) observed that under B deficient conditions, B foliar application increased the vegetative and reproductive dry mass of sunflower. Foliar application of 28-1200 mM B increased the total dry mass of the most B deficient plants by more than three- fold and that of plants grown initially with 1.72 µM B in solution by 37-49 per cent.

Foliar application of boron at 25 ppm along with soil application of 41 kg nitrogen per acre recorded higher plant height, leaf area, and dry matter production in faba bean. (Mahmoud *et al*., 2006)

Das and Ali (1993) observed that the foliar application of Zn, B, Mo to groundnut at 30 to 45 DAS, but application of Zn and B increased vegetative growth, Mo increased per cent nodule number, Zn increased flower number, pod number, pod weight and kernel weight. Also reported that application of Zn and or B increased the seed yields as compared with control in blackgram. Soil application of 20 kg ZnSO4 ha^{-1} and 2.5 kg borax ha^{-1} + foliar application of 0.5% ZnSO4 at 40 DAS + 0.25% borax at 50 DAS recorded the highest seed yield of 1210 kg ha^{-1}.

Nasef*et al.* (2006) observed that the highest oil and protein percentage of peanut seeds in both of seasons were attained when the highest level of B (300 ppm) was used followed by 200 ppm B and 100 ppm in decreasing order.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out during 21 December, 2016 to 6 April, 2017 to application of urea and boron as foliar spray on Soybean in presence of recommended dose. The materials and methods of this experiment are presented in this chapter under the following headings-

3.1 Experimental Site

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU). It is situated at 23°74$^{/}$ North latitude and 90°35$^{/}$ East longitude (Anon., 1989). The land was 8.6 m above the sea level. It belongs to Madhupur Tract (AEZ 28).

3.2 Climate

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979).

3.3 Soil

The field belongs to the general soil type which was characterized by shallow red brown terrace soil. The land of the selected experimental plot was medium high under the Tejgaon series. There was available sunshine during the experimental period. The land topography was medium high and soil texture was silty clay with pH 6.2. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-II.

3.4 Planting materials

The variety BARI soybean 5 and BARI soybean 6 were used as planting material. The seeds were collected from the Agronomy Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur

3.5 Description of the variety

BARI soybean 5

It is developed by Oilseed Research Centre (BARI). Year of release is 2002. Plant height is 40-60 cm, cream color seed, 2-3 seeds pod^{-1}, medium seed size, 90-100 days crop duration. Average yield is 1.6-2.0 t/ha. Mid December-mid January is the sowing time and March-April is the harvesting time.

BARI soybean 6

It is developed by Oilseed Research Centre (BARI). Year of release is 2009. Plant height is 50-55 cm, cream color seed, 2-3 seeds pod^{-1}, medium seed size,100-110 days crop duration. Average yield is 1.8-2.10 t/ha. Mid December-mid January is the sowing time and March-April is the harvesting time.

Major Diseases

Yellow mosaic

Management: Rouging out and buried the diseased plant from the field immediately after appearance of the disease.

Major Pest

Hairy caterpillar

Management: Leaves of infested plant should be destroyed. Nogos 100EC/ Marshal 20EC should be sprayed @ 2ml/L water.

3.6 Layout of the experiment

The experiment was laid out in a Split-plot design with three replications. An area of 24.9 m × 14 m was divided into blocks. The two varieties were assigned in the main plot and fertilizer management in sub-plot. The size of each unit plot was 8.4 m^2 (3.5 m × 2.4 m). The experiment was divided into three blocks and consisted of 10 plots in each block. Therefore, the total no. of plots was 30. The space between two blocks & two plots were

1.2 m & 0.5 m, respectively. Row to row and plant to plant distance were 30 and 10 cm respectively. The layout of experiment field is presented in Fig. 1.

3.7 Experimental treatments

The experiment consists of two factors:

Factor A: Soybean variety (2)

i. V_1= BARI soybean 5
ii. V_2= BARI soybean 6

Factor B: Fertilizer management (5)

T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

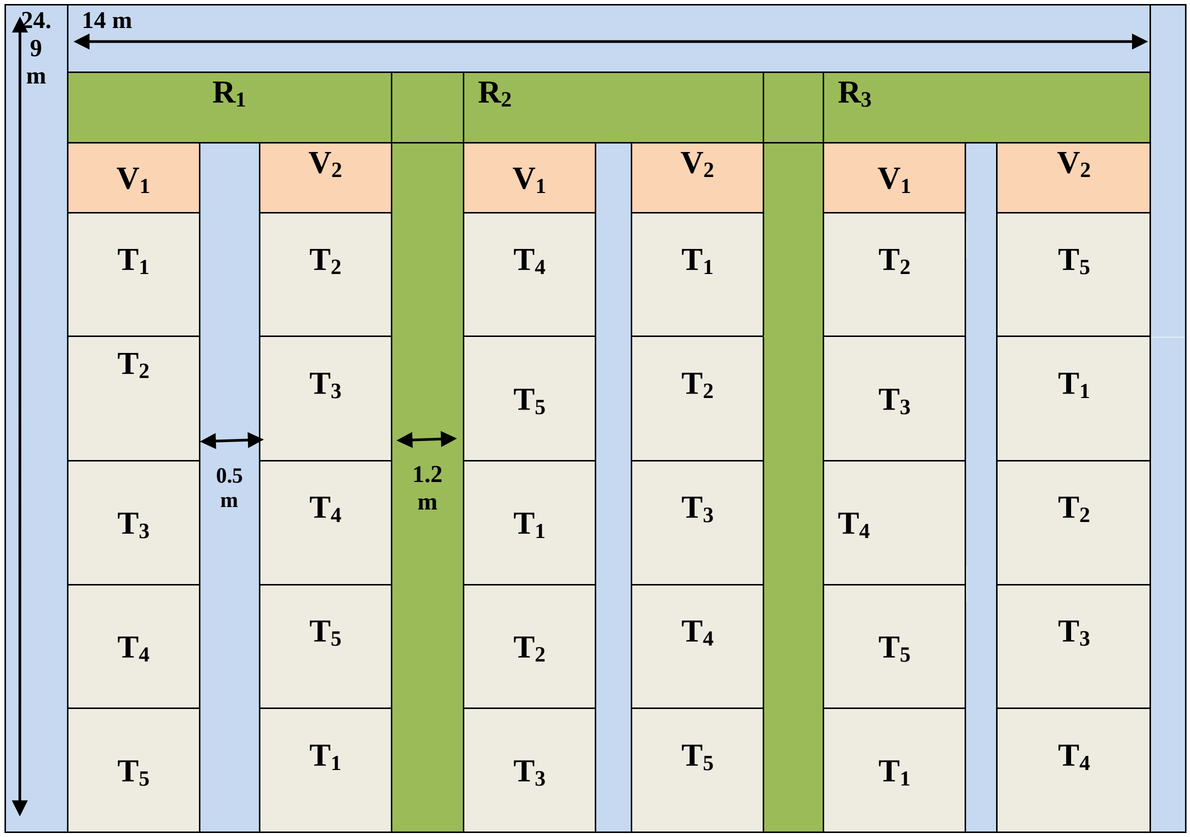
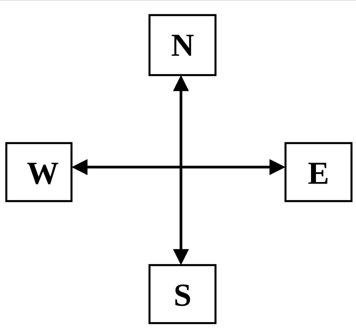


Figure 1. Layout of the Experimental field in split-plot Design

Legend



Treatments:

Factor A: Variety

V_1= BARI Soybean-5

V_2= BARI Soybean-6

Factor B:Fertilizer management

T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Experiment layout:

Plot size = 3.5 m × 2.4 m, Plot to plot distance = 0.5 m, Block to block distance = 1.2 m

Total land size = 24.9m × 14 m, Replication = 3.

Treatments Doses

Treatments	**Doses/plot**
T_1 =Recommended Fertilizer(RF)	Urea:TSP:MOP:Gypsum:Boric acid=16.8g:33.6g:16.8g :16.8g:1.68g
T_2 =RF+ Foliar Spray (FS) of water at flower initiation(FI)	Urea:TSP:MOP:Gypsum:Boric acid=16.8g:33.6g:16.8g :16.8g:1.68g
T_3 =RF+ Urea (2%) FS at FI	RF+20g/L
T_4 =RF+ Boron (1%) FS at FI	RF+10g/L
T_5 =RF+ Urea (2%) + Boron (1%) FS at FI	RF+20g/L+10g/L

3.8 Detail of experimental preparation

3.8.1 Land preparation

The plot selected for the experiment was opened with a power tiller and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross- ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed.

3.8.2 Fertilization

The crop was given fertilizer as N, P_2O, K_2O, Sand B at 20, 40, 20, 20 and 2 kg ha^{-1} respectively in the form of Urea, Triple Super Phosphate (TSP), Muriate of Potash (MOP), Gypsum and Boric acid. All fertilizer wasapplied and mixed up well at the time of final land preparation. In addition, Urea (2%) + Boron (1%) were applied as foliar spray during flower initiation.

3.8.3 Germination test

In germination test, BARI soybean 5 and BARI soybean 6 showed 90% and 100% germination in the petridish, respectively.

3.8.4 Seed sowing

Seeds of the variety BARI soybean 5 and BARI soybean 6 were sown on 21 December, 2016 in lines maintaining a line to line distance 30 cm and plant to plant distance 10 cm in the well-prepared plot.

3.9 Intercultural operations

3.9.1 Irrigation

A light irrigation was given on 21 December 2016 before sowing seed for uniform germination. First irrigation was given on 10 January 2017 which was 20 days after sowing. Second irrigation was given on 20 January, 2017 which was 30 days after sowing and third irrigation was given on 10 February, 2017 which was 50 days after sowing.

3.9.2 Thinning, and weeding

During plant growth period one thinning and one weeding was done, thinning was done on 8 January, 2017 which was 18 days after sowing and the weeding was done on 25 January, 2017 which was 35 after sowing.

3.9.3 Plant protection measures

The Soybean seeds ware treated by autostine @ 10 g per 1.5 kg seed.

3.10 Harvesting

The crops were harvested on 6 April 2017 (106 DAS) when the leaves turn yellow and fall off, the pods turn to brown color and dry. Samples were collected from different places of each plot around 2 m^2 areas in the center avoiding border plant. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated, cleaned and dried in the sun for 3 to 5 consecutive days for achieving safe moisture of seed.

3. 11 Collection of data

The data were recorded on the following parameters

A. Crop growth characters

- Plant height (cm)
- Branches plant^{-1}(no.)
- Above ground dry matter weight plant^{-1}(g)
- Nodules plant^{-1} (no.)
- Crop Growth Rate (CGR) plant^{-1}
- Relative Growth Rate (RGR) plant^{-1}

B. Yield contributing characters

- Pods plant^{-1} (no.)
- Pod length (cm)
- Seeds pod^{-1} (no.)
- 100- seed weight (g)

C. Yield characters

- Seed yield (t ha^{-1})
- Stover yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest index (%)

3.12 Procedure of recording data

3.12.1 Plant height

At different stages of crop growth (20, 40, 60, 80, 100 DAS and at harvest) the height of five randomly selected plants from the inner rows avoiding border plant per plot was measured from ground level to the tip of the plant and the mean value of plant height was recorded in cm.

3.12.2 Number of branches plant^{-1}

At different stages of crop growth (20, 40, 60, 80, 100 DAS and at harvest) the number of branches plant^{-1} was counted from five randomly sampled plants. It was done by counting total number of branches of the 5 sampled plants then the average data were recorded.

3.12.3 Dry matter weight pant^{-1}

Five plants were collected randomly from each plot at (20, 40, 60, 80, 100 DAS and at harvest). The sample plants were oven dried for 72 hours at 70°C and then dry weight plant^{-1} was determined.

3.12.4 Nodules plant^{-1}(no.)

Five plants from each plot was uprooted carefully with soil at (40, 60 and 80 DAS) then washed out with water. The number of nodules plant^{-1} was observed and counted from five plants and average number of nodules plant^{-1} was recorded as per treatment.

3.12.5 Crop Growth Rate (CGR) Plant^{-1}

The crop growth rate is the rate of dry matter production per unit area of land per unit of time. The crop growth rate values at different growth stages were calculated using the following formula:

$CGR = 1/GA * (W_2 - W_1) / (T_2 - T_1)$ $gm^{-2}d^{-1}$

Where,

W_1= Total dry matter production at previous sampling date

W_2= Total dry matter production at current sampling date

T_1= Date of previous sampling, T_2= Date of current sampling, GA= Ground area (m^2)

3.12.6 Relative Growth Rate (RGR) plant^{-1}

The relative growth rate (RGR) values at different growth stages were calculated using the following formula:

$RGR = (Loge\ W_2 - Log_e\ W_1) / (T_2 - T_1)$ $gg^{-1}d^{-1}$

Where,

W_1= Total dry matter production at previous sampling date

W_2= Total dry matter production at current sampling date

T_1= Date of previous sampling

T_2= Date of current sampling Log_e = Natural logarithm

3.12.7 Pods plant^{-1} (no.)

Number of pods plant^{-1} was counted from the 10-selected plant sample and then the average pod number was calculated.

3.12.8 Pod length (cm)

Length of pod was measured by meter scale from selected twenty pods and then average pod length was calculated.

3.12.9 Seeds pod^{-1} (no.)

The number of seeds pod^{-1} was counted randomly from selected pods at the time of harvest. Data were recorded as the average of 20 pods from each plot.

3.12.10 100-seed weight (g)

From the grain stock of each plot 100 grains were counted and the weight was measured by an electrical balance. It was recorded in gram.

3.12.11 Seed yield (t/ha)

Seed yield was recorded from 2 m^2 area and was expressed in terms of yield (t ha^{-1}).

3.12.12 Stover yield (t/ha)

After separation of seeds from plant, the straw and shell from harvested area was sun dried and the weight was recorded and then converted into t ha^{-1}.

3.12.13 Biological yield (t/ha)

The summation of seed yield and above ground stover yield was the biological yield.

Biological yield = Seed Yield + Stover yield.

3.12.14 Harvest Index (%)

Harvest index was calculated on dry basis with the help of following formula:

$$HI\ (\%) = \frac{Economic yield (seed weight)}{Biological yield (total dry weight)} \times 100$$

3.13. Statistical analysis

The obtained data for different characters were statistically analyzed with the statistical computer package program, statistix 10 to find out the effect of different added foliar spray on soybean and the mean values of all characters were evaluated and analysis of variances were performed by the F-test. The significance of the difference among treatment means were estimated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

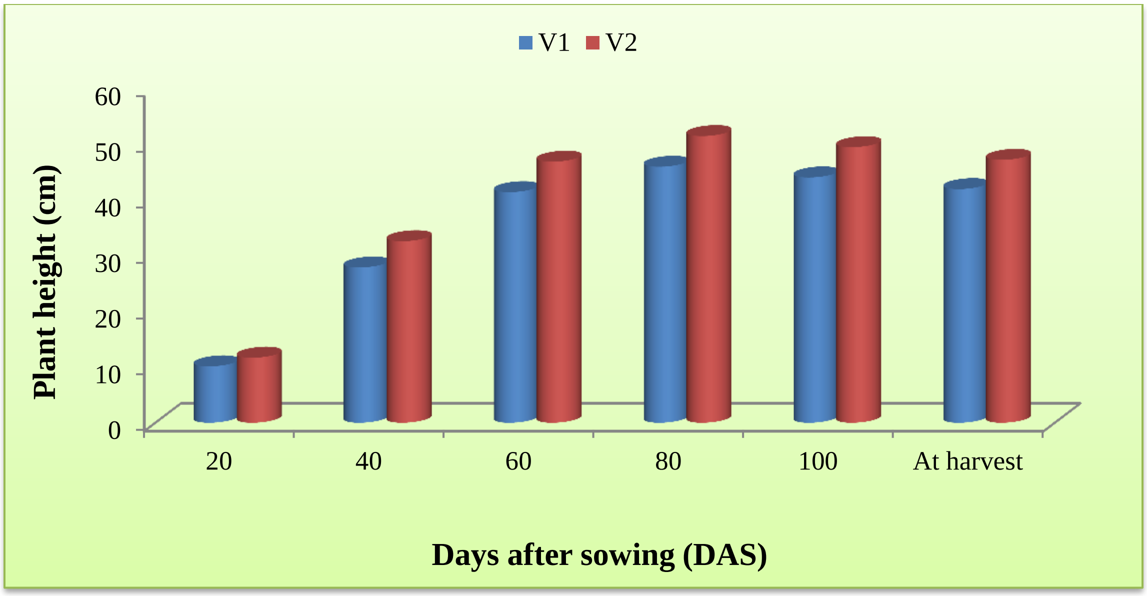
This chapter comprised presentation and discussion of the results obtained from the study on the Impact of added foliar spray of urea and boron on growth, development and yield of soybean varieties. Data on different growth, yield contributing characters and yield of soybean were recorded. The results have been presented and discussed in different tables and graphs and possible interpretations are given under the following headings:

4.1 Growth parameters

4.1.1 Plant height (cm)

4.1.1.1 Effect of variety

Plant height of soybean at different days after sowing (DAS) exhibited significant variation due to varieties. Plant height varied significantly among the soybean varieties at 20 and 60 DAS but at 40, 80, 100 DAS and harvest non-significant variation was observed. At 20, 40, 60, 80, 100 DAS and harvest the tallest plant (11.66, 32.55, 46.81, 51.40, 49.41 and 47.13 cm, respectively) was observed from variety V_2 (BARI soybean 6), which was significantly superior compared to variety V_1 (BARI soybean 5) only in case of 20 and 60 DAS but statistically similar to variety V_1 for 40, 80, 100 DAS harvest. The shortest plant (10.11, 27.83, 41.34, 45.89, 43.98 and 41.89 cm) was observed from variety V_1 (BARI soybean 5) at 20, 40, 60, 80, 100 DAS and harvest respectively.These results were supported by Mandic *et al.*(2008) who found that plant height show significant differences due to varietal differences.

