RESPONSE OF BLACKGRAM TO FOLIAR APPLICATION OF UREA AND BORON

MST. SADIA AFROJ

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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RESPONSE OF BLACKGRAM TO FOLIAR APPLICATION OF UREA AND BORON

BY

MST. SADIA AFROJ

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Prof. Dr. Md. Fazlul Karim	**Dr. Md. Abdullahil Baque**
Supervisor	**Co-Supervisor**

Prof. Dr. Md. Fazlul Karim
Chairman
Examination Committee

DEPARTMENTOFAGRONOMY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **"Response of Blackgram To Foliar Application of Urea And Boron"** submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of *bona fide* research work carried out by **Mst. Sadia Afroj**, Registration No. **15-06966** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December, 2016

Dhaka, Bangladesh

Prof. Dr. Md. Fazlul Karim

Supervisor

Department of Agronomy

Sher-e-Bangla Agricultural University,

Dhaka-1207

Dedicated To

My Beloved Parents

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ABSTRACT

The experiment was conducted at the Agronomy Research Field, Sher-e-Bangla Agricultural University, Dhaka, during the period from March 2016 to June 2016 to study the response of foliar spray of urea and boron on growth and yield of blackgram varieties. The experiment consists of two varieties viz. V_1 = BARI Mash-2 and V_2 = BARI Mash-3 and eight levels of fertilizer management 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, T_6 = Urea (2%) FS at FI, T_7 = Boron (1%) FS at FI and T_8 = Urea (2%) + Boron (1%) FS at FI. The experiment was laid out in Split-Plot Design with three replications. Results indicated that the variety, BARI Mash-2 gave the tallest plant (49.47 cm), branches plant^{-1}(4.45), above ground dry matter content plant-^{1} (20.875 g) and nodules plant^{-1} (96.13), number of pods plant^{-1} (21.70), pod length (4.19 cm), number of seeds pod^{-1} (10.04), 1000 seed weight (34.96 g), seed yield (1.06t ha^{-1}), stover yield (1.38t ha^{-1}) and biological yield(2.45t ha^{-1}) on the other hand the highest number of leaves plant^{-1} (29.47), seeds pod^{-1} (5.77) and harvest index (44.77%) was produced by BARI Mash-3. In case of fertilizer management, the tallest plant (58.42 cm), pods plant^{-1} (28.85), pod length (4.535cm), seeds pod^{-1}(6.190), 1000 seed weight (38.50g g), seed yield (1.24 t ha^{-1}), stover yield (1.55 t ha^{-1}), biological yield(2.79t ha^{-1}) were recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI), whereas the highest number of branches plant^{-1} (4.35), above ground dry weight plant^{-1} (24.67 g) and nodule plant^{-1}(161.8) were recorded from T_7 (Boron 1%) FS at FI) and the highest harvest index (44.80 %) were recorded from T_6 (Urea 2% FS at FI). Regarding combined effect, the tallest plant (54.27cm), highest above ground dry weight plant^{-1}(28.33 g) number of nodules plant^{-1} (170.7), pods plant^{-1} (31.70), pod length (4.58cm), 1000-seeds wt. (39.67 g), seed yield (1.29 t ha^{-1}), stover yield (1.64 t ha^{-1}) and biological yield (2.93 t ha^{-1}) was found from V_1T_5. Maximum leaves plant^{-1} (37.40), branches plant^{-1} (4.87) was recorded from V_2T_5 and harvest index (46.83%) recorded from V_2T_6. So, variety BARI Mash-2 with T_5 (RF + Urea 2% + Boron 1% FS at FI) is suggested for better result in blackgram cultivation.

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LIST OF ACRONYMS

AEZ	Agro- Ecological Zone
B	Boron
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BRRI	Bangladesh Rice Research Institute
Cm	Centimeter
CV	Coefficient of Variance
cv.	Cultivar (s)
DAT	Days After Transplanting
^{0}C	Degree Centigrade
et al.	And others
FAO	Food and Agriculture Organization
g	Gram (s)
HI	Harvest Index
Hr	Hour(s)
i. e.	That is
K_2O	Potassium Oxide
kg	Kilogram (s)
LSD	Least Significant Difference
M	Meter
m^2	Meter squares
Mm	Millimeter
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Non-significant
%	Percentage
P_2O_5	Phosphorus Penta Oxide
SAU	Sher-e- Bangla Agricultural University
SRDI	Soil Resources Development Institute
t ha^{-1}	Ton per hectare
TSP	Triple Super Phosphate
var.	Variety
Wt.	Weight
Zn	Zinc

CHAPTER I

INTRODUCTION

Blackgram [*Vigna mungo* (L.) Hepper] is one of them which are most important legume protein rich pulses crop of rainfed areas grown thought the country which belongs to family Fabaceace. This is the native of India, and is well known by the names of mashkalai, and urid. It has great value as food, fodder and green manure. In additional to improving the soil fertility, it is a cheap source of protein for direct human consumption. The crop not only fixes free atmospheric N_2 but also enrich the soil with NPK for the growth of succeeding crops (Sen, 1996).

This pulse crop is grown in different cropping system as a mixed crop, catch crop, sequential crop in the country. In Bangladesh, blackgram ranks fourth in acreage and production but ranks second in market price. Blackgram is cultivated in the area of 0.0687 million hectares contributing 9.5% of total pulse production (0.0631 million ton) (DAE, 2016). The average yield of blackgram is very low (756 kg ha^{-1}) compare to other growing areas around the globe. It grows well in north or northwest part of Bangladesh, especially in Rajshahi and Chapai Nawabganj districs. It is relatively a hardier pulse crop. Since it is photo-insensitive legume crop, it can be grown in year round.

It contains major amino acids like methionine, cysteine lycine etc. which are excellent components of protein for human nutrition. Its seeds are a good source of minerals and energy. It has been used as food providing major source of protein in cereal based diet. The dried whole seeds or split are used to make dhal, soups, and curries, which are added to various spiced or fried dishes. The daily consumption of pulses in Bangladesh is only 12.27 g per capita compared to 45.0 g, recommended by Food and Agricultural Organization (FAO, 2003).

It is a crops which require least care for cultivation. It is cultivated with minimum tillage, local varieties no or minimum fertilizers, pesticides and very early or very late sowing, no irrigation and drainage facilities etc. when nitrogen given as basal is very limiting when plant requires adequate at different stage of its growth. All these factors are combined responsible for low yield of blackgram (Hussain *et al.*, 2008).

Soil of Bangladesh is mostly deficient in nitrogen. Nitrogen increases the dry matter and protein percentage of grain as well as methionine and triptophen content in seed (Vidhate *et al.*, 1986). Saini and Thakur (1996) stated that moderate doses of nitrogen (60kg N per hectare) significantly increased the plant height, branches plant^{-1} and leaf area index of grain legumes compared to no N. The higher grain yield of Blackgram is associated with significantly superior yield contributing characters such as pods per plant and 1000 seed weight (Singh *et al.*, 1993).

On the otherhand, relatively low Boron (B) contents in most of the soils in Bangladesh is the another serious problem; only soluble B in soils is available for plants and this is usually about 10% of the total soil B content. The occurrence of B deficiency in most of the soil depends on various factors mainly caused by the reduction of the availability of soluble B in the soil, such as weather conditions (drought, high precipitation), soil conditions (low pH soils: B leaching, calcareous soils: B fixation) and the cultivated crop species (Shorroks, 1997). In plant physiological responses of B deficiency include the loss of membrane integrity and cell wall stability, which result in the development of structural damage in the generative and vegetative organs of crop plants such as blossom wilting and necrosis, reduced pollen production and poor fruit set in the generative organs. The various agronomical practices like spacing, seed rate, sowing time, fertilizer application, weed management and irrigation play an important role in increasing production of blackgram.

Among these factors, foliar application of fertilizer like nitrogen and boron is new concept. Foliar fertilization is one of the most important methods of fertilizer application practices in agriculture because foliar nutrients facilitate easy and quick consumption of nutrients by penetrating the stomata or leaf cuticle and enters the cells. Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching, fixation and regulating the uptake of nutrients by plant (Manonmani and Srimathi, 2009).

Foliar application of N at flowering stage may solve the slow growth, nodule senescence and low seed yield of pulse without involving root absorption at critical stage (Latha and Nadanassababady, 2003).

Application of nutrients through foliar spray at appropriate stages of growth becomes important for their utilization and better performance of the crop (Anandhakrishnaveni *et al.*, 2004).

Amutha *et al.* (2012) reported positive effect of foliar application towads improving yield and yield components of blackgram while added foliar spray on blackgram.

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

i) To compare the growth and yield of different varieties of Blackgram.

ii) To study the effect of added foliar spray in blackgram cultivation.

iii) To study the combined effect of variety and foliar fertilizer management on the growth and yield of blackgram.