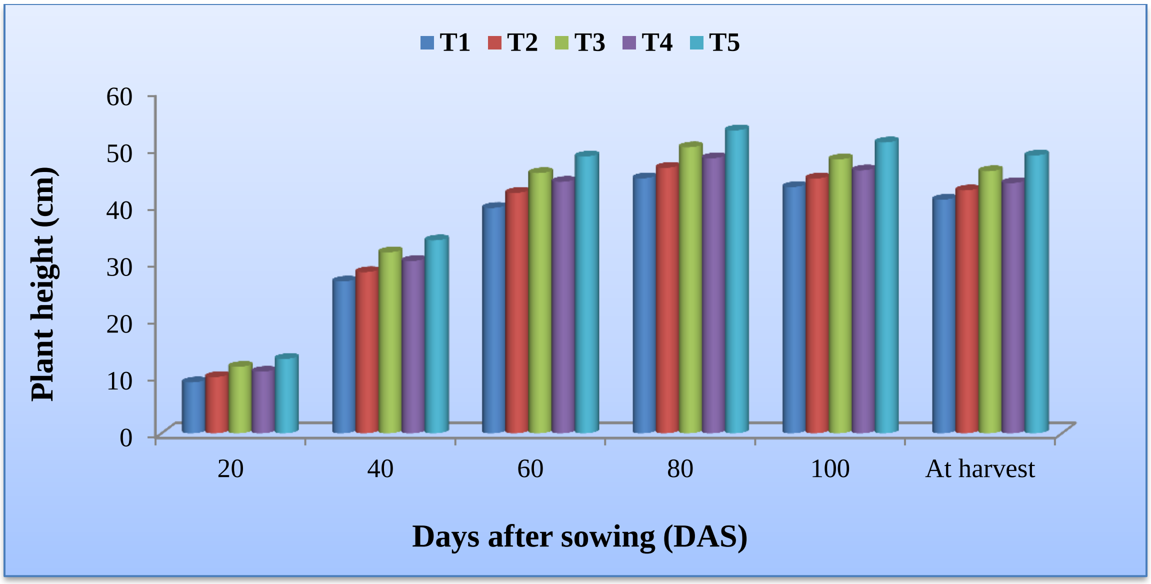


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 2. Effect of variety on the plant height of soybean at different days after sowing ($LSD_{(0.05)}$ = 0.99, 6.46, 3.35, 9.13, 9.10 and NS at 20, 40, 60, 80, 100 DAS and harvest, respectively)

4.1.1.2 Effect of foliar spray

The data pertaining to effect of added foliar spray of urea and boron on plant height at various DAS of soybean is depicted in figure. 3. Statistically significant variation was observed for plant height due to different added foliar spray used in the experiment. At 20 DAS the tallest plant height (13.07cm) was observed in treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI)which was significantly superior compared to all treatments used in the experiment, and the shortest plant height (8.95 cm) was observed in T_1 (Recommended Fertilizer) treatment which was statistically similar with treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation). At 40 DAS the tallest plant height (33.90 cm) was observed in treatment T_5 which was significantly superior compare to all treatments used in the experiment and statistically similar with treatment T_3 (RF+ Urea (2%) FS at FI) and the shortest plant height (26.67 cm) was observed in T_1 (Recommended Fertilizer) treatment which was statistically similar with treatment T_2. At 60 DAS, the tallest plant height (48.63 cm) was observed in treatment T_5 which was significantly highest compared to all other treatments and statistically similar with treatment T_3 (RF+ Urea (2%) FS at FI). The shortest plant height (39.60 cm) was observed in T_1 treatment which was statistically similar with treatment T_2. At 80 DAS, the tallest plant height (53.22 cm) was observed in treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI)which was significantly superior compared to all other treatments and it was statistically similar with treatments T_3 and T_4 and the shortest plant height (44.80 cm) was observed in T_1 treatment which was statistically similar with treatments T_2 and T_4. At 100 DAS, the tallest plant height (51.10 cm) was observed in treatment T_5 which was significantly superior compared to all other treatments used in the experiment and statistically similar with treatments T_3 and T_4. The shortest plant height (43.27 cm) was observed in T_1 Treatment which is statistically similar with all treatments except T_5 (RF+ Foliar Spray (FS) of water at flower initiation). At harvest stage, the tallest plant height (48.82 cm) was observed in treatment T_5 which was significantly superior compare to all treatments used in the experiment, and the shortest plant height (41.05 cm) was observed in T_1 treatment which was statistically similar with treatment T_2. These are an agreement with those of Amany (2007), Gangwar and Singh (2001) who observed that foliar spray of urea increased plant height.Mahmoud *et al*. (2006) found that foliar application of boron at 25 ppm per acre recorded higher plant height. Similar results were also found with Devi *et al.* (2012).



T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 3. Effect of added foliar application on the plant height of soybean at different days after sowing (LSD $_{(0.05)}$ = 1.24, 2.97, 4.08, 4.96, 5.23 and 2.60 at 20, 40, 60, 80, 100 DAS and at harvest, respectively)

4.1.1.3 Combined effect of variety and foliar spray

Combined effect of variety and foliar spray also exposed significant variation in terms of plant height at 20, 40, 60, 80, 100 DAS and at the harvest period (Table1). At 20 DAS the tallest plant height (13.97cm) was observed at V_2T_5 combination which was significantly superior compare to all combinations in the experiment and shortest plant height (8.13 cm) was at V_1T_1 which was statistically similar with V_1T_2 and $V_2T_{1.}$ At 40 DAS the longest plant height (36.50 cm) was recorded from V_2T_5 combination followed by V_2T_3 and V_2T_4 combinations where the shortest plant height (24.17 cm) was observed from V_1T_1 which was statistically similar with V_1T_2 and V_1T_4 combinations. In case of 60 DAS, maximum plant height (51.10 cm) was obtained from V_2T_5 combination followed by V_2T_3, V2T4 and V_1T_5 combinations and at the same DAS the shortest plant height (37.07 cm) was observed from V_1T_1 followed by V_1T_2, $V_1T_4$and V2T1 combinations. At 80 DAS, the longest plant height (56.23 cm) was recorded from V_2T_5 combination followed by V_2T_3, V_2T_4, V_1T_5 and V_2T_2 combinations where the shortest plant height (42.35 cm) was observed from V_1T_1 followed by V_1T_2, V1T3, V_1T_4, V2T1 and V_2T_2combinations. In case of 100 DAS, highest plant height (54.16 cm) was recorded from V_2T_5 combination which was statistically similar with V_2T_3,V_2T_4, V_1T_5 and V_2T_2 combinations and at the same DAS the lowest plant height (41.27 cm) was obtained from V_1T_1 which was statistically similar with all the combinations except V_2T_3,V_2T_4 and V_2T_5 combinations. At harvest, treatment combination V_2T_5 scored the highest plant height (51.60 cm) which was statistically similar with combination V_2T_3. On the other hand, combination V_1T_1 gave the lowest plant height (39.03 cm) which was statistically similar with V_1T_2 and V_1T_4 treatment combinations at harvest.

Table 1. Combined effect of variety and added foliar spray of urea and boron on the plant height of soybean at different days after sowing

Treatment combinations	Plant height (cm) at different days after sowing (DAS)					
	20	40	60	80	100	At harvest
V_1T_1	8.13 f	24.17 e	37.07 f	42.35 d	41.27 d	39.03 e
V_1T_2	9.00 ef	26.20 de	39.23 ef	44.10 cd	42.43 cd	40.30 de
V_1T_3	11.17 b-d	29.37 cd	43.17 b-e	47.33 b-d	45.12 b-d	43.07 cd
V_1T_4	10.07 c-e	28.13 c-e	41.07 d-f	45.48 cd	43.03 cd	41.02 de
V_1T_5	12.62 b	31.30 bc	46.17 a-d	50.22 a-c	48.05 a-d	46.03 bc
V_2T_1	9.77 d-f	29.17 cd	42.13 c-f	47.25 b-d	45.28 b-d	43.07 cd
V_2T_2	10.78 b-e	30.43 b-d	45.27 b-d	49.18 a-d	47.11 a-d	45.07 c
V_2T_3	12.20 b	34.23 ab	48.27 ab	53.17 ab	51.15 ab	49.03 ab
V_2T_4	11.57 bc	32.40 a-c	47.30 a-c	51.17 a-c	49.35 a-c	46.90 bc
V_2T_5	13.97 a	36.50 a	51.10 a	56.23 a	54.16 a	51.60 a
$LSD_{(0.05)}$	1.76	4.19	5.77	7.02	7.39	3.68
CV (%)	9.32	8.03	7.57	8.34	9.15	4.77

NS = Non-significant

In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1= BARI soybean 5

V_2= BARI soybean 6

T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

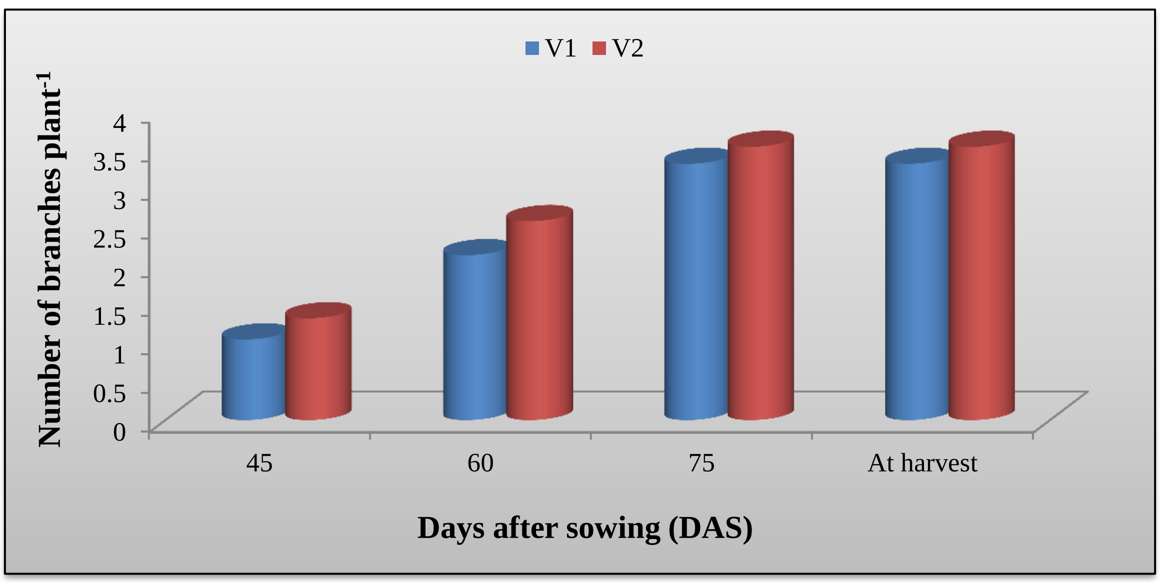
T_4= RF+ Boron (1%) FS at FI,

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

4.1.2 Branches plant^{-1} (no)

4.1.2.1 Effect of variety

Statistically significant variation of branches plant^{-1} was observed due to varietal variation of soybean. Variety of soybean showed statistically significant variation in terms of branches plant^{-1} at 45 and 60 DAS but at 75 DAS and harvest non-significant variation was obtained (Fig.4). Results showed that the highest branches plant^{-1} at 45 DAS and 60 DAS (1.31 and 2.57, respectively) was observed from variety V_2 (BARI soybean 6), which was significantly superior compare to variety V_1 (BARI soybean 5) whereas the lowest branches plant^{-1} (1.04 and 2.13 at 45 and 60 DAS, respectively) was observed from variety V_1 (BARI soybean 5). On the other hand at 75 DAS and harvest numerically highest branches plant^{-1} (3.53 and 3.53 respectively) was observed from variety V_2 (BARI soybean 6), while the lowest (3.31 and 3.31 at 75 DAS and harvest, respectively) was observed from variety V_1 (BARI soybean 5).

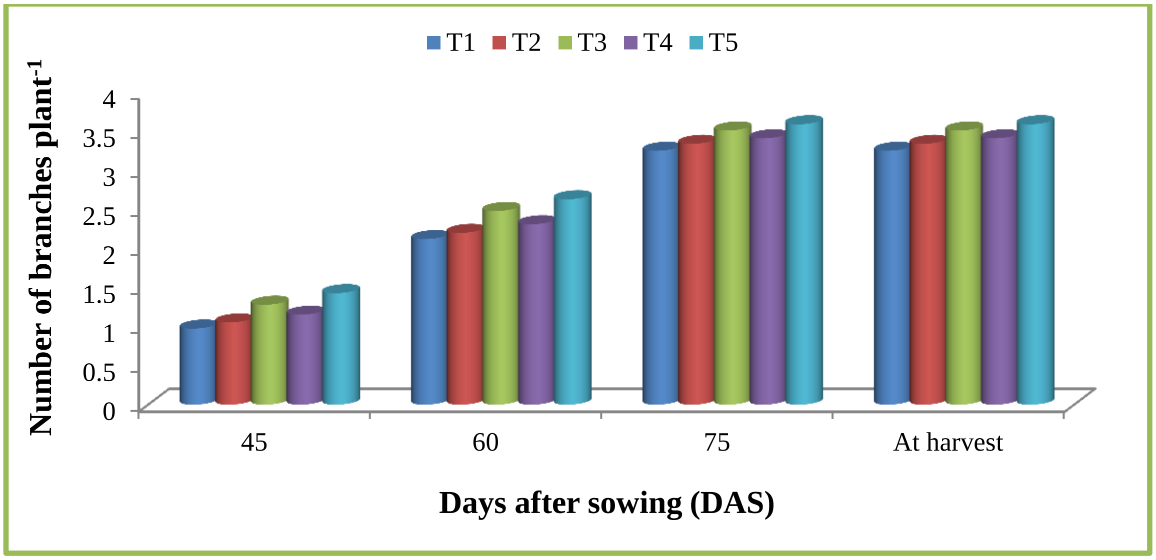


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 4. Effect of variety on branches plant^{-1} of soybean at different days after sowing (LSD $_{(0.05)}$ = 0.18, 0.19, NS and NS at 45, 60, 75 DAS and at harvest, respectively)

4.1.2.2 Effect of foliar spray

Branches plant^{-1} varied significantly due to the effect of added foliar spray of urea and boron at various DAS of soybean is depicted in figure5. Statistically significant variation was observedat 45 DAS and 60 DAS but at 75 DAS and at harvest non-significant variation was obtained. Results obtained that, at 45 DAS the highest branches plant^{-1} (1.43) was observed in treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI)which was significantly superior compare to all treatments, and the lowest branches plant^{-1} (0.97) was observed in T_1 (Recommended Fertilizer) treatment which was statistically similar with treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation). At 60 DAS the maximum branches plant^{-1} (2.63) was observed in treatment T_5 which was statistically similar with treatment T_3 (RF+ Urea (2%) FS at FI), and the minimum branches plant^{-1} (2.12) was observed in T_1 Treatment which was statistically similar with treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation) and treatment T_4 (RF+ Boron (1%) FS at FI). On the other hand at 75 DAS and at harvest the highest branches plant^{-1} (3.59 and 3.59 respectively) was observed in treatment T_5, while the lowest branches plant^{-1} (3.25 and 3.25 at 75 DAS and harvest) was observed in T_1 (Recommended Fertilizer) treatment. The present findings were supported by Venkatesh and Basu (2011) studied that the foliar application of urea at 2 per cent concentration recorded higher number of branches plant^{-1} which was at par with one or two sprays of urea over control and water spray. Schon and Blevins (1990) revealed that foliar application of B @ 1.12 kg ha^{-1} and 2.24 kg ha^{-1} increased the number of branches plant^{-1}.



T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 5. Effect of added foliar application on branches plant^{-1} (no) of soybean at different days after sowing (LSD $_{(0.05)}$ = 0.11, 0.29, NS and NS at 45, 60, 75 DAS and at harvest, respectively)

4.1.2.3 Combined effect of variety and foliar spray

Combined effect of variety and different foliar spray of urea and boron showed statistically significant variation for branches plant^{-1} at 45 DAS and 60 DAS but at 75 DAS and at harvest non-significant variation was obtained (Table 2). At 45 DAS the highest branches plant^{-1} (1.69) was observed at V_2T_5 combination which was significantly superior compare to all combinations in the experiment and the lowest branches plant^{-1} (0.93) was observed in V_1T_1 which was statistically similar with V_1T_2, V_1T_4 and V_2T_1 treatment combinations. At 60 DAS the highest branches plant^{-1} (2.91) was recorded from V_2T_5 combination followed by V_2T_3 and V_2T_4 combinations where lowest branches plant^{-1} (1.94) was observed from V_1T_1 which was statistically similar with V_1T_2, V_1T_3, V_1T_4 and V_2T_1 combinations, respectively. On the other hand at 75 DAS and at harvest the highest branches plant^{-1} (3.71 and 3.71, respectively) was observed from

V_2T_5treatment combination and the lowest branches plant^{-1} (3.13 and 3.13 at 75 DAS and harvest, respectively) was observed in V_1T_1 treatment combination.

Table 2. Combined effect of variety and added foliar spray of urea and boron on branches plant^{-1}of soybean at different days after sowing

Treatment combinations	Branches plant^{-1} (no.) at different days after sowing (DAS)			
	45	60	75	At harvest
V_1T_1	0.93 f	1.94 e	3.13	3.13
V_1T_2	0.98 ef	2.03 de	3.22	3.22
V_1T_3	1.097 de	2.23 c-e	3.41	3.41
V_1T_4	1.03 d-f	2.12 c-e	3.31	3.31
V_1T_5	1.17 cd	2.35 b-d	3.48	3.48
V_2T_1	1.02 d-f	2.29 c-e	3.38	3.38
V_2T_2	1.13 c-e	2.38 b-d	3.45	3.45
V_2T_3	1.46 b	2.74 ab	3.61	3.61
V_2T_4	1.27 c	2.51 a-c	3.52	3.52
V_2T_5	1.67 a	2.91 a	3.71	3.71
LSD $_{(0.05)}$	0.16	0.41	NS	NS
CV (%)	7.80	10.03	9.01	9.01

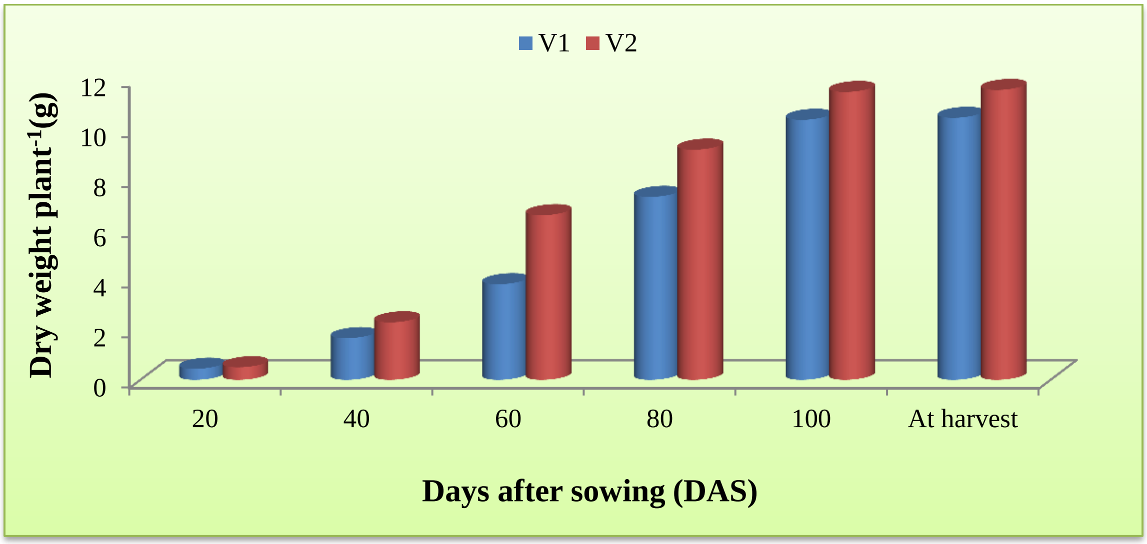
NS = Non-significant
In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1= BARI soybean 5
V_2= BARI soybean 6
T_1= Recommended Fertilizer (RF)
T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)
T_3= RF+ Urea (2%) FS at FI
T_4= RF+ Boron (1%) FS at FI,
T_5= RF+ Urea (2%) + Boron (1%) FS at FI

4.1.3 Dry weight plant^{-1}(g)

4.1.3.1 Effect of variety

Soybean varieties varied significantly in terms ofdry weight plant^{-1} at 40, 60, 80, 100 DAS and at harvest but at 20 DAS non-significant variation was observed. Figure 6 represents the effect of variety on dry weight plant^{-1} at different days after sowing (DAS) of soybean. Results showed that at 20, 40, 60, 80, 100 DAS and harvest the highest dry weight plant^{-1} (0.50, 2.29, 6.56, 9.17, 11.47 and 11.55 g respectively) was observed from variety V_2 (BARI soybean 6), which was significantly highest compared to variety V_1 (BARI soybean 5) except 20 DAS. On the other hand the lowest dry weight plant^{-1} (0.44, 1.66, 3.81, 7.29, 10.36 and 10.44 g, respectively) was observed from variety V_1 (BARI soybean 5) at 20, 40, 60, 80, 100 DAS and harvest, respectively.