CHAPTER II

REVIEW OF LITERATURE

Blackgram is one of the important pulse crops in the country. This crop usually grows with limited care. However, to mitigate climate change effect blackgram draws attention to the researcher. In this connection some research works have been carried out on fertilizer management for improving the yield of field crops. Among the fertilizer management practices, foliar application of nutrients influences growth and yield of field crops have been studied. In this review, an attempt has been made to present relevant literature about the foliar application of fertilizers on morphological characters and yield contributing characters in blackgram and other field crops.

2.1 Effect of foliar application of nitrogen on field crops

Kandagal *et al.* (1990) observed that in pre bloom stage application of 2 percent urea in mungbean showed significantly higher number of flowers. Rajendran (1991) stated that foliar application of 3 percent DAP at flowering and then a fortnight later significantly increased the number of pods plant^{-1}, 1000 grain weight and ultimately grain yield in blackgram and greengram. Gomathi (1996) observed that the number of pods significantly increased in greengram after foliar spray of 1 percent urea.

Barik and Rout (1990) found that foliar application of urea and diammonium phosphate enhanced the yield and yield contributing characters as well as protein content of the seed of blackgram. Application of 2 percent urea increased remarkably protein content in seed of blackgram than other foliage applications.

Sesay and Shibles (1990) reported that the effect of foliar appication of N, P, K on soybean during seed filling stage and also observed that significant yield was increased for foliar nutrients application over control. They also observed that foliar application of nutrients caused delay in leaf senescence. Rupp and Derman (1988) stated that the available literature concerning the correlative influence of seed development of soybean by foliar application of nutrients. Nooden and Leopold (1998) also gave similar opinion about the effect of foliar application of nutrients in legumes.

Sarandon and Gianibelli (1990) reported that the effect of foliar application of urea and nitrogen at sowing on dry matter and nitrogen distribution in wheat (*Triticum aestivum* L.). They reported that foliar spray of urea at the end of tillering showed in increased biological yield, grain yield and total N uptake. Moreover, foliar spray of urea at anthesis or afterwards showed in increased N percent of grain. Spraying of urea at the end of tillering only increased N percent in grain and total N percent when N nutrient availability at sowing was high.

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

Kalarani (1991) reported that the foliar application of 1 percent urea and 50 ppm NAA (nepthelin acetic acid) significantly increased the specific leaf area in soybean. Rajendran (1991) observed that foliar application of 1 percent urea significantly influenced the number of leaves from 7.9 to 9.0 in greengram.

Extensive research was carried out from 1980 to 1990s on foliar fertilization of soybean during reproductive stages showed significant increased grain yield (Mallarino *et al.*, 2001). Garcia and Hanway (1986) reported yield increased of 27 to 31% when liquid N-P-K-S fertilizers were sprayed in soybean at late reproductive stage (R_5-R_6). Several researchers showed that foliar fertilization of soybean either did not increased or decreased 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 results (yield increased > 12%) under irrigated condition of soybean.

Response of cowpea to foliar nutrition of 2 percent urea and 2 percent DAP sprayed on 20 and 30 DAS was found by Srinivasan and Ramasamy (1992). Spraying of 2 percent DAP produced similar yield to that of soil application of N and P and higher yield than urea spray. Sabino *et al.* (1994) reported that the application of urea as side dressing and by foliar spray to cotton crop at Sao Paulo (Portuguese) during 1987-88.

Nitrogen was applied at 0, 25, 50 and 75 kg ha^1 at 35 days after sowing as top dressing with and without urea spray at 1.2 kg N ha^1 at 50 to 85 days after emergence. Increasing rates of applied urea with foliar spray, significantly influenced foliar N content in leaves and seed yield of cotton.

Ramamoorthy *et al.* (1995) studied a field experiment during the rainy seasons of 1989-91 at Vamban, Maharashtra with blackgram 14 treatments compared foliar and/or basal applications of N, P and K. Foliar application of 1% KCl at flowering + pod formation stages and basal applications of 12.5 kg N + 37.5 kg P/ha gave the maximum seed yield of 553 kg/ha, followed by foliar application of 1% K_2SO_4 + basal applications of N + P giving 536 kg/ha.

The field experiment was conducted at the Regional Agricultural Research Station, Nandyal (Andhra Pradesh) during 1992-1993 to obsrved the effect of foliar application of 2 % urea at three growth stages on promising genotypes of blackgram. Urea spray of 2 % at pre flowering, flowering and pod development stages recorded the maximum seed yield (2.082 t ha^{-1}) as compared to water spray (1.185 t ha^{-1}) in the LBG-20 genotype (Manjula Devi and Pillai, 1997).