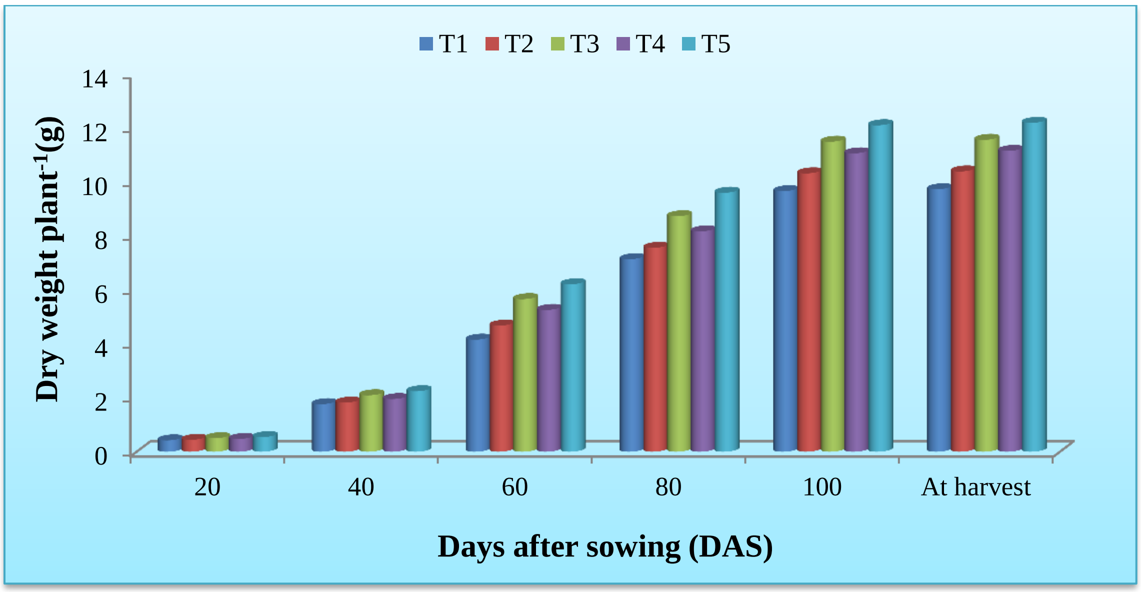
V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 6. Effect of variety on the dry weight plant^{-1} of soybean at different days after sowing (LSD $_{(0.05)}$ = NS, 0.35, 1.32, 0.64, 0.90 and 1.04 at 20, 40, 60, 80, 100 DAS and at harvest, respectively)

4.1.3.2 Effect of foliar spray

The effect of added foliar spray of urea and boron exerts statistically significant variation on dry weight plant^{-1} at different DAS of soybean (Fig. 7). Dry weight plant^{-1} showed statistically significant variation at 20, 40, 60, 80, 100 DAS and at harvest. Results revealed that at 20, 40, 60, 80, 100 DAS and harvest the maximum dry weight plant^{-1} (0.54, 2.24, 6.20, 9.59, 12.09 and 12.18 g, respectively) was obtained from treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) which was significantly highest compare to all treatments in the experiment and statistically similar with treatment T_3 (RF+ Urea (2%) FS at FI) where the value was (0.50, 2.09, 5.65, 8.72, 11.48 and 11.55 g, respectively), except 60 and 80 DAS. On the other hand at 20, 40, 60, 80, 100 DAS and harvest the minimum dry weight plant^{-1} (0.42, 1.76, 4.15, 7.13, 9.65 and 9.72 g, respectively) was observed from T_1 (Recommended Fertilizer) treatment which was statistically similar with treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation) for 60, 80, 100 DAS and harvest, respectively and at the same time similar with treatment T_2 (RF+ Foliar

Spray (FS) of water at flower initiation) and treatment T_4 (RF+ Boron (1%) FS at FI) for 20 DAS and 40 DAS. Similarly, Gupta *et al.*(2011) found that foliar application of 2 per cent urea at flowering and 10 days after flowering resulted in higher dry weight due to enhanced biological nitrogen fixation. Hemantaranjan *et al.* (2000) studied that effect of foliar application of boron at the rate of 50 and 100 ppm increase total dry matter production.



T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 7. Effect of added foliar application on the dry weight plant^{-1} of soybean at different days after sowing (LSD $_{(0.05)}$ = 0.055, 0.24, 0.53, 0.86, 0.73 and 0.75 at 20, 40, 60, 80, 100 DAS and at harvest, respectively)

4.1.3.3 Combined effect of variety and foliar spray

Combined effect of variety and foliar spray of urea and boron showed statistically significant variation for dry weight plant^{-1} at 20, 40, 60, 80, 100 DAS and harvest period (Table 3). At 20 DAS the maximum dry weight plant^{-1} (0.56 g) was observed at V_2T_5 combination followed by V_2T_3, V_2T_4 and V_1T_5 combinations and minimum dry weight plant^{-1} (0.38 g) was at V_1T_1 which was statistically similar with V_1T_2, V_1T_4

andV_2T_1combinations. At 40 DAS the maximum dry weight plant^{-1} (2.58 g) was recorded from V_2T_5 combination followed by V_2T_3 and V_2T_4 combinations whereas the minimum dry weight plant^{-1} (1.45 g) was at V_1T_1 followed by V_1T_2, V_1T_3 andV_1T_4 combinations. In terms of 60 DAS the maximum dry weight plant^{-1} (7.90 g) was recorded from V_2T_5 combination which was significantly highest compared to all combinations except V_2T_3 combination and the minimum dry weight plant^{-1} (3.07 g) observed at V_1T_1 which was statistically similar with V_1T_2 combination. At 80 DAS the maximum dry weight plant^{-1} (10.35 g) was recorded from V_2T_5 combination which was significantly highest compared to all combinations and statistically similar with V_2T_3 combination and the minimum dry weight plant^{-1} (6.14 g) observed at V_1T_1 which was statistically similar with V_1T_2 and V_1T_4 combinations. In case of 100 DAS, the maximum dry weight plant^{-1} (12.77 g) was recorded from V_2T_5 combination which was significantly highest compared to all combinations except V_2T_3 (12.07g) combination and the minimum dry weight plant^{-1} (9.18 g) observed at V_1T_1 combination which was statistically similar with V_1T_2 and V_2T_1 combinations. At harvest, treatment combination V_2T_5 scored the maximum dry weight plant^{-1} (12.86 g) which was significantly highest compare to all combinations except V_2T_3 (12.12g) combination and the minimum dry weight plant^{-1} (9.24 g) observed at V_1T_1 combination which was statistically similar with V_1T_2 (9.92g) and V_2T_1 (10.19g) combinations.

Table 3. Combined effect of variety and added foliar spray of urea and boron on the dry weight plant^{-1} of soybean at different days after sowing

Treatment combinations	Dry weight plant^{-1} (g) at different days after sowing (DAS)					
	20	40	60	80	100	At harvest
V_1T_1	0.38 e	1.45 f	3.07 g	6.14 g	9.18 f	9.24 f
V_1T_2	0.41de	1.53 f	3.47 fg	6.59 fg	9.84 ef	9.92 ef
V_1T_3	0.47 b-d	1.77 d-f	4.10 ef	7.66 d-f	10.90 b-d	10.98 b-e
V_1T_4	0.44 c-e	1.63 ef	3.90 ef	7.22 e-g	10.46 c-e	10.55 c-e
V_1T_5	0.51 a-c	1.90 c-e	4.50 de	8.83 b-d	11.43 bc	11.51 b-d
V_2T_1	0.45 c-e	2.07 c-e	5.23 de	8.12 c-e	10.13 d-f	10.19 d-f
V_2T_2	0.48 b-d	2.10 b-d	5.87 cd	8.52 cd	10.78 c-e	10.85 c-e
V_2T_3	0.53 ab	2.42 ab	7.20 ab	9.78 ab	12.07 ab	12.12 ab
V_2T_4	0.50 a-c	2.27 a-c	6.60 bc	9.11 bc	11.63 bc	11.74 bc
V_2T_5	0.56 a	2.58 a	7.90 a	10.35 a	12.77 a	12.86 a
LSD $_{(0.05)}$	0.078	0.34	0.75	1.21	1.04	1.06
CV (%)	9.59	10.09	8.37	8.53	5.52	5.58

NS = Non-significant
In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

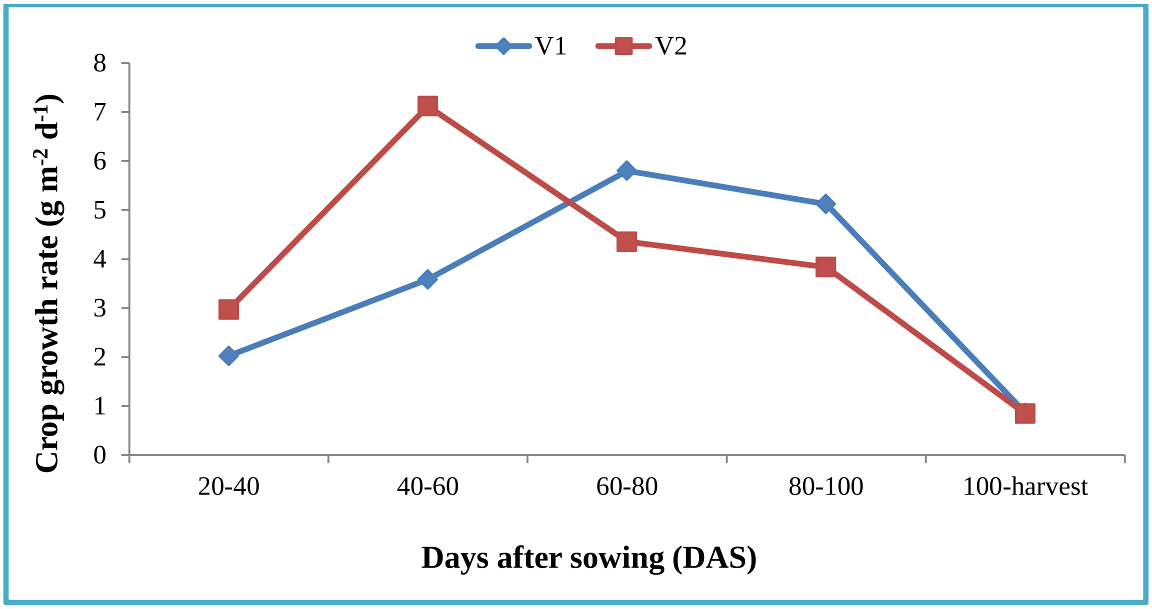
V_1= BARI soybean 5
V_2= BARI soybean 6
T_1= Recommended Fertilizer (RF)
T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)
T_3= RF+ Urea (2%) FS at FI
T_4= RF+ Boron (1%) FS at FI,
T_5= RF+ Urea (2%) + Boron (1%) FS at FI

4.1.4 Crop growth rate (g m^{-2} d^{-1})

4.1.4.1 Effect of Variety

Crop growth ratevaried significantly due to different soybean varieties at 20-40 DAS and 40-60 DAS but at 60-80 DAS, 80-100 DAS and 100 DAS-at harvest non-significant variation was observed. Results depicted in figure 8 represent the effect of variety on crop growth rateat different days after sowing (DAS). At 20-40 DAS and 40-60 DAS the highest CGR (2.97 and 7.12 g m^{-2} d^{-1}, respectively) was recorded from variety V_2 (BARI soybean 6), which was significantly superior compared to variety V_1 (BARI soybean 5) and as the lowest CGR (2.02 and 3.58 g m^{-2} d^{-1}, respectively) from variety V_1 (BARI soybean 5) at the same DAS. At 60-80, 80-100 and 100 DAS at harvest the highest CGR (5.80, 5.12 and 0.86 g m^{-2} d^{-1} respectively) was recorded from variety V_1 (BARI soybean

5) and the lowest CGR (4.36, 3.83 and 0.84 g m^{-2} d^{-1}, respectively) was observed from variety V_2 (BARI soybean 6).



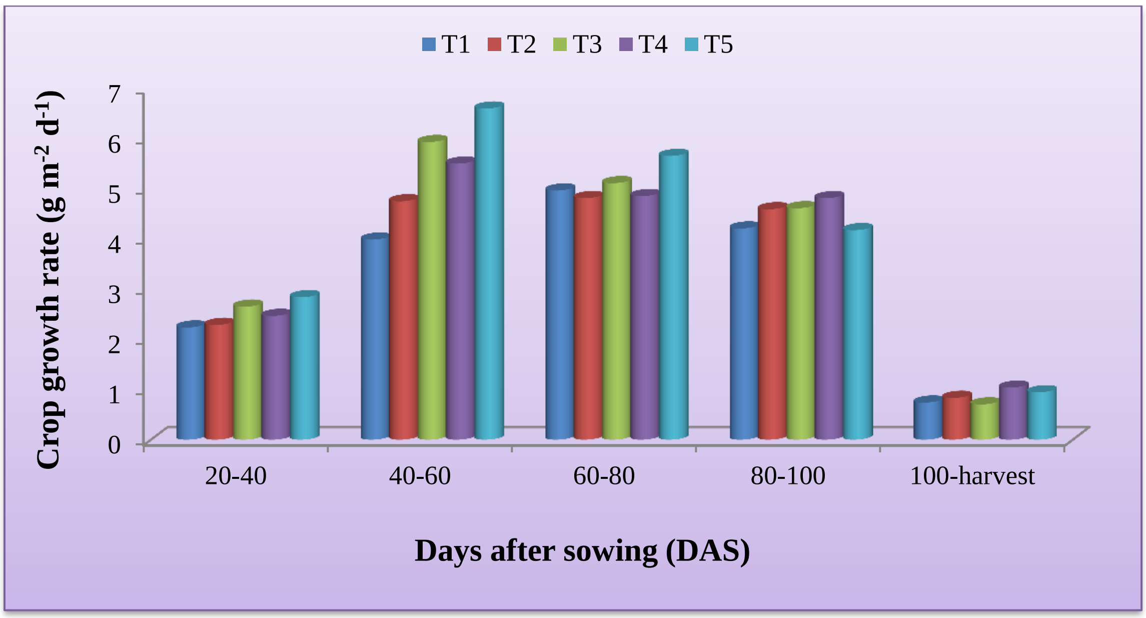
V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 8. Effect of variety on the crop growth rateof soybean at different days after sowing (LSD $_{(0.05)}$ = 0.63, 2.75, NS, NS and NS at 20-40, 40-60, 60-80, 80-100, 100-At harvest, respectively)

4.1.4.2 Effect of foliar spray

The data pertaining to effect of added foliar spray of urea and boron on crop growth rateat various DAS of soybean is depicted in fig. 9. Statistically significant variation was observed for crop growth rate due to different added foliar spray at 20-40 and 40-60 DAS but at 60-80, 80-100 and 100 DAS at harvest non-significant variation was observed. At 20-40 DAS the highest CGR (2.84 g m^{-2} d^{-1}) was observed in treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI)which was significantly superior compared to all treatments, and statistically similar with treatment T_3 (RF+ Urea (2%) FS at FI) and treatment T_4 (RF+ Boron (1%) FS at FI) where the value was (2.65 and 2.47 g m^{-2} d^{-1} respectively) and the lowest CGR (2.23 g m^{-2} d^{-1}) was observed in T_1 (Recommended Fertilizer) Treatment which is statistically similar with treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation) and treatment T_4 (RF+ Boron (1%) FS at FI) where the value was (2.28 and 2.47 g m^{-2} d^{-1}, respectively). At 40-60 DAS the highest CGR (6.59 g m^{-2} d^{-1})

was observed in treatment T_5 which was statistically similar with treatment T_3 (5.93 g m^{-2} d^{-1}) and the lowest CGR (3.98 g m^{-2} d^{-1}) was observed in T_1 treatment which was statistically at par with treatment T_2 (4.75 g m^{-2} d^{-1}). At 60-80 DAS and 100 DAS-at harvest the highest CGR (5.65 and 0.94 g m^{-2} d^{-1}, respectively) was observed in treatment T_5 and the lowest CGR (4.96 and 0.74 g m^{-2} d^{-1}, respectively) was observed in T_1 treatment. The results obtained from the present findings was similar with the findings of Manivannan *et al.* (2002) they reported that combined foliar application recorded markedly higher crop growth rate when compared to control (no application) .



T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 9. Effect of added foliar application on the crop growth rateof soybean at different days after sowing (LSD $_{(0.05)}$ = 0.39, 0.92, NS, NS and NS at 20-40, 40-60, 60-80, 80-100, 100-at harvest, respectively)

4.1.4.3 Combined effect of variety and foliar spray

Interaction effect of variety and foliar spray of urea and boron showed statistically significant variation for crop growth rate at 20-40, 40-60 and 60-80 DAS but at 80-100 and 100 DAS-at harvest non-significant variation was observed (Table 4). At 20-40 DAS the highest CGR (3.36 g m^{-2} d^{-1}) was observed at V_2T_5 combination followed by V_2T_3 (3.14 g m^{-2} d^{-1}) and V_2T_4 (2.94 g m^{-2} d^{-1}) combinations, whereas the lowest CGR (1.78 g m^{-2} d^{-1}) was observed at V_1T_1 combination which was statistically identical with V_1T_2, V_1T_3, V_1T_4 andV_1T_5 combinations. At 40-60 DAS the maximum CGR (8.86 g m^{-2} d^{-1}) was obtained from V_2T_5 combination which was statistically at par with V_2T_3 (7.97 g m^{-2} d^{-1}) combination.The minimum CGR (2.69 g m^{-2} d^{-1}) was observed at V_1T_1 combination which was statistically similar with V_1T_2, V_1T_3 andV_1T_4 combinations. At 60-80 DAS the maximum CGR (7.22 g m^{-2} d^{-1}) was obtained from V_1T_5 combination which was statistically at par with all other combinations except V_2T_4 and V_2T_5 combinations. The minimum CGR (4.08 g m^{-2} d^{-1}) was observed at V_2T_5 combination and it was statistically similar with all combinations except V_1T_5 combination. At 80-100 DAS and 100 DAS-at harvest the maximum CGR (5.41 and 1.14 g m^{-2} d^{-1}) was obtained from V_1T_4 andV_2T_4 combinations respectively. And the minimum CGR (3.34 and 0.55 g m^{-2} d^{-1}, respectively) was obtained from V_2T_1 andV_2T_3 combinations respectively.

Table 4. Combined effect of variety and added foliar spray of urea and boron on the crop growth rate at different days after sowing

Treatment combinations	Crop growth rate ($g\ m^{-2}\ d^{-1}$) at different days after sowing (DAS)				
	20-40	40-60	60-80	80-100	100-at harvest
V_1T_1	1.78 e	2.69 g	5.12 ab	5.07	0.70
V_1T_2	1.87 e	3.22 fg	5.21 ab	5.40	0.92
V_1T_3	2.16 de	3.89 e-g	5.93 ab	5.40	0.85
V_1T_4	1.98 de	3.78 e-g	5.53 ab	5.41	0.92
V_1T_5	2.31 c-e	4.33 ef	7.22 a	4.32	0.89
V_2T_1	2.69 b-d	5.27 de	4.81 ab	3.34	0.78
V_2T_2	2.69 b-d	6.27 cd	4.42 ab	3.78	0.74
V_2T_3	3.14 ab	7.97 ab	4.29 ab	3.82	0.55
V_2T_4	2.94 a-c	7.22 bc	4.18 b	4.21	1.15
V_2T_5	3.36 a	8.86 a	4.08 b	4.03	0.99
$LSD_{(0.05)}$	0.56	1.31	2.53	NS	NS
CV (%)	13.00	14.12	28.82	33.19	76.83

NS = Non-significant
In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

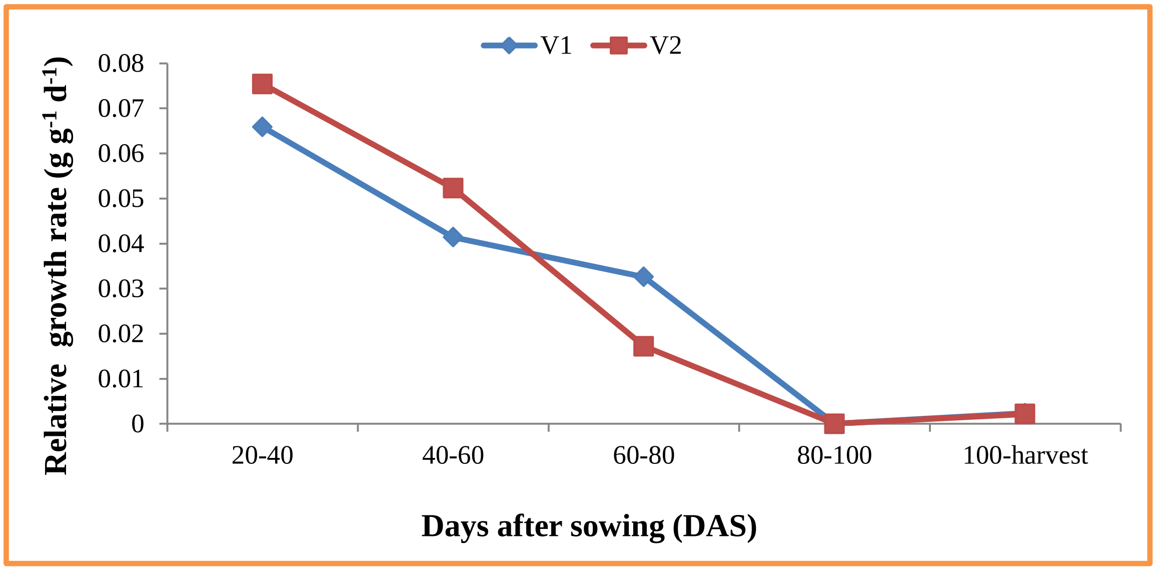
V_1= BARI soybean 5
V_2= BARI soybean 6
T_1= Recommended Fertilizer (RF)
T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)
T_3= RF+ Urea (2%) FS at FI
T_4= RF+ Boron (1%) FS at FI,
T_5= RF+ Urea (2%) + Boron (1%) FS at FI

4.1.5 Relative growth rate ($g\ g^{-1}\ d^{-1}$)

Relative growth rate (RGR) expresses the dry weight increase in a time interval in relation to the initial weight. Relative growth rate is also a measure used to quantify the speed of plant growth. It is measured as the mass increase per aboveground biomass per day.

4.1.5.1 Effect of Variety

Relative growth ratevaried significantly due to different soybean varieties at 60-80 DAS and 80-100 DAS but at 20-40 DAS, 40-60 DAS and 100 DAS-at harvest non-significant variation was observed. Results presented in figure 10 represent the effect of variety on relative growth rateat different days after sowing (DAS). At 20-40 and 40-60 DAS, the highest RGR (0.0754 and 0.0523 g g^{-1} d^{-1}, respectively) was recorded from variety V_2 (BARI soybean 6), where as the lowest RGR (0.0659 and 0.0414 g g^{-1} d^{-1}, respectively) was recorded from variety V_1 (BARI soybean 5) at the same DAS. At 60-80 and 80-100 DAS, the highest RGR (0.0326 and 0.0178 g g^{-1} d^{-1}, respectively) was recorded from variety V_1 (BARI soybean 5) and the lowest (0.0172 and 0.0112 g g^{-1} d^{-1}) observed from variety V_2 (BARI soybean 6). At 100 DAS-at harvest the maximum RGR (0.00237 g g^{-1} d^{-1}) was recorded from variety V_1 (BARI soybean 5) and the minimum RGR (0.00217 g g^{-1} d^{-1}) from variety V_2 (BARI soybean 6).

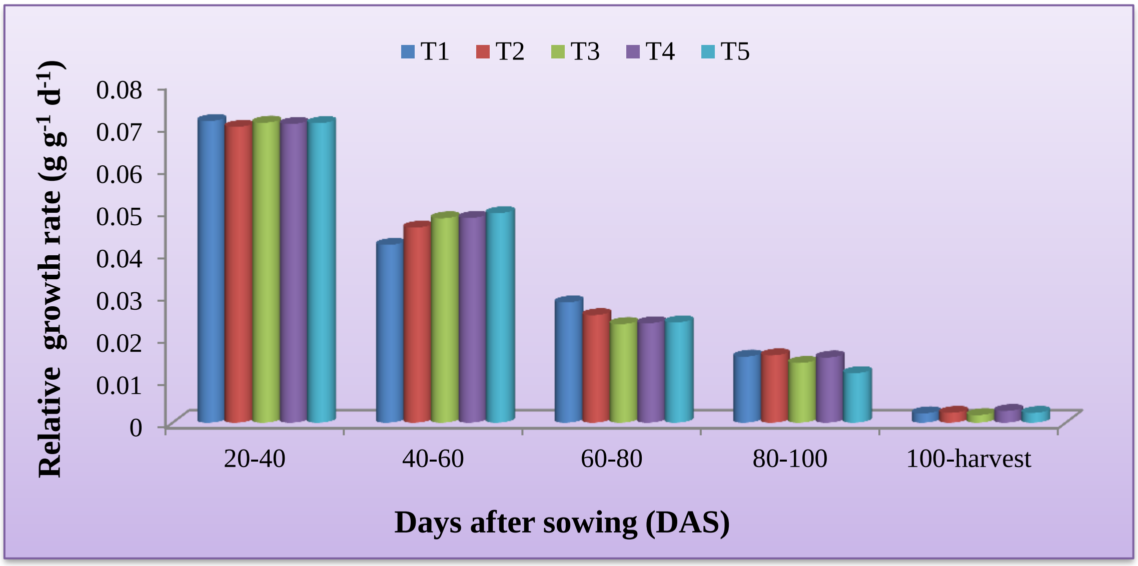


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 10. Effect of variety on the relative growth rateof soybean at different days after sowing (LSD $_{(0.05)}$ = NS, NS, 0.0114, 0.00610 and NS at 20-40, 40-60, 60-80, 80-100, 100-At harvest, respectively)

4.1.5.2 Effect of foliar spray

The data presented due to the effect of added foliar spray of urea and boron on relative growth rateat various DAS of soybean is depicted in fig. 11.Relative growth rate was also not significantly affected by foliar spray of urea and boron.Result showed that the maximum RGR (0.0713, 0.0495, 0.0284, 0.0159 and 0.00275 g g^{-1} d^{-1} at 20-40, 40-60, 60-80, 80-100 and 100 DAS- at harvest, respectively) were gained from treatments T_1, T_5, T_1, T_2, and T_4 respectively, whereas the minimum RGR (0.0699, 0.0420, 0.0233, 0.0117 and 0.00178 g g-1 d-1 at 20-40, 40-60, 60-80, 80-100 and 100 DAS- At harvest) were attained from treatments T_2, T_1, T_3, T_5, and $T_{3,}$ respectively.



T_1= Recommended Fertilizer (RF)
T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)
T_3= RF+ Urea (2%) FS at FI
T_4= RF+ Boron (1%) FS at FI
T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure 11. Effect of added foliar application of urea and boron on the relative growth rateof soybean at different days after sowing (LSD $_{(0.05)}$ = NS, NS, NS, NS and NS at 20-40, 40-60, 60-80, 80-100, 100-At harvest, respectively)

4.1.5.3 Combinedeffect of variety and foliar spray

Interaction effect of variety and foliar spray of urea and boron showed statistically significant variation for relative growth rate at 60-80 DAS and 80-100 DAS but at 20-40 DAS, 40-60 DAS and 100 DAS-at harvest non-significant variation was observed (Table 5). Result observed that the highest RGR (0.0762, 0.0559, 0.0347, 0.0201 and 0.00297 g g-1 d-1 at 20-40, 40-60, 60-80, 80-100 and 100 DAS- at harvest, respectively) were gained from the combined effect of V_2T_1, V_2T_5, V_1T_1, V_1T_4 and $V_2T_{4,}$ respectively. And the lowest RGR (0.0654, 0.0374, 0.0135, 0.0105 and 0.00134 g g-1 d-1 at 20-40, 40-60, 60-80, 80-100 and 100 DAS- at harvest, respectively) were attained from the combinations of V_1T_5, V_1T_1, V_2T_5, V_2T_5 and $V_2T_{3,}$ respectively.

Table 5. Combined effect of variety and added foliar spray of urea and boron on the relative growth rate at different days after sowing

Treatment combinations	Relative growth rate (g g^{-1} d^{-1}) at different days after sowing (DAS)				
	20-40	40-60	60-80	80-100	100-at harvest
V_1T_1	0.0665	0.0374	0.0347 a	0.0201 a	.00219
V_1T_2	0.0659	0.0408	0.0322 ab	0.0200 a	.00267
V_1T_3	0.0662	0.0421	0.0313 ab	0.0176 ab	.00223
V_1T_4	0.0656	0.0435	0.0308 ab	0.0186 ab	.00253
V_1T_5	0.0654	0.0431	0.0338 a	0.0128 ab	.00223
V_2T_1	0.0762	0.0465	0.0220 a-c	0.0110 ab	.00221
V_2T_2	0.0738	0.0513	0.0187 bc	0.0118 ab	.00196
V_2T_3	0.0756	0.0546	0.0153 c	0.0105 b	.00134
V_2T_4	0.0756	0.0534	0.0162 c	0.0122 ab	.00297
V_2T_5	0.0761	0.0559	0.0135 c	0.0105 b	.00236
LSD $_{(0.05)}$	NS	NS	0.0110	0.00841	NS
CV (%)	8.83	14.00	25.56	33.49	73.41

NS = Non-significant

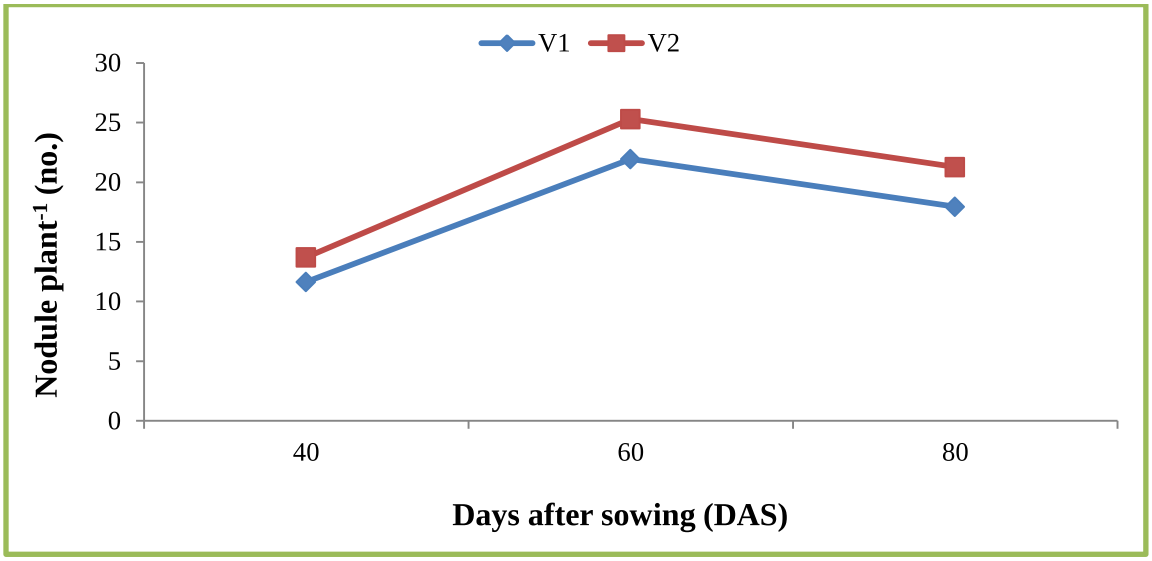
In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1= BARI soybean 5
V_2= BARI soybean 6
T_1= Recommended Fertilizer (RF)
T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)
T_3= RF+ Urea (2%) FS at FI
T_4= RF+ Boron (1%) FS at FI,
T_5= RF+ Urea (2%) + Boron (1%) FS at FI

4.1.6 Nodules plant^{-1} (no.)

4.1.6.1 Effect of Variety

Varietal effect on number of nodule plant^{-1}of soybean is shown in fig. 12. Results depicted in Fig.12, showed that number of nodule plant^{-1}influenced significantly by soybean varieties only at 60 DAS but at 40 and 80 DAS non-significant variation was observed. At 40 and 80 DAS the maximum number of nodule plant^{-1}(13.71 and 21.29, respectively) was observed from variety V_2 (BARI soybean 6) which was statistically similar to variety V_1 (BARI soybean 5) and the minimum number of nodule plant^{-1}(11.642 and 17.94, respectively) was observed from variety V_1 (BARI soybean 5). At 60 DAS the maximum number of nodule plant^{-1}(25.29) was observed from variety V_2(BARI soybean 6) which was significantly superior compared to variety V_1 (BARI soybean 5). And the minimum number of nodulesplant^{-1}(21.94) was observed from variety V_1.



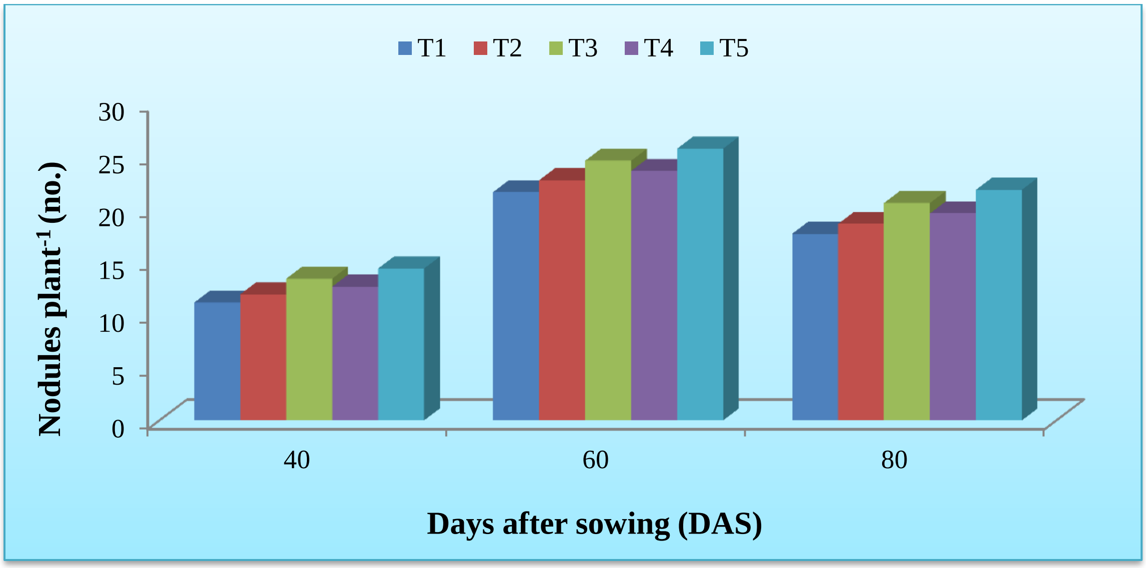
V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 12. Effect of variety on the nodules plant^{-1}of soybean at different days after sowing (LSD $_{(0.05)}$ = NS, 2.78, and NS at 40, 60 and 80 DAS, respectively)

4.1.6.2 Effect of foliar spray

The data pertaining to effect of added foliar spray of urea and boron on the number of nodule plant^{-1}at various DAS of soybean is depicted in fig. 13. Due to different added foliar spray statistically significant variation was observed for number of nodulesplant^{-1}.At 40 DAS the maximum number of nodulesplant^{-1}(14.35) was observed in treatment T_5 which was significantly superior compared to all treatments and statistically similar with treatment T_3 (13.38) (RF+ Urea (2%) FS at FI), and the minimum number of nodules plant^{-1}(11.12) was observed in T_1 (Recommended Fertilizer) treatment which was statistically similar with treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation). At 60 and 80 DAS maximum number of nodule plant^{-1}(25.68 and 21.79 respectively) was observed in treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI)which was significantly superior compared to all treatments and statistically similar with treatment T_3 and T_4 and the minimum number of nodulesplant^{-1}(21.58 and 17.63 respectively) was observed in T_1 Treatment which was statistically similar with treatment

T_2 and T_4 (RF+ Boron (1%) FS at FI). The results were supported by Basher *et al.* (2006) concluded that the application of foliar B significantly increased the effective number of nodules per plant.



T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure 13. Effect of added foliar application of urea and boron on the nodules plant^{-1}of soybean at different days after sowing (LSD $_{(0.05)}$ = 1.38, 2.79 and 2.60 at 40, 60 and 80 DAS respectively)

4.1.6.3 Combined effect of variety and foliar spray

Interaction effect of variety and foliar spray of urea and boron also exposed significant variation in terms of number of nodulesplant^{-1}at 40, 60 and 80 DAS (Table 6). At 40 DAS the highest number of nodulesplant^{-1}(14.97) was obtained from V_2T_5 combination followed by V_2T_3, V_2T_4, V_2T_2 and V_1T_5 combinations and the lowest number of nodulesplant^{-1}(10.21) was observed from V_1T_1 combination which was statistically similar with V_1T_2,V_1T_4 and V_2T_1 combinations.In case of 60 DAS the highest number of nodulesplant^{-1}(27.60) was obtained from V_2T_5 combination followed by V_2T_3, V_2T_4, V_2T_2 and V_1T_5 combinations and the lowest number of nodulesplant^{-1}(20.08) was observed from V_1T_1 combination which was statistically similar with all other combinations except

V_2T_3,V_2T_4 and V_2T_5 combinations.In terms of 80 DAS the highest number of nodulesplant^{-1}(23.77) was obtained from V_2T_5 combination followed by V_2T_3 and V_2T_4 combinations and the lowest number of nodulesplant^{-1}(16.09) was observed from V_1T_1 combination which was statistically similar with V_1T_2,V_1T_3, V_1T_4 and V_2T_1 combinations.