Selvam *et al.* (1999) observed that top dressing of 10 kg N/ha to groundnut as foliar application at 2 percent Urea pod yielded 2.82 ton/ha while soil application produced 2.47 ton/ha.

Haq and Mallarino (2000) studied that early foliar application of N, P, K increased plant growth and development which resulted increased total dry matter and yield but foliar application of N, P, K at reproductive stage significantly increased seed yield due to increase pod number per plant.

Rawluk *et al.* (2000) observed that at Canada the uptake of foliar application of 15N labelled urea solution at antesis period and its effect on grain yield and protein content of wheat. They observed that grain protein was maximum when urea was applied to the soil than when applied to the foliage.

Pandian *et al.* (2001) observed that the application of basal dose of N and P sprayed along with 2 percent DAP spray registered significantly increased the number of pods /plant and 1000 seed weight as compared to control in greengram.

Mitra *et al.* (1989) conducted a field experiment to 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 decreased the loss of chlorophyll and leaf nitrogen which enhance total dry matter production, pod production, 1000 seed weight and seed yield and similar result was found by Pawar and Bhatia (1980) and Thakare *et al.* (1981) in mungbean.

Subramani and Solaimalai (2002) conducted an experiment to observe the poor production potential of blackgram attributed to poor photosynthetic efficiency, lack of partitioning of photosynthates to pods and seed setting. They reached a conclusión that the favourable influences of foliar application of nutrients with 1 percent DAP + 0.5 per cent urea + 0.25 percent N.

Manivannan *et al.* (2002) was carried out an experiment to observe the combined application of Rhizobium seed treatment and foliar application of N, P, K and chelated micronutrients at 15,30 and 45 DAS resulted in significant increase in growth and yield characters of blackgram. Foliar application of 1 percent DAP + 0.5 per cent urea recorded significantly more number of pods/plant in irrigated blackgram (Subramani *et al*., 2002).

Yakadri and Thatikunta (2002) conducted an experiment and concluded that more number of pods plant^{-1} was found in blackgram when 2 percent DAP and 1percent Urea was sprayed along with soil application of potassium.

Bhattacharya *et al.* (2004) concluded that balanced foliar application of NPK along with B and Mo will be an effective solution in red and lateritic soils for higher grain yield of pulses. Adequate application of NPK fertilizer increased green and blackgram yields by 13% and 38% over the control.

Sritharan *et al.* (2005) observed that significant increase in the growth characters like plant height and leaf area due to foliar application of 2 percent urea sprayed at three stages of crop growth like vegetative, flowering and pod filling stage for blackgram.

Elayaraja and Angayarkanni (2005) stated that foliar application of 2 percent urea applied at 20, 30 and 45 DAS resulted maximum NPK uptake in both seed and stover of blackgram.

Raman and Venkataramana (2006) was conducted a field experiment to evaluate the effect of foliar nutrition on crop nutrient uptake and yield of greengram. There were 10 foliar spray treatments, consisting of water spray, 2% diammonium phosphate at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA. Crop nutrient uptake, yield and its attributes (number of pods per plant and number of seeds per pod) of greengram increased significantly due to foliar nutrition. The foliar application of 2% diammonium phosphate + NAA + Penshibao was significantly superior to other treatments in increasing the values of yield attributes.

Sritharan *et al.* (2007) concluded that 2 percent (%) urea had the profound effect in improving the total chlorophyll content, soluble protein content and NRase activity. Foliar sprays of 2 percent urea showed the highest grain yield of 955.20 kg/ha. The yield may be enhancement due to the improved morphological, physiological, biochemical and yield parameters, viz., plant height, number of pods per plant, grain yield, harvest index, chlorophyll content, soluble protein content and nitrate reductase activity.

Jeyakumar *et al.* (2008) found that foliar spray of 3 percent (%) urea at flowering and then increased significantly the number of pods / plant, 1000 grain weight and ultimately grain yield in blackgram.

Deshmukh *et al.* (2008) a field experiment was conducted during rabi season of 2004-05 at Pulse Research Unit, Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola on medium black soil to evaluate the effect of graded fertility levels and urea spray on growth, yield and economics of rajma. They observed that soil application of 120kg N: 60kg P_2O_5: 40kg K_2O ha^{-1} with foliar spray of 2 % urea at pre flowering and recorded significantly increased growth and yield of rajma at 25 % pod initiation stage.

Kumar *et al.* (2008) a field experiment was conducted to study the effect of organic and inorganic foliar nutrients on the performance of blackgram during summer season of 2002. The growth parameters and yield contributing characters were significantly increased in foliar treatment of 1 % urea sprayed at floral initiation and 15 days after flowering.

Verma *et al*. (2009) concluded that the effect of concentration of urea applied @ 0.25, 0.50 and 1.00 % as foliar application at 45 and 65 DAS on chickpea genotypes during rabi 2005-06 and 2006-07 under rainfed conditions. They observed that all the genotypes significantly improved their nitrate reductase, relative water content and chlorophyll content in leaf with increase in urea concentration upto 1.0 percent. In all gemotypes plant height, 1000 seed weight, seed yield and harvest index were increased with spray of urea up to 1 percent.

Geetha and Velayutham (2009) found that all the growth parameters, NPK uptake and yield were significantly influenced when foliar application of 2% DAP+1% KCl was given at flowering and pod filling stages of crop growth. Interaction between fertilizer application and foliar spray was significant for growth parameters, dry mater production (DMP), and yield.

Mondal *et al.* (2010) concluded that seed protein content, leaf area, chlorophyll content, yield and yield attributes of greengram was increased by foliar application of 1.5 % urea at an interval of 4 days of vegetative growth stages at Mymensingh (Bangladesh).

Yassen *et al.* (2010) resulted that nitrogen concentration and uptake in grain and straw as well as protein yield were significantly increased with spray of 1% urea on wheat as compared to control.

Venkatesh and Basu (2011) observed that the effect of foliar application of urea on growth, yield and quality of chick pea. Seed yield and yield contributing characters were the highest recorded with 2 % foliar spray of urea at 75 DAS. Seed size, leaf and seed nitrogen content as well as protein content were also higher recorded in same treatment.

Khalilzadeh *et al*. (2012) was carried out an experiment on growth characteristics of mungbean affected by foliar application of urea and bio-organic fertilizers. They found that foliar application of urea and organic manure substantially improved leaves plant^{-1}.

Khalilzadeh *et al.* (2012) was carried out an experiment on growth characteristics of mungbean and observed that foliar application of urea and organic manure substantially improved number and dry weight of nodule.

Mondal *et al.* (2012) was carried out a field experiment at the field laboratory of the Bangladesh Institue of Nuclear Agriculture, Mymensingh, Bangladesh to know the effect of foliar spray of urea on physiological characters and yield of soyabean. They observed that foliar application of 1.5 % urea thrice from the beginning of flowering to pod development stage with an interval of 10 days indicated higher seed yield of soyabean and showed superiority in physiological characters and yield contributiong characters.

Salehin and Rahman (2012) was conducted an experiment in factorial format based on RCBD to evaluate the effects of Zn spray (0 and 1 g L^{-1}) and N fertilizer (0, 25, 50 and 75 kg ha^{-1} pure nitrogen) on yield and yield components of Phaseolus vulgaris. In maturity time, seed yield, 1000 seed weight, number of pods $plant^{-1}$ and number of seeds pod^{-1} were measured. Results showed that, use of Zn spray had a significant effect in 1% probability level on all measured traits. Interaction effect of Zn spray and nitrogen fertilizer on number of seed pod^{-1} in 1% and on seed yield in 5% was significant and on other traits was non significant. The highest seed yield was obtained by Zn spray application with 1996 kg ha^{-1}.

Lateef *et al.* (2012) two sets of field experiments were conducted in two successive summer seasons to study the effect of soil and foliar fertilization of mungbean. The first set consider the effect of late foliar application of N or K under different levels of phosphatic fertilization on mungbean yield and chemical constituents. Mungbean (*Vigna radiata* (L) var. Kawmy-l was fertilized with 0,19,38,57 and 76 Kg P_20_5 ha^{-1} at sowing and foliar application of N as 1 % urea solution with K as potassium sulphate 36% K_20 solution; both N and K were applied at early pod formation stage. The second set of experiments objectives was to evaluate the effect of micronutrient application when combined with urea. From this experiment it could be resulted that mungbean productivity responds to combined soil application of P at 57 Kg P_20_5 ha^{-1} and late foliar applied N at early pod formation stage. Foliar spray of urea combined with Fe or Zn may increase seed yield and improve the quality of seeds.