Table. 6. Combined effect of variety and added foliar spray of urea and boron on the nodule plant^{-1}of soybean at different days after sowing

Treatment combinations	Nodule plant^{-1}at different days after sowing (DAS)		
	40	60	80
V_1T_1	10.21 f	20.08 d	16.09 e
V_1T_2	10.67 ef	21.10 cd	17.11 de
V_1T_3	12.37 b-e	22.80 b-d	18.87 b-e
V_1T_4	11.23 d-f	21.96 cd	17.82 c-e
V_1T_5	13.73 a-c	23.77 a-d	19.81 b-d
V_2T_1	12.03 c-f	23.07 b-d	19.17 b-e
V_2T_2	13.13 a-d	24.31a-d	20.02 b-d
V_2T_3	14.40 ab	26.28 ab	22.22 ab
V_2T_4	14.03 a-c	25.20 a-c	21.30 a-c
V_2T_5	14.97 a	27.60 a	23.77 a
LSD $_{(0.05)}$	1.96	3.95	3.68
CV (%)	8.93	9.68	10.85

NS = Non-significant
In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

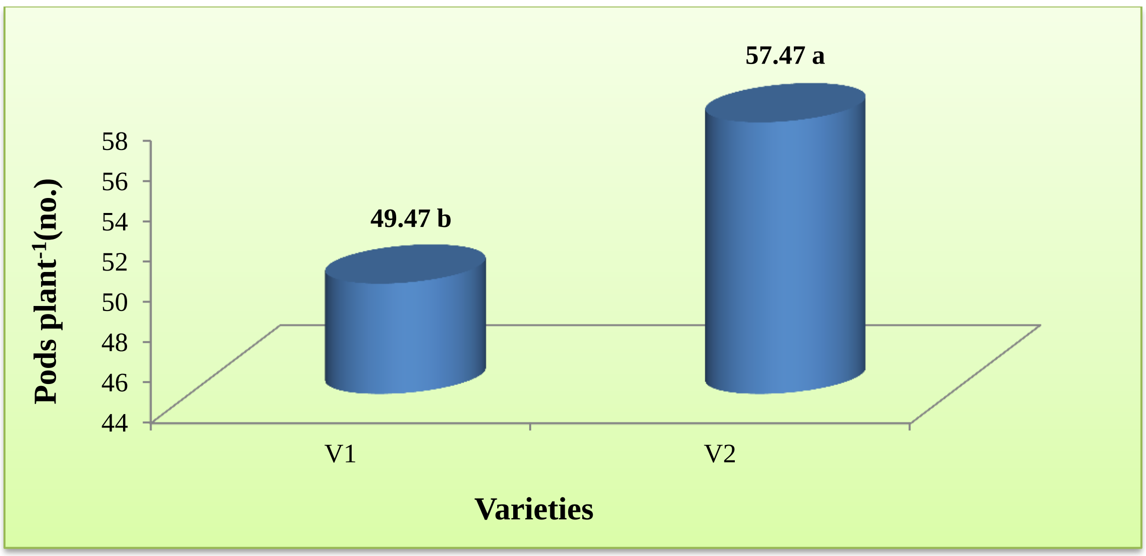
V_1= BARI soybean 5
V_2= BARI soybean 6
T_1= Recommended Fertilizer (RF)
T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)
T_3= RF+ Urea (2%) FS at FI
T_4= RF+ Boron (1%) FS at FI,
T_5= RF+ Urea (2%) + Boron (1%) FS at FI

4.2 Yield contributing parameters

4.2.1 Pods plant^{-1}(no.)

4.2.1.1 Effect of variety

Results depicted in Figure14, showed that pods plant^{-1} influenced by soybean varieties which showed significant difference. Figure 14 represents the effect of variety on pods plant^{-1} of soybean. The maximum pods plant^{-1}(57.47) was observed from variety V_2 (BARI soybean 6), which was significantly highest compared to variety V_1 (BARI soybean 5) and the minimum pods plant^{-1}(49.47) was observed from variety V_1 (BARI soybean 5).

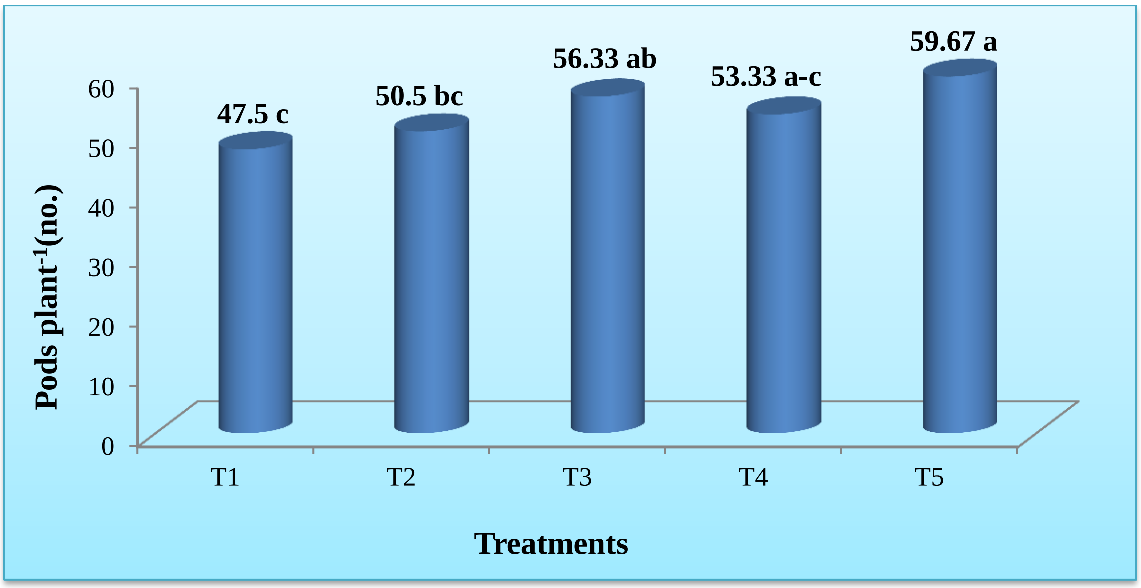


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 14. Effect of variety on pods plant^{-1}of soybean (LSD $_{(0.05)}$ = 6.72)

4.2.1.2 Effect of foliar spray

Statistically significant variation was observed for pods plant^{-1} of soybean due to the effect of added foliar spray of urea and boron shown in Figure. 15.Results showed that the highest pods plant^{-1}(59.67) was obtained from treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) which was significantly highest compare to all treatments in the experiment and shows statistically similarity with treatment T_3 (RF+ Urea (2%) FS at FI) and treatment T_4 (RF+ Boron (1%) FS at FI) where the value for treatment T_3 was(56.33) and for treatment T_4 was (53.33). The lowest pods plant^{-1}(47.50) was observed from T_1 (Recommended Fertilizer) treatment which was statistically at par with treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation) and treatment T_4 (RF+ Boron (1%) FS at FI) where the value for treatment T_2 was (50.50). Similar results were found by Kulsum (2009) found that foliar application of urea had significant effect on number of pods plant^{-1}. El-Yazied and Mady (2012) also reported that foliar applications of boron (0, 25 and 50 ppm) significantly stimulatenumber of pods plant^{-1}.



T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 15. Effect of foliar spray of urea and boron on pods plant^{-1} (no.) of soybean (LSD $_{(0.05)}$ = 6.38)

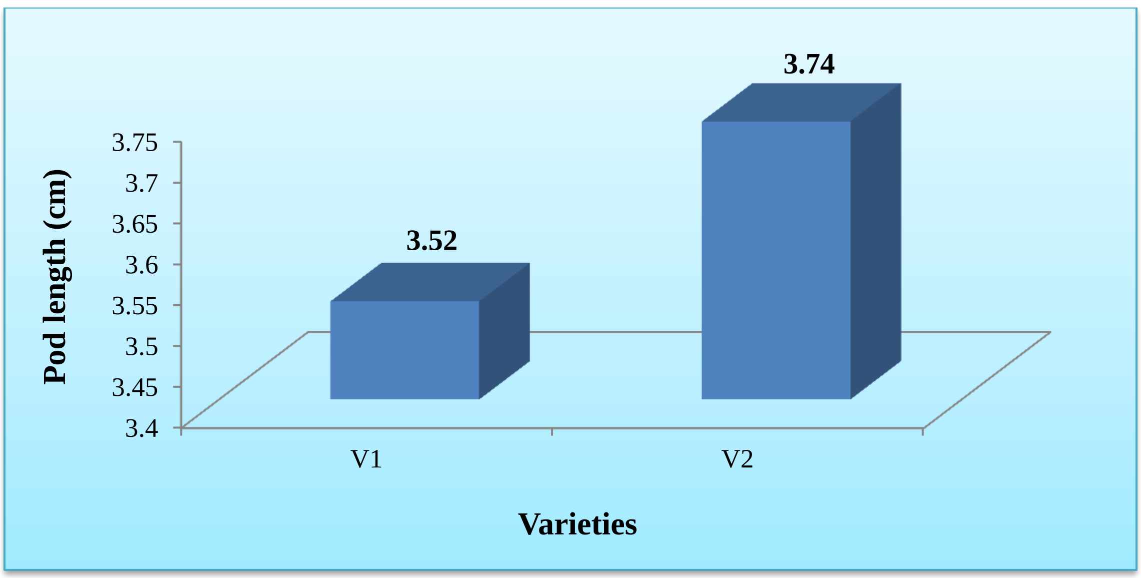
4.2.1.3 Combined effect of variety and foliar spray

According to the results presented in Table 7, it is clear that the number of pods plant^{-1} of soybean was significantly influenced by interaction effect of varieties and added foliar spray of urea and boron (Table 7). It was found that the highest pods plant^{-1}(63.67) was obtained from the treatment combination of V_2T_5 followed by V_2T_3, V_2T_4, V_2T_2 and V_1T_5 combinations where the value was 60.33, 57.33, 54.67 and 55.57, respectively. On the other hand the lowest pods plant^{-1}(43.67) was found from V_1T_1 treatment combination followed by V_1T_2, V_1T_3, V_1T_4 and V_2T_1 combinations where the value was 46.33, 52.33, 49.33 and 51.33 respectively.

4.2.2 Pod length (cm)

4.2.2.1 Effect of variety

Pod length (cm) of soybean showed statistically non-significant variation due to different variety of soybean (Fig 16). Numerically maximum pod length (3.74 cm) was observed from variety V_2 (BARI soybean 6) which was statistically par with variety V_1 (BARI soybean 5) and the minimum pod length (3.52 cm) was obtained from variety V_1 (BARI soybean 5).

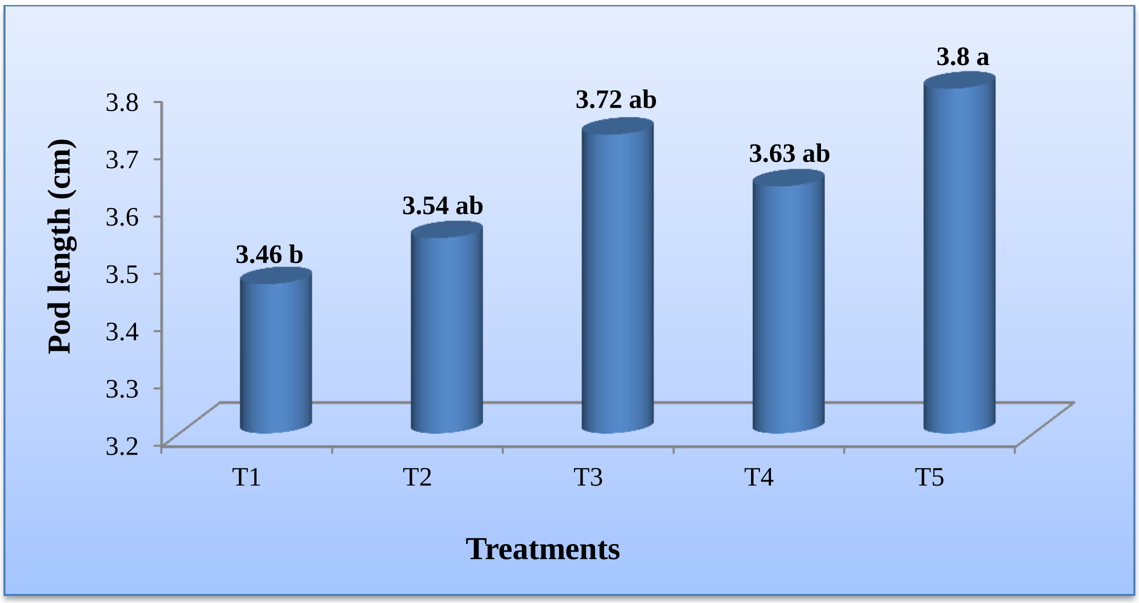


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 16. Effect of variety on pod length of soybean (LSD $_{(0.05)}$ = 1.19)

4.2.2.2 Effect of foliar spray

Data pertaining to effect of added foliar spray of urea and boron on pod length (cm) of soybean is depicted in figure 17. Statistically significant variation was obtained for pod length (cm) due to different foliar spray.Results indicated that the highest pod length (3.80 cm) was obtained from treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) which was significantly highest over T_1 (Recommended Fertilizer) treatment and showed statistically identical with treatment T_3 (RF+ Urea (2%) FS at FI), treatment T_4 (RF+ Boron (1%) FS at FI) and treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation) where the value for treatment T_3 was (3.72 cm), for treatment T_4 (3.63 cm), and for treatment T_2 was (3.54 cm). And the lowest pod length (3.46 cm) was observed from T_1 (Recommended Fertilizer) treatment which was statistically at par with treatment T_2, T_3 and T_4. The present finding was similar with the findings of Gulumser *et al.* (2005) stated that the foliar application of B had significant effects on the pod length.



T_1= Recommended Fertilizer (RF)
T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)
T_3= RF+ Urea (2%) FS at FI
T_4= RF+ Boron (1%) FS at FI
T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 17. Effect of foliar spray of urea and boron on pod length (cm) of soybean (LSD $_{(0.05)}$ = 0.28)

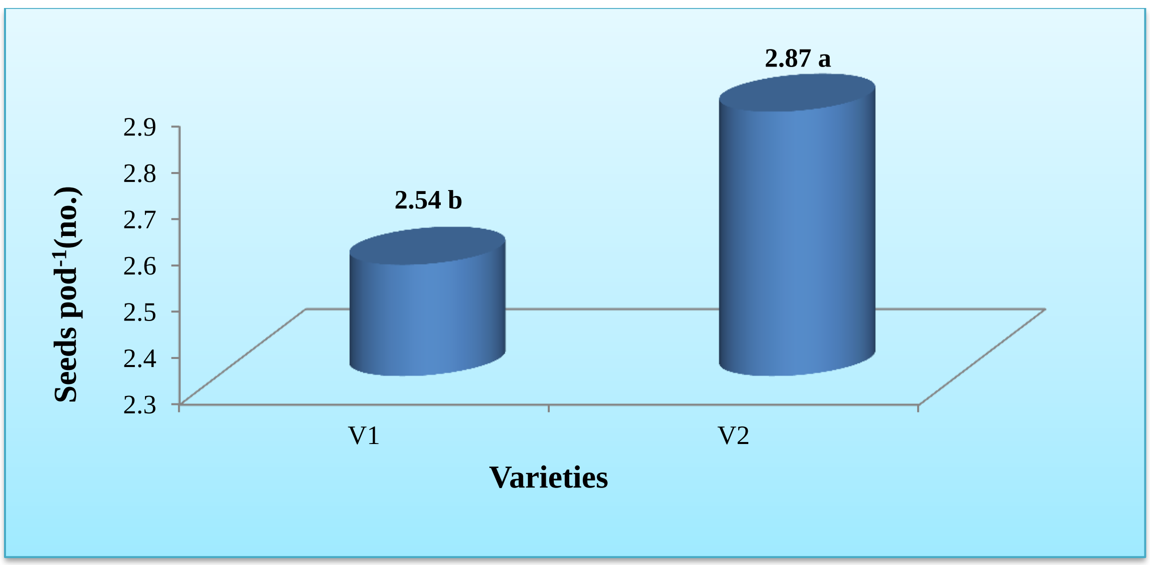
4.2.2.3 Combined effect of variety and foliar spray

Perusal of data (Table 7) showed that the pod length (cm) of soybean was not significantly influenced by interaction effect of varieties and added foliar spray of urea and boron. It was found that numericallymaximumpod length (3.91 cm) was obtained from the treatment combination of V_2T_5. On the other hand, the minimum pod length (3.34 cm) was found from V_1T_1 treatment combination.

4.2.3 Number of seeds pod^{-1}

4.2.3.1 Effect of variety

Varietal effect on seeds pod^{-1} of soybean was found statistically significant in this experiment (Fig.18). Results depicted in Figure.18, showed that seeds pod^{-1} influenced by soybean varieties. It was found that the higherseeds pod^{-1}(2.87) was observed from variety V_2 (BARI soybean 6), which was significantly highest compared to variety V_1 (BARI soybean 5) and the lowest seeds pod^{-1}(2.54) was observed from variety V_1 (BARI soybean 5).

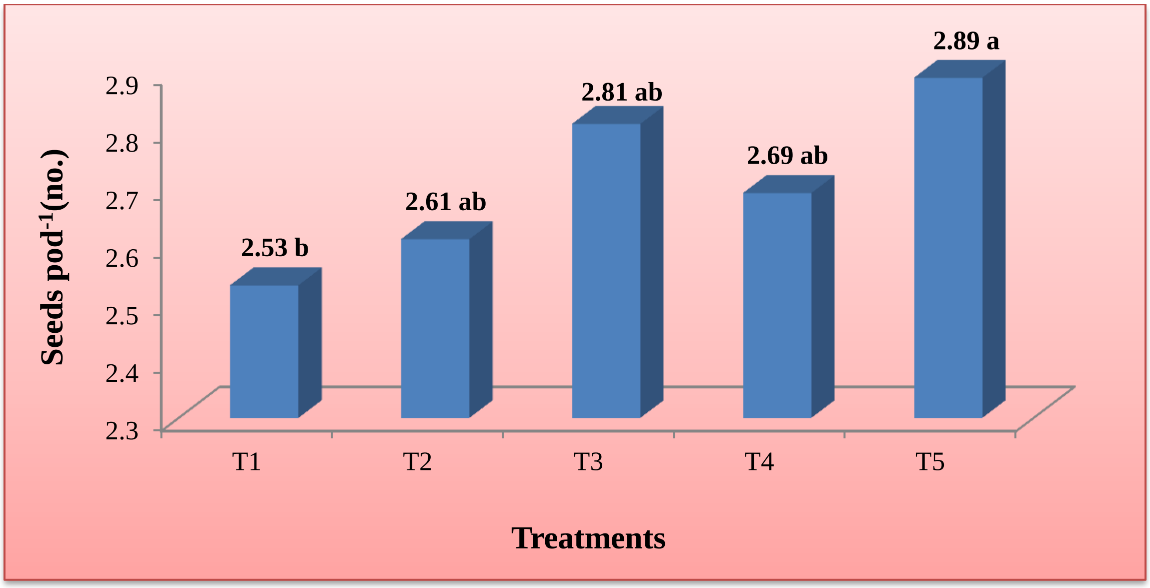


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 18. Effect of variety on seeds pod^{-1} of soybean (LSD $_{(0.05)}$ = 0.28)

4.2.3.2 Effect of foliar spray

Data obtained due to the effect of added foliar spray of urea and boron on seeds pod^{-1} of soybean is depicted in figure 19. It was found that seeds pod^{-1} varied significantly due to different foliar spray.The results showed that maximum seeds pod^{-1} (2.89) was obtained from treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) which was significantly highest over treatment T_1 (Recommended Fertilizer) and showed statistically similarity with treatment T_3 (RF+ Urea (2%) FS at FI), treatment T_4 (RF+ Boron (1%) FS at FI) and treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation) where the value for treatment T_3 (2.81), for T_4 (2.69), and for treatment T_2 was (2.61). And the minimum seeds pod^{-1}(2.53) was observed from T_1 (Recommended Fertilizer) treatment which was statistically at par with treatment T_2, T_3 and T_4. Similar results were found by Uikey (2012) and Rajni and Meitei (2004). They found that foliar application of urea and boron influencing the number of seeds pod^{-1}.