Doss *et al.* (2013) Pot culture experiment was carried out to evaluate the effect of Diammonium phosphate (DAP), Potash (K), Nitrogen (N) and Naphthalene Acetic Acid (NAA) foliar spray treatment on the growth, yield and biochemical constituents of blackgram. The experiment was conducted at Agriculture Farm of St. Joseph‟s College, Trichy, Tamilnadu state during winter 2006 to 2007. Foliar spray treatment with the aqueous solution of nutrients (2% DAP, 1% K, 2% N and 200 ppm NAA, w/v) was done to the 22nd and 30th day old black gram seedlings and also observed that growth, yield and grain yield was significantly increased with foliar application of nutrients. Maximum grain yield was recorded when spread with 1% K + 200 ppm NAA concentration.

Shashikumar *et al.* (2013) conducted a field experiment during kharif season of 2011 to evaluate the effect of growth regulator, organic and inorganic foliar nutrition on yield and yield contributing charecters of blackgram. Application of recommended dose of fertilizers (RDF) as a basal dose and foliar spray of 40ppm NAA+0.5% chelated micronutrient+2% Urea given at 35 and 50 DAS recorded significantly higher growth components like plant height (37.11 cm), number of branches (8.27 plant^{-1}), leaf area index (4.18), and total dry matter production (15.98 g plant^{-1}) and also higher grain yield (1298 kg ha^{-1}), net returns and B/C ratio (Rs 52,900 ha-1 and 3.03 respectively), over rest of the treatments but it was at par with RDF+foliar spray of 2% Urea + 0.5% chelated micronutrient. Phosphorus and potassium uptake (88.32, 10.72 and 35.09 kg ha^{-1} respectively), and available N and P_2O_5 content of soil (278.13 and 28.55 kg ha^{-1} respectively) was significantly higher with the application of RDF+foliar spray of 40 ppm NAA+0.5% chelated micronutrient+2% Urea which was at par with RDF+foliar spray of 2% Urea+0.5% chelated micronutrient.

Wei *et al.* (2013) was carried out an experiment to observe the effect of foliar spray of fertilizers on nutrient status in soil under potato crop. They reported that available N and P content in soil markebly decreased with spraying of 0.5 % urea but yield increasing effect was better under foliar application of nitrogen fertilizers.

Juli *et al.* (2013) observed the effect of foliar application of urea at different stages on growth and yield of chickpea. The highest seed yield and yield contributing characters were recorded with double spray of 2 % urea at 50 % flowering and at 10 days after 50 % flowering. The results also showed double spray of 2 % urea through foliar application significantly increased the pod plant^{-1}, seed size, number of seeds pod^{-1} and 1000 seed weight.

Surendar *et al.* (2013) carried out an experiment to evaluate the effect of nutrients and plant growth regulator on growth and productivity of blackgram variety CO-5. The N, P and K content were estimated at different phenological phases of blackgram. The N and P content of the leaf of blackgram was significantly increased due to foliar spray of Urea 2% and 0.1 ppm brassinolide.

Rahman *et al.* (2014) was carried out a trial and observed that foliar spray of N, P and K significantly increased number of pods/plant, number of seeds / pod, biomass and grain yield. It may be resulted that foliar spray of N, P and K is the suitable application for the maximum yield of blackgram.

Chandrakar *et al.* (2014) carried out an experiment to observe the effect of fertilization on growth and yield of rainfed blackgram. They stated that plant dry weight, plant height, trifoliage leaves plant^{-1}, number of pods plant^{-1} and yield of seed and stover of blackgram were significantly higher recorded with 2 % urea spray (twice fifteen days intervals) as compared to control.

Rao *et al.* (2016) a field experiment was carried out during Rabi season of 2012-13 at Regional Agricultural Research Station, Lam, Guntur, to find out effect of foliar nutrition on physiological and biochemical parameters of mungbean under irrigated conditions. Among foliar nutrients Urea @ 2% resulted higher yield and superior over other foliar sprays. Application of 2% urea resulted more plant height, leaf area, shoot dry weight and by increasing total chlorophyll content, photosynthetic rate and total protein content.

Mahajan *et al.* (2016) carried out a field experiments in sesame on deep black soil of Mamurabad farm, Oilseed Research Station, Jalgaon (Maharashtra) during 2009 and 2010 to find out suitable combination of soil and foliar application of urea and diammonium phosphate for seed yield maximization and remunerative treatments. They found that soil application of RDF + foliar spray of 2 percent urea twice at flowering and pod formation stages significantly increased the yield contributing characters *viz*., number of pod plant $^{-1}$ and number of seeds pod^{-1}. These characters significantly contributed in producing higher seed and oil yields and also more remunerative over soil application of RDF alone.

2.2 Effect of foliar application of boron on field crops

Saxena and Mehrotra (1995) observed that growth and yield of groundnut increased by the foliar application of boron and molybdenum and found that application of 11.2 kg borax per ha. gave the maximum yield. Gupta and Potalia (1997) studied that foliar application of Zn, B and Mo increased total dry matter as well as yield in groundnut.

Varshney (1995) found that foliar application of B, Mo and Cu increased the seed yield of Vigna mungo while Zn, Fe and Mn were less effective. Singh *et al.* (1972) showed that height and total dry matter production were influenced by application of B and Mn.

Patil *et al.* (1993) carried out an experiment to evaluate the effect of boron application on groundnut yield and found that both soil and foliar application of B increased the pod yield significantly. Patel and Golakiya (1996) conducted a pot experiment and found that B at 2 ppm gave the highest pod yield in groundnut. Walker *et al.* (1986) made a conclusion between soil and foliar application of Mn on peanut and concluded that Mn treatments increased yield where 1.68 kg ha^{-1} in 6 application was the best.

Marschner (1995) stated that the rates of foliar B absorption and subsequent translocation increased with other mineral nutrients such as phosphorous (P). It was observed that the rate of P absorption and subsequent translocation by the leaves of phosphorus-deficient plants was higher then in the control.

Barik and Rout (2000) showed in their experiment that foliar spray of micronutrients enhanced the yield, yield contributing characters, nitrogen content of plants and protein content of grains of blackgram. Similar result was also reported by Rulkarim *et al.* (1999) in groundnut. Godonov and Kotyarov (1984) stated that Mo, Mn, B and Zn increased the yield of legume by 23.4, 27.5, 21.3 and 23.5 g against 18.4 g of control.

Wojcik *et al.* (1999) Boron application either as soil or foliar fertilizers is a widely used strategy to increase yield formation (pollination), fruit quality, fruit storage capability and tolerance towards abiotic stress (reduction of reactive oxygen species (ROS) development).

Torun *et al.* (2001) suggested that foliar application of different micronutrients (B, Mn, Mo and Cu) equally or more effective as soil application by different research. They reported that foliar application could be used effectively to overcome the problem of micronutrients deficiency in subsoil. Leiw (1988) have reported increase in crop production due to micronutrients application. Salam (2004) found that foliar application of B increased the plant growth, leaf area index, and root length and root nodules of bean.

Bhattacharya *et al.* (2004) concluded that foliar application of B and Mo improved yield by 38% for greengram and 50% for blackgram over the control. An economic evaluation of each treatment revealed that the complete treatment was most profitable in greengram. However, NPK plus B returned the highest profits in blackgram as marginal yield gains obtained with Mo could not support the current added cost.

Tahlooth *et al.* (2006) carried out two field experiments to evaluate the effect of foliar application of Zn, K or B on growth, yield and yield contributing characters and some chemical constituents of mungbean plants grown under water stress conditions. Irrespective to water stress, foliar application of Zn, K, or B significantly increased all the yield contributing characters compared with control plants. Potassium foliar application had the greatest stimulatory effect on pods number plant^{1}, pods dry weight, number of seeds pod^{1}, seeds dry weight plant^{1}, seed index and seed yield kg fed^{1}. On the other hand, Zn application was superior with respect to straw and biological yield fed^{1}.

Khayyat *et al.* (2007) reported that for comercial plant productiion, providing a sufficient B application is particularly important for fruit formation, fruit quality and crop storability. Cakmak and Romheld (1997) reported that for comercial plant productiion, providing a sufficient B application is particularly important for stress tolerance of blackgram.

Dixit and Elamathi (2007) concluded that foliar application of B (0.5%) in green gram increased the plant height (32.26 cm), number of nodules plant^{-1} (30.8) and dry weight plant^{-1} (12.90 g).

Eichert and Goldbach (2010) observed that the application of foliar formulations nocturnal or diurnal showed no significant differences in foliar B absorption on lychee leaves. But, subsequent translocation of foliar applied B out of the treated leaflet was significantly higher after nocturnal versus diurnal application. During night time stomatal closure may limit the transpiration flow and improve the rate of B distribution from the point of application. Recent publications showed increased B distribution via phloem, after foliar application, in relation to the interruption of the transpiration stream.

Gangwar and Singh (2002) observed the growth and development behaviour of lentil in relation to foliar application of Zn and B in the field experiment and found increased plant height and dry matter production by such in treatment. Similar result was also reported by Devarajan *et al.* (1993) in pulse crops. Sakal *et al.* (1995) studied the effect of Zn and B in Kharif and Rabi maize and observed a significant increase in the dry matter production and grain yield over the control.