T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 19. Effect of foliar spray of urea and boron on seeds pod^{-1} of soybean (LSD $_{(0.05)}$= 0.32)

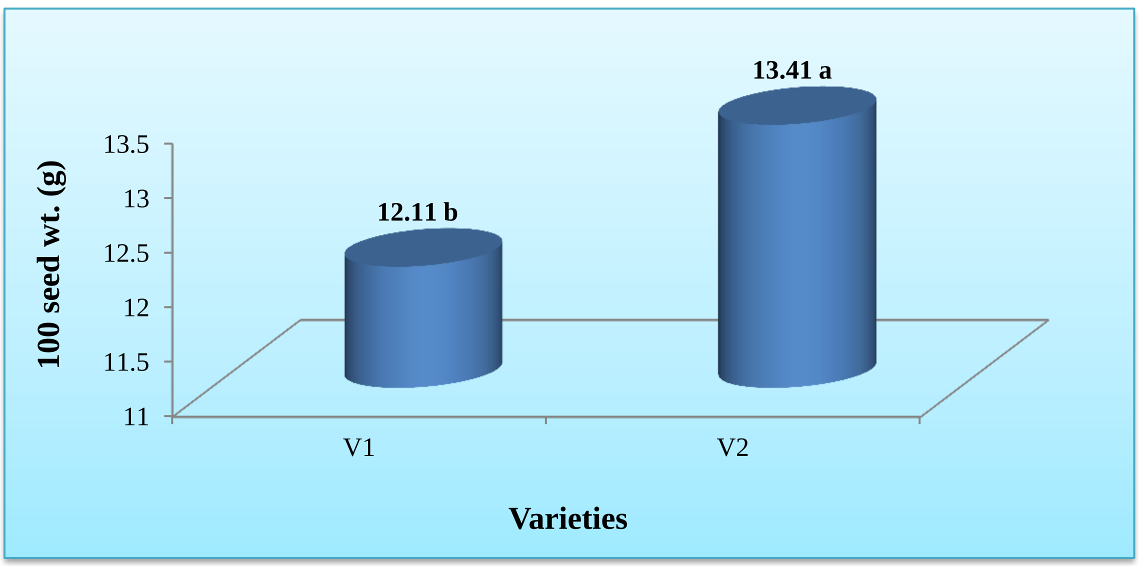
4.2.3.3 Combined effect of variety and foliar spray

The results presented in Table 7, indicated that seeds pod^{-1} of soybean was varied significantly due to the interaction effect of soybean varieties and added foliar spray of urea and boron. The results revealed that the highest seeds pod^{-1}(3.05) was obtained from the treatment combination of V_2T_5 which was statistically par with all other treatment combinations except V_1T_1 and V_1T_2. On the other hand the lowest seeds pod^{-1}(2.37) was found from V_1T_1 treatment combination which was also statistically similar with all other treatment combinations except V_2T_3 (2.97), V_2T_4 (2.85) and V_2T_5 (3.05).

4.2.4 Weight of 100-seeds (g)

4.2.4.1 Effect of variety

Weight of 100 seeds varied significantly between the soybean varieties. A result depicted in figure 20 represents the effect of variety on weight of 100 seeds of soybean. As per the results obtainedit was found that the highest weight of 100 seeds (13.41 g) was observed from variety V_2 (BARI soybean 6), which was significantly superior compared to variety V_1 (BARI soybean 5) and the lowest weight of 100 seeds (12.11 g) was observed from variety V_1 (BARI soybean 5). SimilarlyPopovic *et al.* (2013) reported that soybean varieties had higher 1000- seed weight in the variant with foliar fertilization (composition: 12% N and 0.008% B) than in the control.

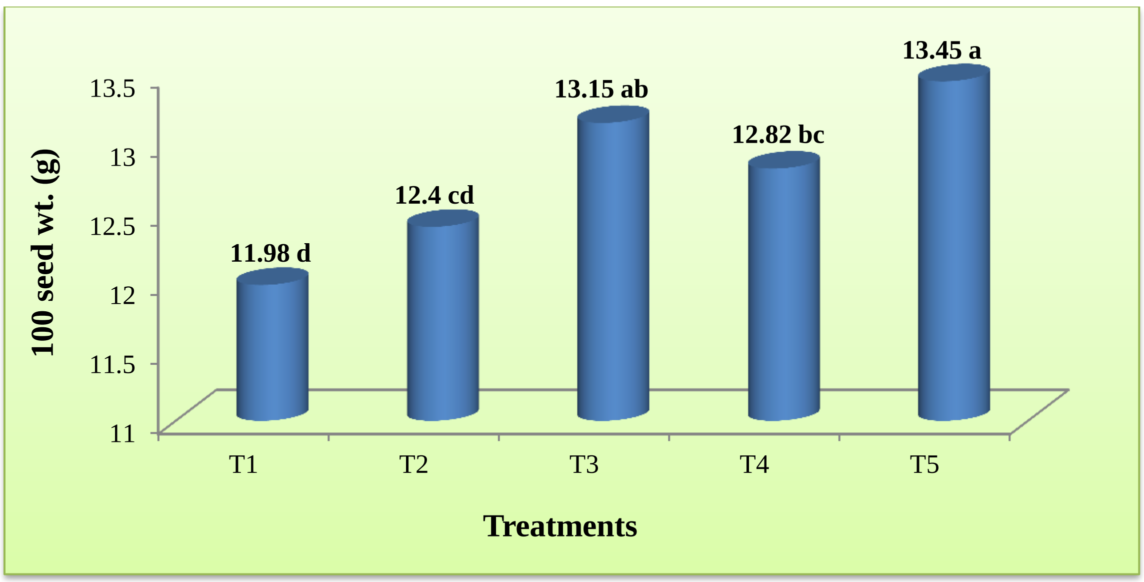


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 20. Effect of variety on the weight of 100 seeds of soybean (LSD $_{(0.05)}$ = 0.86)

4.2.4.2 Effect of foliar spray

Data pertaining to effect of added foliar spray of urea and boron on the weight of 100 seeds of soybean is depicted in figure 21. Statistically significant variation was found for weight of 100-seeds of soybean due to different foliar spray. Results indicated that the highest weight of 100-seeds (13.45 g) was recorded from treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) which was significantly highest compared to all treatments in the experiment and exerts statistically at par with treatment T_3 (RF+ Urea (2%) FS at FI) where the value for treatment T_3 was 13.15 g. These two treatment combinations were significantly different from rest of the combinations. The lowest weight of 100 seeds (11.98 gm) was observed from T_1 (Recommended Fertilizer) treatment which was statistically at par with treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation) where the value for treatment T_2 was 12.40 g. Similarly, Crak *et al.* (2006) observed that foliar application of boron (0, 0.5, 1, 1.5 and 2 kg ha^{-1}) improved 1000- seed weight (5%) of soybean. Manonmani and Srimathi (2009) reported that, spraying with urea one percent recorded higher 100 seed weight (5.6 and 5.5 g).



T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 21. Effect of foliar spray of urea and boron on the weight of 100 seeds of soybean ($LSD_{(0.05)}$ = 0.63)

4.2.4.3 Combined effect of variety and foliar spray

Combined effect of variety and foliar spray of urea and boron showed statistically significant variation for the weight of 100-seeds of soybean(Table 7).As per the results presented in Table 7, it was found that the highest weight of 100 seeds (14.03 g) was obtained from the treatment combination of V_2T_5 which was statistically similar with

V_2T_3 and V_2T_4 combinations (13.77 and 13.40 g, respectively). On the other hand, the lowest weight of 100-seeds (11.23 g) was recorded from V_1T_1 treatment combination which was statistically at par with V_1T_2 (11.67 g) combination.

Table: 7. Combined effect of variety and added foliar spray of urea and boron on the pods plant^{-1}, pod length, seeds pod^{-1} and 100 seed weight of soybean

Treatment combinations	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	100 seed weight (g)
V_1T_1	43.67 e	3.34	2.37 d	11.23 f
V_1T_2	46.33 de	3.44	2.44 cd	11.67 ef
V_1T_3	52.33 b-e	3.61	2.64 a-d	12.53 c-e
V_1T_4	49.33 c-e	3.51	2.54 b-d	12.23 de
V_1T_5	55.67 a-c	3.69	2.74 a-d	12.87 b-d
V_2T_1	51.33 b-e	3.57	2.69 a-d	12.73 c-e
V_2T_2	54.67 a-d	3.65	2.78 a-d	13.13 b-d
V_2T_3	60.33 ab	3.83	2.97 ab	13.77 ab
V_2T_4	57.33 a-c	3.75	2.85 a-c	13.40 a-c
V_2T_5	63.67 a	3.91	3.05 a	14.03 a
LSD $_{(0.05)}$	9.03	NS	0.45	0.89
CV (%)	9.76	6.31	9.65	4.04

NS = Non-significant

In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1= BARI soybean 5

V_2= BARI soybean 6

T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI,

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

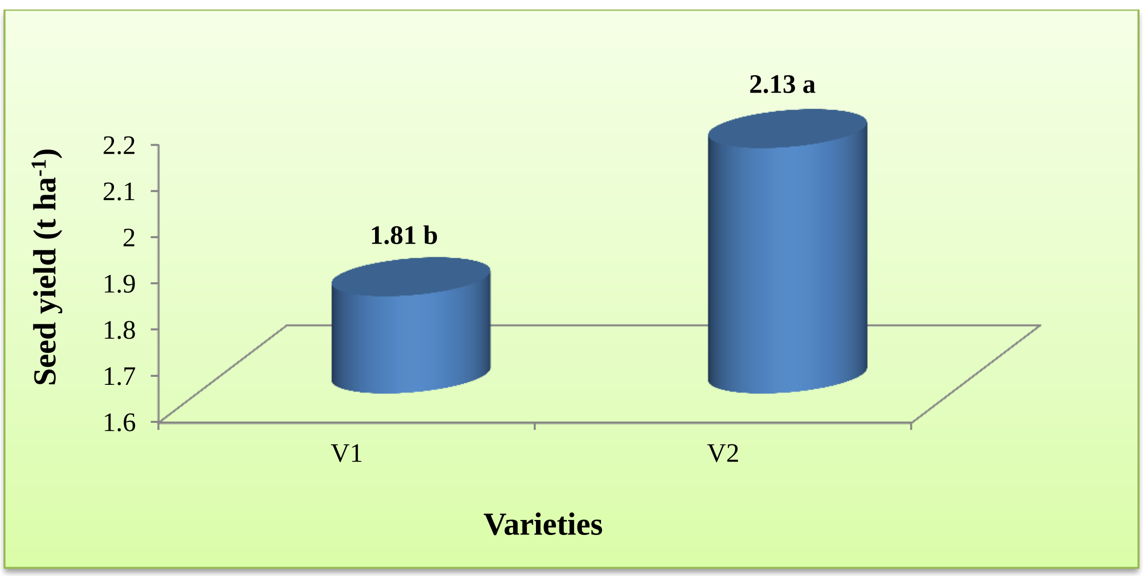
4.3 Yield parameters

4.3.1 Seed yield (t ha^{-1})

The grain yield is the ultimate outcome for final assessment of treatments in any agronomical investigation. The data pertaining to seed yield have been given in Table 8 and also depicted in figure 22 and 23.

4.3.1.1 Effect of variety

Seed yield (t ha^{-1}) varied significantly between the two soybean varieties. Figure 22 represents the effect of variety on seed yield (t ha^{-1}) of soybean. The higher seed yield (2.13 t ha^{-1}) was recorded from variety V_2 (BARI soybean 6), which was significantly superior compared to variety V_1 (BARI soybean 5) and the lower seed yield (1.81 t ha^{-1}) was observed from variety V_1 (BARI soybean 5). The results were supported by Popovic *et al.* (2013c) reported that soybean varieties had higher yield in the variant with foliar fertilization (composition: 12% N and 0.008% B) than in the control. Oppositely, Chowdhury *et al.* (1985) obtained that foliar fertilization did not significantly effect on the grain yield in soybean cultivars.

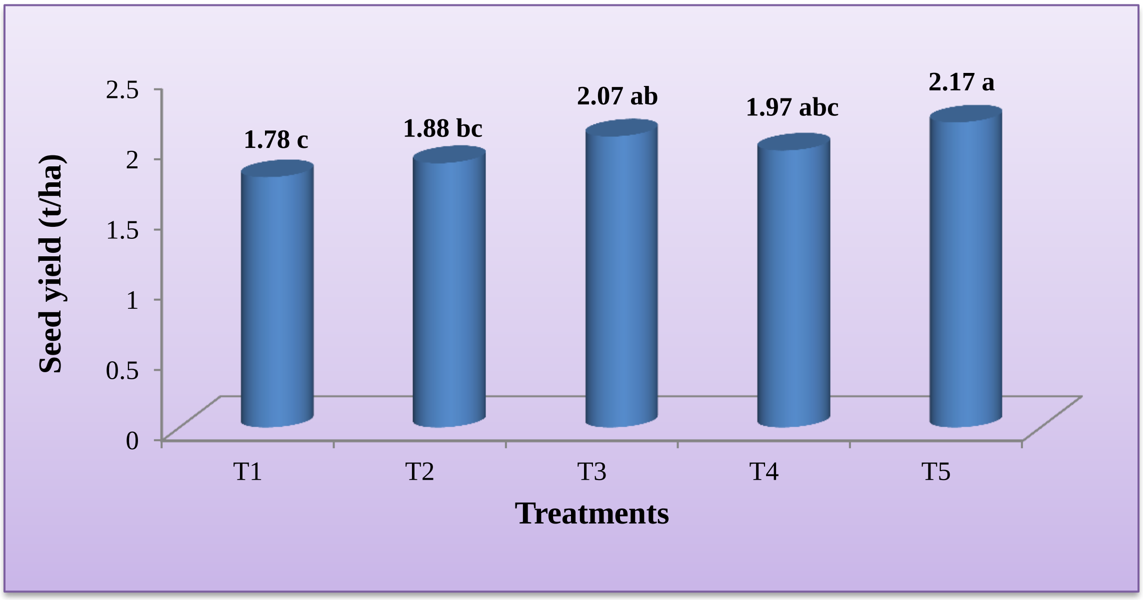


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 22. Effect of variety on the seed yield of soybean (LSD $_{(0.05)}$ = 0.31)

4.3.1.2 Effect of foliar spray

Data pertaining to effect of added foliar spray of urea and boron for seed yield are depicted in Figure. 23. Statistically significant variation was recorded for seed yield of soybeandue to foliar spray of urea and boron. Results obtained that the highest seed yield (2.17 t ha^{-1}) was obtained from treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) which was significantly highest compared to all treatments in the experiment and statistically similar with treatment T_3 (RF+ Urea (2%) FS at FI) and treatment T_4 (RF+ Boron (1%) FS at FI) where the value for treatment T_3 (2.07 t ha^{-1}) and for treatment T_4 (1.97 t ha^{-1}). These three treatments, however, were significantlydifferent from rest of the treatments. The lowest seed yield (1.78 t ha^{-1}) was observed from T_1 (Recommended Fertilizer) treatment which was statistically similar with treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation) and treatment T_4 (RF+ Boron (1%) FS at FI) where the value for treatment T_2 was (1.88 t ha^{-1}) and for treatment T_4 was (1.97 t ha^{-1}). The results of the present study on seed yield ha^{-1} was supported by the findings of Bruns (2017) reported that soybean yield increased due to foliar boron application. Kamel *et al.* (2008) reported that seed yield increased significantly with N foliar application of soybeans. Saravana (2012) also found higher yield in soybean due to foliar application of N @ 2 per cent+ boron spray @ 0.15 per cent.



T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 23. Effect of added foliar spray of urea and boron on the seed yield of soybean (LSD $_{(0.05)}$ = 0.23)

4.3.1.3 Combinedeffect of variety and foliar spray

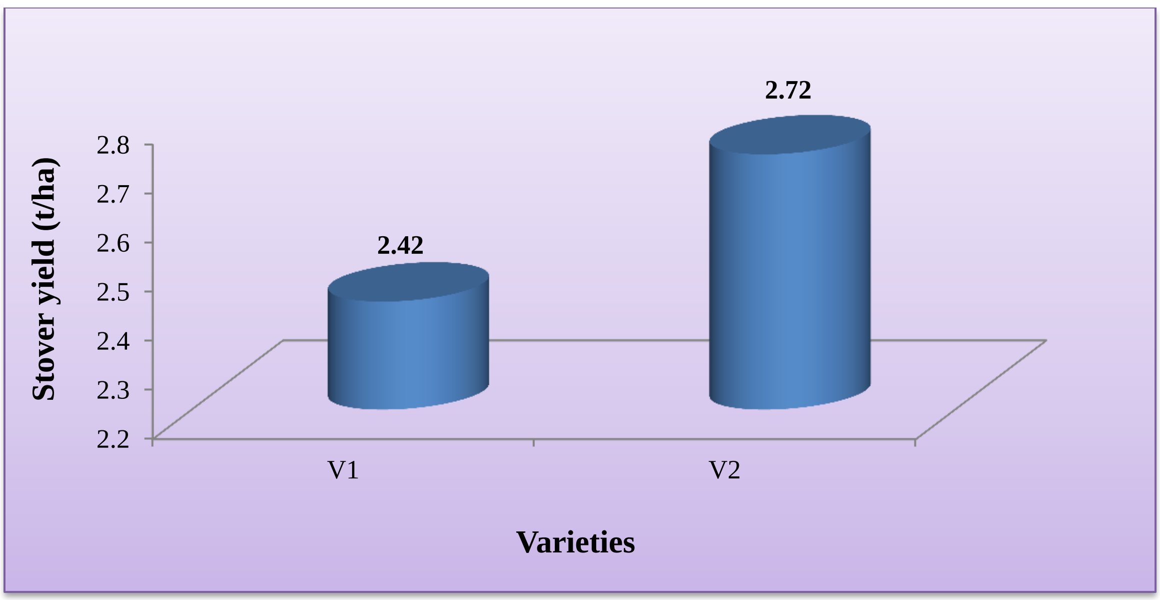
Seed yield of soybean was significantly influenced by interaction effect of varieties and added foliar spray of urea and boron (Table 8). Results showed that seed yield of soybean differed from 1.62 to 2.33 t ha^{-1} due to foliar spray of urea and boron combination in presence of recommended dose.The highest seed yield (2.33 t ha^{-1}) was observed from the treatment combination of V_2T_5 which was statistically identical with V_2T_3, V_2T_4, V_2T_2 and V_1T_5 combinations.The yield increase due to RF+ Urea (2%) + Boron (1%) FS at FI i.e. V_2T_5 treatment combination was 0.71 t ha^{-1}which was 44% over V_1T_1 combinations. Inclusion of urea (2%) only as foliar spray with RF (V_2T_3) was efficient in improving yield of the crop, which was 38% over V_1T_1 combination. Use of boron (1%) only as foliar spray with RF (V_2T_4) was also improving yield, which was 31% over V_1T_1 combination.Application of urea (2%) and boron (1%) as foliar spray either singly or both along with recommended fertilizer (T_5) offered favorable response, which resulted in higher yield due to higher pods plant^{-1} and 100- seed weight. The lowest seed yield(1.62 t ha^{-1}) was found from V_1T_1 treatment combination followed by V_1T_2, V_1T_3,

V_1T_4 andV_2T_1 combinations where the value was (1.72, 1.9, 1.83 and 1.95 t ha^{-1}, respectively).

4.3.2 Stover yield (t ha^{-1})

4.3.2.1 Effect of variety

There were no marked differences in stover yield of soybean due to varietal variation are depicted in Figure 24. Varietal effect on stover yield of soybean was found statistically insignificant in this experiment.Though varietal variation had no effect on stover yield, the maximum stover yield (2.72 t ha^{-1}) was observed from variety V_2 (BARI soybean 6) and the minimum stover yield (2.42 t ha^{-1}) was obtained from variety V_1 (BARI soybean 5).

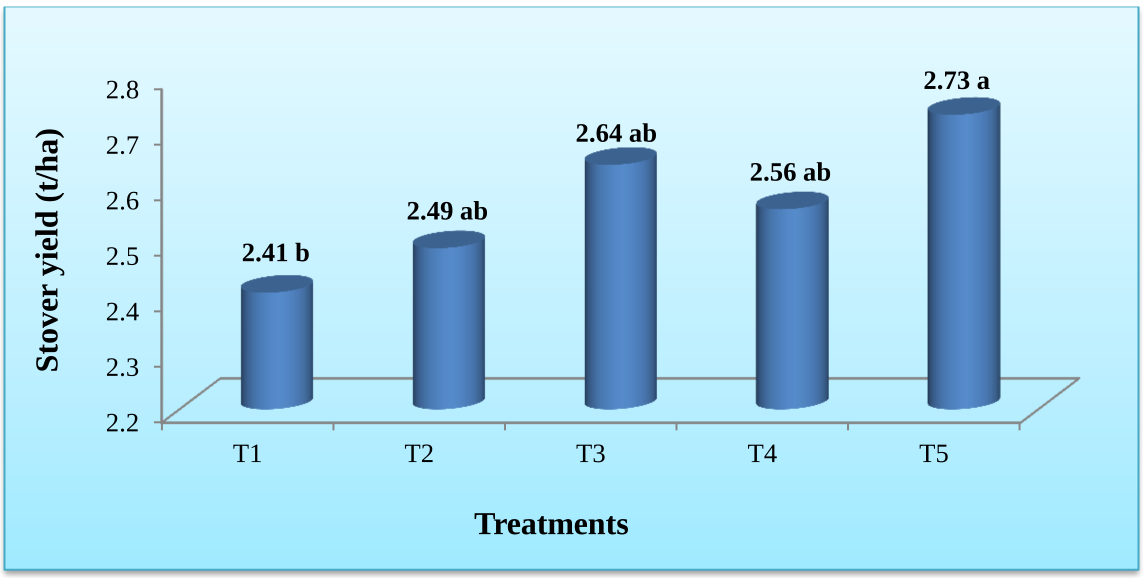


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 24. Effect of variety on the stover yield of soybean (LSD $_{(0.05)}$ = NS)

4.3.2.2 Effect of foliar spray

The data related to the effect of added foliar spray of urea and boron on stover yield of soybean presented in figure 25. Stover yield of soybean was affected significantly due to the different foliar treatments of urea and boron.The results showed that the highest stover yield (2.73 t ha^{-1}) was gained from treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) which was significantly highest over treatment T_1 (Recommended Fertilizer) and exhibit statistical similarity with treatment T_3 (RF+ Urea (2%) FS at FI), treatment T_4 (RF+ Boron (1%) FS at FI) and treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation) where the value for treatment T_3 (2.64 t ha^{-1}), for T_4 (2.56 t ha^{-1}), and for treatment T_2 was (2.49 t ha^{-1}). And the lowest stover yield (2.41 t ha^{-1}) was observed from T_1 (Recommended Fertilizer) Treatment which was statistically at par with treatment T_2, T_3 and T_4. The results of the present study were similar with the findings of El-Abady *et al.* (2008) reported that foliar applications treatment of urea and boron significantly increase stover yield and seed yield.



T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 25. Effect of foliar spray of urea and boron on the stover yield of soybean (LSD $_{(0.05)}$ = 0.28)

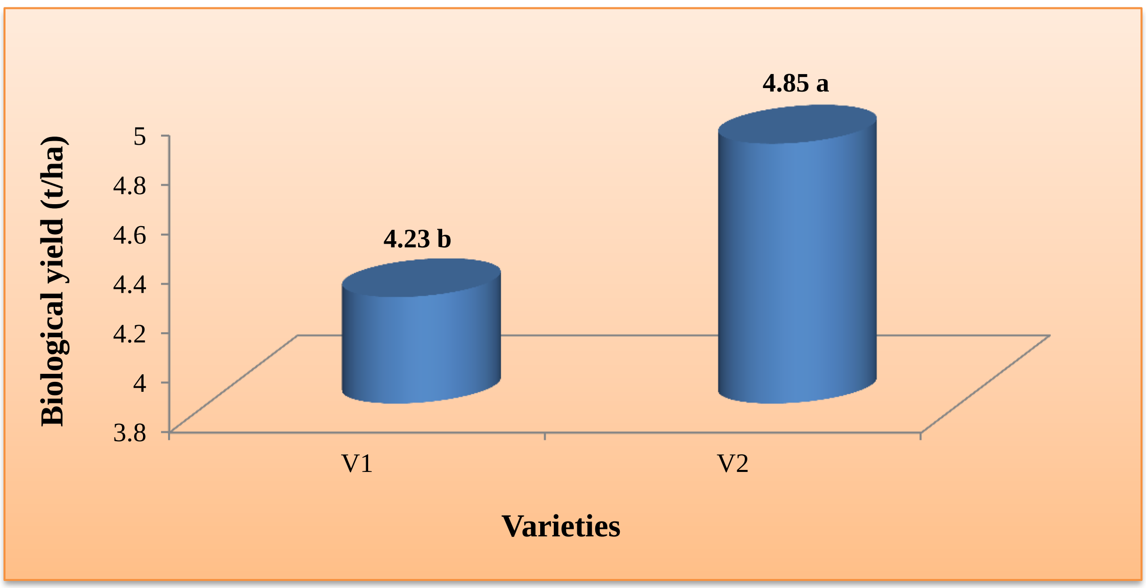
4.3.2.3 Combined effect of variety and foliar spray

Perusal of data that are presented in Table 8 showed that the stover yield of soybean was varied significantly due to the interaction effect of soybean varieties and added foliar spray of urea and boron. The results revealed that the highest stover yield (2.90 t ha^{-1}) was obtained from the treatment combination of V_2T_5 which was statistically at par with all other treatment combinations except V_1T_1. And the lowest stover yield (2.28 t ha^{-1}) was found from V_1T_1 treatment combination which was also statistically similar with all other treatment combinations except V_2T_5.

4.3.3 Biological yield (t ha^{-1})

4.3.3.1 Effect of variety

Results depicted in figure 26 represent the effect of variety on biological yield of soybean. Biological yield varied significantly due to the different soybean varieties. It was found that the highest biological yield (4.85 t ha^{-1}) was recorded from variety V_2 (BARI soybean 6), which was significantly superior compared to variety V_1 (BARI soybean 5) and the lowest biological yield (4.23 t ha^{-1}) was observed from variety V_1 (BARI soybean 5).

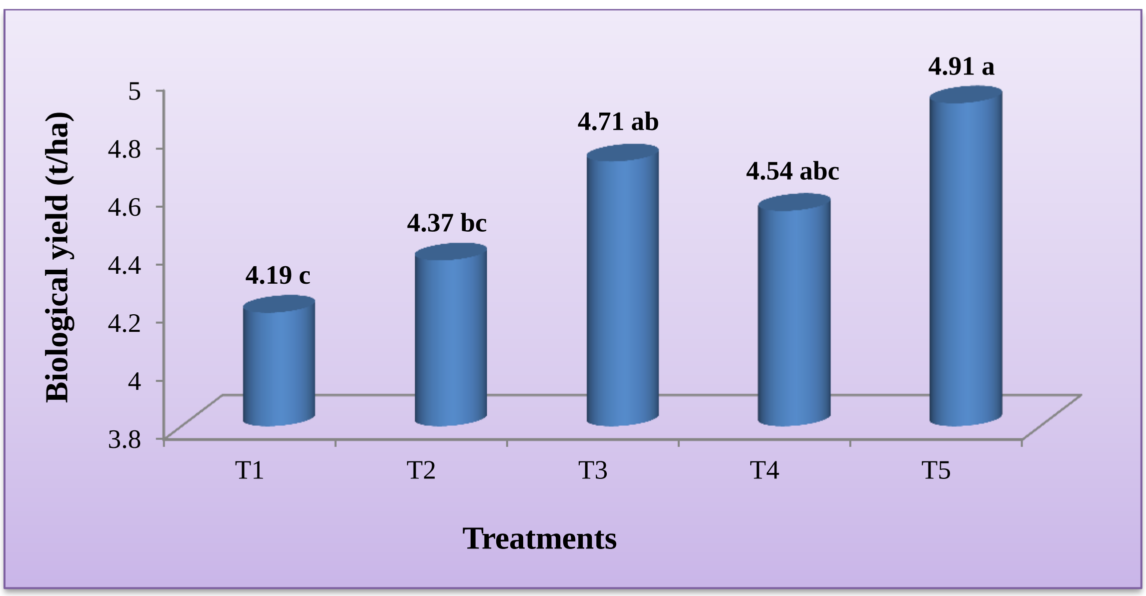


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 26. Effect of variety on the biological yieldof soybean (LSD $_{(0.05)}$ = 0.53)

4.3.3.2 Effect of foliar spray

The effect of added foliar spray of urea and boron on biological yieldof soybean is depicted in Figure 27. Statistically significant variation was recorded for biological yield of soybeandue to different foliar spray of urea and boron. Results obtained that the highest biological yield (4.91 t ha^{-1}) was obtained from treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) which was significantly highest compared to all treatments in the experiment and statistically identical with treatment T_3 (RF+ Urea (2%) FS at FI) and treatment T_4 (RF+ Boron (1%) FS at FI) where the value for treatment T_3 was (4.71 tha^{-1}) and for treatment T_4 was (4.54 t ha^{-1}). The lowest biological yield (4.19 t ha^{-1}) was observed from T_1 (Recommended Fertilizer) treatment which was statistically at par with treatment T_2 (RF+ Foliar Spray (FS) of water at flower initiation) and treatment T_4 (RF+ Boron (1%) FS at FI) where the value for treatment T_2 was 4.37 t ha^{-1} and for treatment $T_4$4.54 t ha^{-1}.



T_1= Recommended Fertilizer (RF)
T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)
T_3= RF+ Urea (2%) FS at FI
T_4= RF+ Boron (1%) FS at FI
T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 27. Effect of foliar spray of urea and boron on the biological yieldof soybean (LSD $_{(0.05)}$ = 0.41)

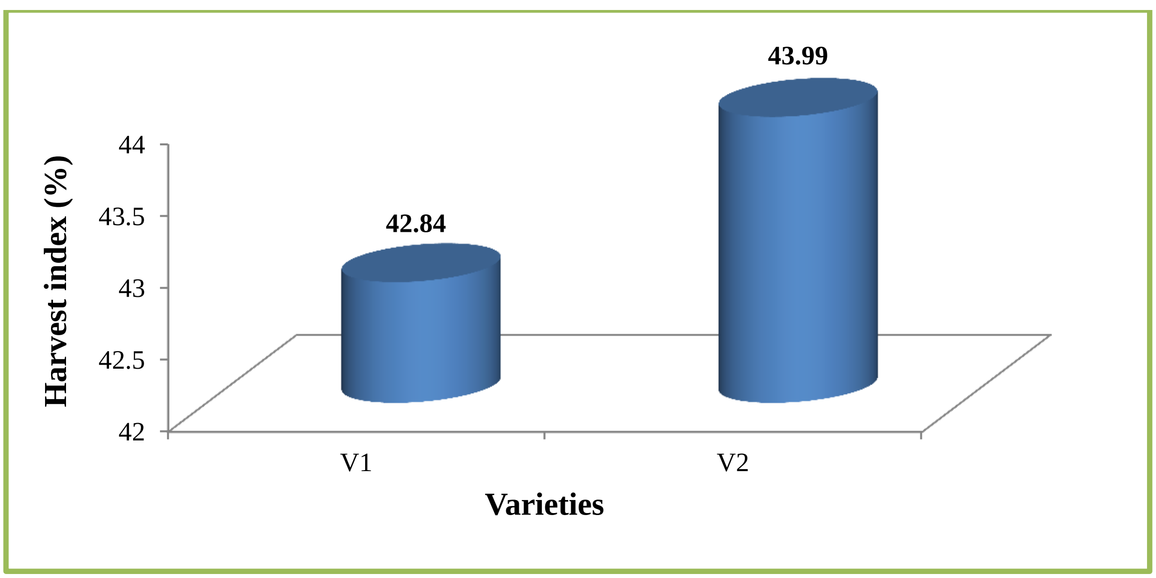
4.3.3.3 Combined effect of variety and foliar spray

According to the data presented in the Table 8 indicated that biological yield of soybean was significantly influenced by the interaction effect of varieties and added foliar spray of urea and boron (Table 08). The highest biological yield (5.24 t ha^{-1}) was obtained from the treatment combination of V_2T_5 which was statistically identical with V_2T_3, V_2T_4, V_2T_2 and V_1T_5 combinations (5.04, 4.83, 4.68 and 4.58 t ha^{-1}, respectively). On the other hand the lowest biological yield (3.90 t ha^{-1}) was found from V_1T_1 treatment combination followed by V_1T_2, V_1T_3, V_1T_4 andV_2T_1combinations (4.07, 4.38, 4.24 and 4.48 t ha^{-1}, respectively).

4.3.4 Harvest index (%)

4.3.4.1 Effect of variety

Variety of soybean showed no significant variation in terms of harvest index (Fig. 28). The maximum harvest index (43.99 %) was observed from variety V_2 (BARI soybean 6) and the minimum harvest index (42.84 %) was obtained from variety V_1 (BARI soybean 5).

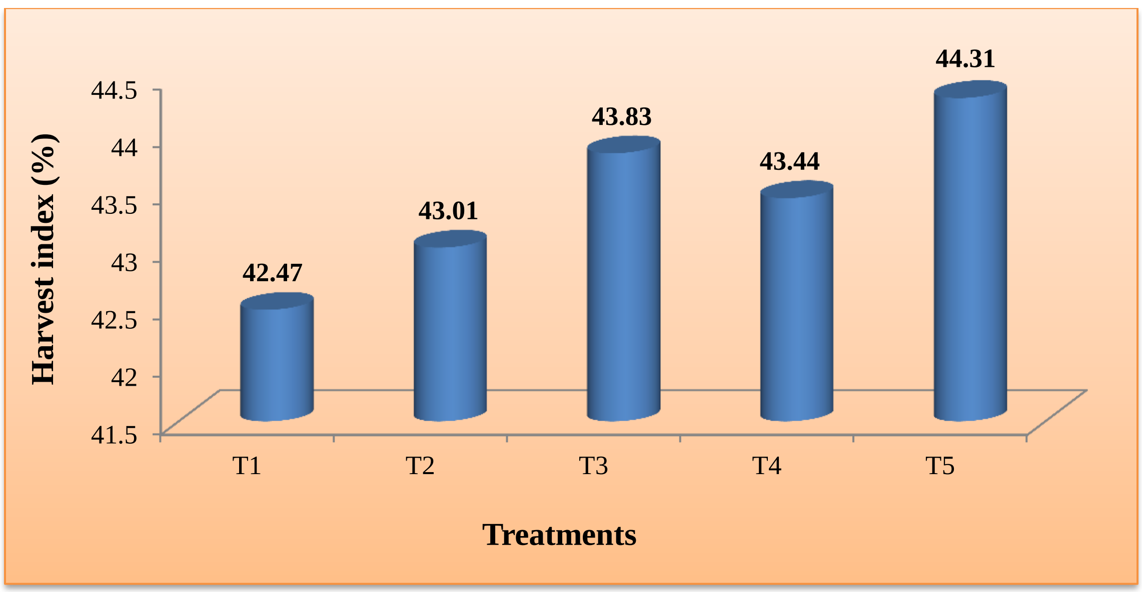


V_1= BARI soybean 5 V_2= BARI soybean 6

Figure. 28. Effect of variety on harvest index (%) of soybean (LSD $_{(0.05)}$ = NS)

4.3.4.2 Effect of foliar spray

Data obtained on harvest index of soybean due to effect of added foliar spray of urea and boron is depicted in Figure 29. Statistically non-significant variation was recorded for harvest index. The highest harvest index (44.31 %) was observed treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) and the lowest harvest index (42.47 %) was observed from T_1 (Recommended Fertilizer) treatment. Similar results were found by Uikey (2012) concluded with the findings that harvest index remains unchanged due to foliar boron treatments. Opposite results were found by Ahmad *et al.* (2009) and the results showed that application of 1% boron solution significantly affected harvest index.



T_1= Recommended Fertilizer (RF)
T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)
T_3= RF+ Urea (2%) FS at FI
T_4= RF+ Boron (1%) FS at FI
T_5= RF+ Urea (2%) + Boron (1%) FS at FI

Figure. 29. Effect of foliar spray of urea and boron on harvest index of soybean (LSD $_{(0.05)}$ = NS)

4.3.4.3 Combined effect of variety and foliar spray

Perusal of data that is presented in Table 8 showed that the harvest index of soybean was not significantly influenced by interaction effect of varieties and added foliar spray of urea and boron. It was observed that the maximum harvest index (44.59 %) was obtained from the treatment combination of V_2T_5. On the other hand the minimum harvest index (41.50 %) was found from V_1T_1 treatment combination.

Table: 8. Combined effect of variety and added foliar spray of urea and boron on the seed yield, stover yield, biological yield and harvest index of soybean

Treatment combinations	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1T_1	1.62 d	2.28 b	3.90 e	41.50
V_1T_2	1.72 cd	2.35 ab	4.07 de	42.23
V_1T_3	1.9 b-d	2.48 ab	4.38 b-e	43.35
V_1T_4	1.83 b-d	2.42 ab	4.24 c-e	43.08
V_1T_5	2.02 a-c	2.57 ab	4.58 a-d	44.03
V_2T_1	1.95 b-d	2.53 ab	4.48 b-e	43.44
V_2T_2	2.05 a-c	2.63 ab	4.68 a-d	43.78
V_2T_3	2.23 ab	2.81 ab	5.04 ab	44.31
V_2T_4	2.12 a-c	2.71 ab	4.83 a-c	43.79
V_2T_5	2.33 a	2.90 a	5.24 a	44.59
LSD $_{(0.05)}$	0.33	0.40	0.58	NS
CV (%)	9.62	9.02	7.41	6.22

NS = Non-significant
In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1= BARI soybean 5

V_2= BARI soybean 6

T_1= Recommended Fertilizer (RF)

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI)

T_3= RF+ Urea (2%) FS at FI

T_4= RF+ Boron (1%) FS at FI,

T_5= RF+ Urea (2%) + Boron (1%) FS at FI

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was carried out at the experimental field of Sher-e-Bangla Agricultural University, Dhaka 1207, during the period from 21 December, 2016 to 6 April, 2017 to examine the impact of application of urea and boron as foliar spray on soybean in presence of recommended fertilizer. Soybean varieties *viz*. V_1 = BARI soybean5 and V_2 = BARI soybean6 and five treatments *viz*. T_1 = Recommended fertilizer (RF) (Urea:TSP:MOP:Gypsum:Boric acid=16.8g:33.6g: 16.8g:16.8g:1.68g),T_2 = RF + Foliar spray (FS) of water at flower initiation (FI), T_3 = RF + Urea (2%) FS at FI, T_4 = RF + Boron (1%) FS at FI, T_5 = RF + Urea (2%) + Boron (1%) FS at FI used as experiment in treatment. The experiment was laid out in split-plot design with three replications. The size of the unit plot was 3.5 m × 2.4 m. Seeds of soybean varieties were sown as sowing was 21 December, 2016 and the crop were harvested on 6 April, 2017. Data were recorded on different growth, yield and yield contributing characters.

Different growth, yield and yield contributing parameters were significantly influenced by the varieties of soybean. The variety V_2 (BARI soybean-6) performed the tallest plant (11.66, 32.55, 46.81, 51.40, 49.41 and 47.13 cm at 20, 40, 60, 80, 100 DAS and harvest respectively, in which statistically significant value was obtained at 20 and 60 DAS), maximum branches plant^{-1} (1.31, 2.57, 3.53 and 3.53 at 45, 60, 75 DAS and harvest, respectively, where significant variation was observed at 45 and 60 DAS), highest dry weight plant^{-1} (0.50, 2.29, 6.56, 9.17, 11.47 and 11.55 g at 20, 40, 60, 80, 100 DAS and harvest, respectively, in which statistically significant mean was recorded for 40, 60, 80, 100 DAS and harvest, respectively), highest crop growth rate (2.97 and 7.12 g m^{-2} d^{-1} at 20-40 and 40-60 DAS, respectively), highest relative growth rate (0.0754 and 0.0523 g g^{-1} d^{-1} at 20-40 and 40-60 DAS respectively) and highest nodules plant^{-1} (13.71, 25.29 and 21.29 at 40, 60 and 80 DAS, respectively, where significant value recorded only at 60 DAS). Variety V_1 (BARI soybean5) performed the shortest plant (10.11, 27.83, 41.34, 45.89, 43.98 and 41.89 cm at 20, 40, 60, 80, 100 DAS and harvest, respectively), minimum branches plant^{-1} (1.04, 2.13, 3.31 and 3.31 at 45, 60, 75 DAS and harvest, respectively), lowest dry weight plant^{-1} (0.44, 1.66, 3.81, 7.29, 10.36 and 10.44 gm at 20, 40, 60, 80, 100 DAS and harvest, respectively), lowest crop growth rate (2.02 and 3.58 g m^{-2} d^{-1} at 20-40 and 40-60 DAS, respectively), lowest relative growth rate (0.0659 and 0.0414 g g^{-1} d^{-1} at 20-40 and 40-60 DAS respectively) and lowest nodules $plant^{-1}$ (11.64, 21.94 and 17.94 at 40, 60 and 80 DAS, respectively). In terms of yield and yield contributing parameters, highest pods $plant^{-1}$ (57.47), pod length (3.74 cm), seeds pod^{-1} (2.87), 100 seed weight (13.41 g), seed yield (2.13 t ha^{-1}), stover yield (2.72 t ha^{-1}), biological yield (4.85 t ha^{-1}) and harvest index (43.99 %) were observed from variety V_2 (BARI soybean6) whereas the lowest pods $plant^{-1}$ (49.47), pod length (3.52 cm), seeds pod^{-1} (2.54), 100 seed weight (12.11 g), seed yield (1.81 t ha^{-1}), stover yield (2.42 t ha^{-1}), biological yield (4.23 t ha^{-1}) and harvest index (42.84 %) were also obtained from variety V_1 (BARI soybean5).

Application of urea and boron as foliar spray also significantly influenced different growth, yield and yield contributing parameters of soybean. The results showed that significantly highest plant height (13.07, 33.90, 48.63, 53.22, 51.10 and 48.82 cm at 20, 40, 60, 80, 100 DAS and harvest, respectively), maximum branches $plant^{-1}$ (1.43, 2.63, 3.59 and 3.59 at 45, 60, 75 DAS and harvest, respectively, where significant variation was observed at 45 and 60 DAS), significantly highest dry weight $plant^{-1}$ (0.54, 2.24, 6.20, 9.59, 12.09 and 12.18 g at 20, 40, 60, 80, 100 DAS and harvest, respectively), highest crop growth rate (2.84, 6.59 and 5.65 g m^{-2} d^{-1} at 20-40, 40-60 and 60-80 DAS, respectively), highest relative growth rate (0.0495 g g^{-1} d^{-1} at 40-60 DAS), significantly highest nodules $plant^{-1}$ (14.35, 25.68 and 21.79 at 40, 60 and 80 DAS, respectively), significantly highest pods $plant^{-1}$ (59.67), significantly highest pod length (3.80 cm), significantly highest seeds pod^{-1} (2.89), significantly highest 100 seed weight (13.45 g), significantly highest seed yield (2.17 t ha^{-1}), significantly highest stover yield (2.73 t ha^{-1}), significantly highest biological yield (4.91 t ha^{-1}) and highest harvest index (44.31 % which is non-significant) were observed from treatment T_5 (RF+ Urea (2%) + Boron (1%) FS at FI). On the other hand the shortest plant height (8.95, 26.67, 39.60, 44.80, 43.27 and 41.05 cm at 20, 40, 60, 80, 100 DAS and harvest, respectively), minimum branches $plant^{-1}$ (0.97, 2.12, 3.25 and 3.25 at 45, 60, 75 DAS and harvest, respectively), lowest dry weight $plant^{-1}$ (0.42, 1.76, 4.15, 7.13, 9.65 and 9.72 gm at 20, 40, 60, 80, 100 DAS and harvest, respectively), lowest crop growth rate (2.23 and 3.98 g m^{-2} d^{-1} at 20-40 and 40-60 DAS, respectively), lowest relative growth rate (0.0420 g g^{-1} d^{-1} at 40-60 DAS), lowest nodules $plant^{-1}$ (11.12, 21.58 and 17.63 at 40, 60 and 80 DAS, respectively), lowest pods $plant^{-1}$ (47.50), lowest pod length (3.46 cm), lowest seeds pod^{-1} (2.53), lowest 100 seed weight (11.98 gm), lowest seed yield (1.78 t ha^{-1}), lowest stover yield (2.41 t ha^{-1}), lowest biological yield (4.19 t ha^{-1}) and lowest harvest index (42.47 %) were obtained from T_1 (Recommended fertilizer) treatment.

Combined effect of varieties and added foliar application of urea and boron also significantly influenced growth as well as yield and yield contributing characters of soybean. The results found that significantly highest plant height (13.97, 36.50, 51.10, 56.23, 54.16 and 51.60 cm at 20, 40, 60, 80, 100 DAS and harvest, respectively), maximum branches $plant^{-1}$ (1.67, 2.91, 3.71 and 3.71 at 45, 60, 75 DAS and harvest, respectively, where significant variation was observed at 45 and 60 DAS), significantly highest dry weight $plant^{-1}$ (0.56, 2.58, 7.90, 10.35, 12.77 and 12.86 g at 20, 40, 60, 80, 100 DAS and harvest, respectively), highest crop growth rate (3.37 and 8.86 g m^{-2} d^{-1} at 20-40 and 40-60, respectively), highest relative growth rate (0.0559 g g^{-1} d^{-1} 40-60 DAS), significantly highest nodules $plant^{-1}$ (14.97, 27.60 and 23.77 at 40, 60 and 80 DAS, respectively), significantly highest pods $plant^{-1}$ (63.67), highest pod length (3.91 cm), significantly highest seeds pod^{-1} (3.05), significantly highest 100 seed weight (14.03 gm), significantly highest seed yield (2.33 t ha^{-1}), significantly highest stover yield (2.90 t ha^{-1}), significantly highest biological yield (5.24 t ha^{-1}) and highest harvest index (44.59 % which is non-significant) were recorded from the treatment combination of $V_2T_5$and on the other hand the shortest plant height (8.13, 24.17, 37.07, 42.35, 41.27 and 39.03 cm at 20, 40, 60, 80, 100 DAS and harvest, respectively), minimum branches $plant^{-1}$ (0.93, 1.94, 3.13 and 3.13 at 45, 60, 75 DAS and harvest, respectively), lowest dry weight $plant^{-1}$ (0.38, 1.45, 3.07, 6.14, 9.18 and 9.24 g at 20, 40, 60, 80, 100 DAS and harvest, respectively), lowest crop growth rate (1.78 and 2.69 g m^{-2} d^{-1} at 20-40 and 40-60 DAS, respectively), lowest relative growth rate (0.0374 g g^{-1} d^{-1} at 40-60 DAS), lowest nodules $plant^{-1}$ (10.21, 20.08 and 16.09 at 40, 60 and 80 DAS, respectively), lowest pods $plant^{-1}$ (43.67), lowest pod length (3.34 cm), lowest seeds pod^{-1} (2.37), lowest 100 seed weight (11.23 gm), lowest seed yield (1.62 t ha^{-1}), lowest stover yield (2.28 t ha^{-1}), lowest biological yield (3.90 t ha^{-1}) and lowest harvest index (41.50 %) were obtained from the treatment combination of V_1T_1.

Based on the results of the present experiment, the following conclusion can be drawn: Foliar spray of nitrogen or boron or their combination at flowering stage along with recommended dose (as basal) had positive effect on plant growth and yield. BARI soybean 6 along with foliar treatment RF (as basal) + urea (2%) + boron (1%) or RF + urea (2%) or RF+ boron (1%) apply in flowering stage gave maximum growth and yield of soybean.

Recommendations

As the results of present study clearly indicates that the foliar application of urea and boron was found superior to soybean crop,further investigation is needed to confirm present findings at different soybeangrowing areas of Bangladesh covering different environment.

CHAPTER VI

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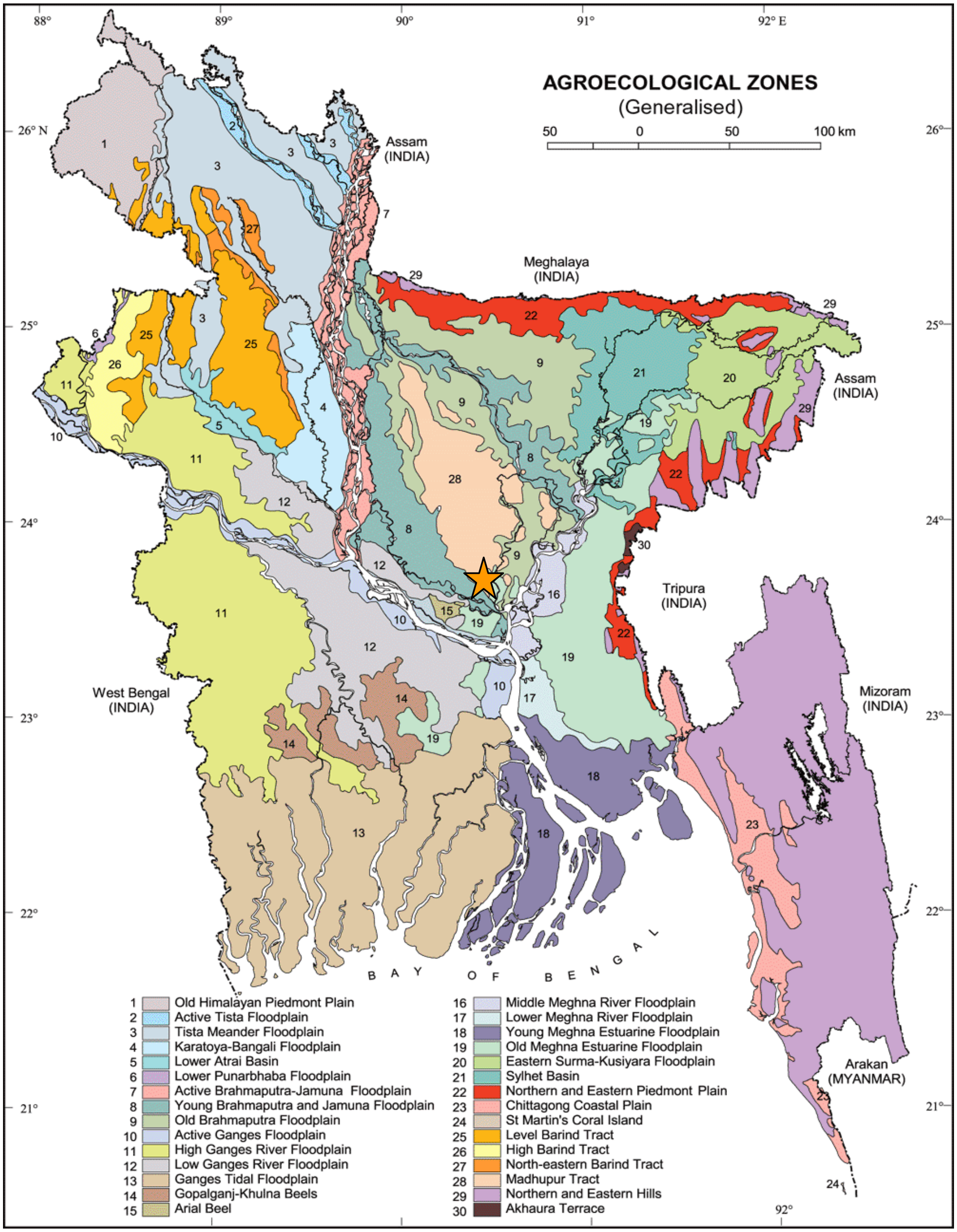
APPENDICES

Appendix I. Map showing the experimental sites under study



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, Madhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	Medium high land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	24
Silt	44
Clay	28
Textural class	Silty clay
Chemical characteristics	
Soil characters	**Value**
pH	6.2
Organic carbon (%)	0.44
Organic matter (%)	0.79
Total N (%)	0.07
Available P (ppm)	20.56
Exchangeable K (me/100 g soil)	0.11

Source: Soil Resource and Development Institute (SRDI), Farmgate, Dhaka

AppendixIII. Monthly record of air temperature, relative humidity and total rainfall of the experimental site during the period from December2016 to April 2017

Month (2016-17)	Air temperature (degrees Celsius)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
December	30.10	17.56	44.11	40
January	31.56	19.56	49.33	45
February	32.79	23.38	63.48	166
March	34.07	25.42	67.83	185
April	34.75	26.70	74.57	375

Source: Bangladesh Meteorological Department (Climate & weather division), Agargaon, Dhaka- 1212

Appendix IV. Analysis of variance of the data on plant height of soybean as influenced by combined effect of variety and foliar spray

Source of variation	df	Mean square of plant height at different days after sowing (DAS)					
		20	40	60	80	100	At harvest
Replication	2	1.327	4.861	47.310	35.211	7.347	288.426
Variety (A)	1	18.02*	166.616 NS	224.680*	227.150 NS	221.245 NS	206.194 NS
Error (a)	2	0.4008	16.902	4.552	33.811	33.571	11.236
Foliar spray (B)	4	15.198**	48.428**	70.262**	63.678*	55.715*	54.797**
Variety (A) X Foliar spray (B)	4	0.1475*	0.290*	0.558*	0.354*	1.565*	1.023*
Error (b)	16	1.0295	5.873	11.138	16.461	18.274	4.514

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Analysis of variance of the data on branches plant^{-1} of soybean as influenced by combined effect of variety and foliar spray

Source of variation	df	Mean square of branches plant^{-1}(no.)			
		45 DAS	60 DAS	75 DAS	At harvest
Replication	2	0.03889	0.01008	0.01794	0.01794
Variety (A)	1	0.55760*	1.39536*	0.3740 NS	0.3740 NS
Error (a)	2	0.01385	0.01562	0.06058	0.0605 NS
Foliar spray (B)	4	0.19577**	0.26146*	0.1114 NS	0.1114 NS
Variety (A) X Foliar spray (B)	4	0.04370**	0.01417*	0.0004 NS	0.00044
Error (b)	16	0.00844	0.05560	0.09517	0.09517

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

AppendixVI. Analysis of variance of the data on dry weight plant^{-1} of soybean as influenced by combined effect of variety and foliar spray

Source of variation	df	Mean square of dry weightat different days after sowing (DAS)					
		20	40	60	80	100	At harvest
Replication	2	0.00102	0.01033	0.6323	0.1905	5.30622	5.96473
Variety (A)	1	0.029 NS	2.977*	56.856*	26.696**	9.307*	9.285*
Error (a)	2	0.00217	0.04900	0.7043	0.1662	0.33033	0.44100
Foliar spray (B)	4	0.014**	0.236**	3.885**	5.647**	5.542**	5.597**
Variety (A) X Foliar spray (B)	4	0.00009*	0.0028*	0.379*	0.0758*	0.0423*	0.046*
Error (b)	16	0.00207	0.03956	0.1883	0.4933	0.36290	0.37635

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

AppendixVII. Analysis of variance of the data on crop growth rate of soybean as influenced by combined effect of variety and foliar spray

Source of variation	df	Mean square of crop growth rateat different days after sowing				
		20-40	40-60	60-80	80-100	100-harvest
Replication	2	0.04922	1.5617	1.2142	11.0912	2.37648
Variety (A)	1	6.719*	93.909*	15.645 NS	12.435 NS	0.0016 NS
Error (a)	2	0.16155	3.0698	1.8537	2.3662	1.73957
Foliar spray (B)	4	0.381*	6.202**	0.697 NS	0.459 NS	0.116 NS
Variety (A) X Foliar spray (B)	4	0.0105*	0.911*	1.737*	0.523 NS	0.0706 NS
Error (b)	16	0.10525	0.5710	2.1423	2.2105	0.42821

NS = Non-significant * = Significant at 5% level ** = Significant at 1% leve

AppendixVIII. Analysis of variance of the data on relative growth rate of soybean as influenced by combined effect of variety and foliar spray

Source of variation	df	Mean square of relative growth rateat different days after sowing				
		20-40	40-60	60-80	80-100	100-harvest
Replication	2	4.408E-05	1.573E-05	2.458E-05	7.462E-05	1.418E-05
Variety (A)	1	6.78E-04 NS	9.02E-04 NS	1.78E-03*	3.295E-04*	3.03E-07 NS
Error (a)	2	8.884E-05	1.511E-04	5.275E-05	1.509E-05	1.359E-05
Foliar spray (B)	4	1.75E-06 NS	5.41E-05 NS	2.75E-05NS	1.82E-05NS	7.15E-07 NS
Variety (A) X Foliar spray (B)	4	1.73E-06 NS	3.92E-06 NS	1.35E-05*	1.024E-05*	4.86E-07 NS
Error (b)	16	3.899E-05	4.304E-05	4.039E-05	2.365E-05	2.772E-06

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IX. Analysis of variance of the data on nodule plant^{-1}of soybean as influenced by combined effect of variety and foliar spray

Source of variation	Degrees of freedom	Mean square of nodule plant^{-1}		
		40 DAS	60 DAS	80 DAS
Replication	2	1.4481	15.4740	7.0008
Variety (A)	1	32.1782 NS	84.2693*	84.5712 NS
Error (a)	2	3.2125	3.1443	4.7342
Foliar spray (B)	4	9.4838*	15.1766*	15.9612*
Variety (A) X Foliar spray (B)	4	0.5447*	0.1512*	0.2430*
Error (b)	16	1.2804	5.2299	4.5330

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

AppendixX. Analysis of variance of the data on yield contributing parameters of soybean as influenced by combined effect of variety and foliar spray

Source of variation	Degrees of freedom	Mean square of yield contributing parameters			
		Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Weight of 100-seeds
Replication	2	11.233	0.00988	0.29786	0.9930
Variety (A)	1	480.0*	0.385 NS	0.79056*	12.8053*
Error (a)	2	18.30	0.5827	0.03308	0.3023
Foliar spray (B)	4	136.617**	0.1132*	0.12797*	2.0463**
Variety (A) X Foliar spray (B)	4	0.083*	0.00016 NS	0.00035*	0.0403*
Error (a)	16	27.225	0.05254	0.06825	0.2656

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XI. Analysis of variance of the data on yield parameters of soybean as influenced by combined effect of variety and foliar spray

Source of variation	Degrees of freedom	Mean square of yield parameters			
		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.03176	0.06379	0.14609	6.3167
Variety (A)	1	0.77120*	0.666 NS	2.871*	9.866 NS
Error (a)	2	0.04034	0.10399	0.11297	20.2595
Foliar spray (B)	4	0.14129*	0.0971*	0.474*	3.033 NS
Variety (A) X Foliar spray (B)	4	0.00051*	0.0017*	0.0019*	0.506 NS
Error	16	0.03614	0.05374	0.11347	7.2997

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

PLATES

Plate 1. Experimental field

Plate 2. Intercultural operation

Plate 3. Foliar Spray on flowering stage

Plate 4. Vegetative stage