Anwarullah and Shivashankar (1999) worked in two separate field experiments with different doses of molybdenum and Boron on green gram and black gram and found that application of molybdenum increased the number of branches, leaves, leaf area index, total dry matter and yield. On the other hand, Srivastova and Varma (1998) concluded that the application of molybdenum failed to exert significant influence on yield attributes, yield and qualitative characters of field pea.

Buneo (1997) found that when Fe, Zn, B and Mn were applied with urea as foliar spray at 30 days after sowing on soybean increased dry matter as compared to control. Hallock (1990) applied B both in broadcast and foliar spray and reported that foliar spray was better than broadcast in peanut.

Gabal *et al.* (1995) conducted an experiment on effect of Cu, Mn, B and Zn foliar application on common bean growth, flowering and seed yield and concluded that spraying with 40 ppm Cu, 25 ppm Mn, 25ppm B and 25 ppm Zn considerably increased the number of flowers plant. Fruit set percentage was considerably increased by 10-20 ppm Cu compared to other treatments. Application of 100 ppm Mn increased the weight of 100 seeds. They also concluded that application of 10 ppm Cu, 100 ppm Mn 50ppm B and 50 ppm Zn significantly increased the total dry matter and seed yield.

Quddus *et al.* (2011) conducted an experiment to evaluate the effect of foliar application of Zn and B on the yield and yield contributing characters of mungbean (*Vigna radiata* L.) and to find out the optimum dose of Zn and B for yield maximization. There were four levels of Zn (0, 0.75, 1.5, and 3.0 % ha^{-1} and B (0, 0.5, 1.0, and 2 % ha^{-1}) along with a blanket dose of N_{20} P_{25} K_{35} S_{20} kg ha^{-1}. Among the treatments, the highest plant height 47.8 cm and 44.0 cm were recorded with Zn level 1.5 % ha^{-1} in the year of 2008 and 2009, respectively, which were statistically identical with T_4 treatment (3.0 % Zn ha^{-1}) for both the years, but statistically significant to others.

Valenciano *et al.* (2010) stated that Spain is the main chickpea producing country in Europe, despite there are few studies on micronutrient application to chickpea. The response of chickpea to the foliar applications of Zn, B and Mo was studied in pot experiments with natural conditions and acidic soils in northwest Spain from 2006 to 2008 following a factorial statistical pattern (5×2×2) with three replications. Five concentrations of Zn (0, 1, 2, 4 and 8 mg Zn pot^{-1}), two concentrations of B (0 and 2 mg B pot^{-1}), and two concentrations of Mo (0 and 2 mg Mo pot^{-1}) were added to the pots. Chickpea resulted to the Zn, B and Mo applications. There were differences between soils. The mature plants fertilized with Zn, with B and with Mo had a greater total dry matter production.

Paul (2009) reported that growth, nodulation, yield and yield contributing characters of blackgram were influenced by the effect of N, Mo, B and Bradyrhizobium inoculant. Bradyrhizobium inoculation in presence of Mo and B recorded the highest root and shoot length.

Vishwakarma *et al.* (2008) stated that maximum plant height (60.33 cm) and number of branches (5.83 $plant^{-1}$) in groundnut were recorded with application of borax as soil application.

Pandey and Gupta (2013) conducted an experiment to study the effect of foliar application of B on reproductive biology and seed quality of black gram. Black gram (*Vigna mungo* L. var. DPU–88–31) was grown under controlled sand culture condition at deficient and sufficient B levels. After 32 days of sowing B deficient plants were sprayed with three concentrations of B (0.05%, 0.1% and 0.2% borax) at three different stages of reproductive development. Foliar spray at all the three concentrations and at all stages increased the yield parameters like number of pods, pod size and number of seeds formed plant^{-1}. Foliar B application also improved the seed yield of black gram.

Nassar (2005) conducted an experiment to study the effect of foliar application of B, Zn, Mn and Fe on the seed and pod yields of groundnut as well as on the nutrient, oil and protein content of seeds. Boron was applied at rates of 75, 150 and 300 mg litre^{-1} as boric acid, whereas Zn, Mn and Fe were applied at rates of 150, 300 and 600 mg litre^{-1} in EDTA from. Foliar spraying with 600 mg Fe, 600 mg Zn, 300 mg Mn and 150 mg B litre^{-1} gave the highest seed and pod yields.

Niranjana (2005) conducted an experiment to evaluate the effect of B (1.0 % kg^{-1} seed), Zn (2% and 4 % kg^{-1} seed) and Mo (2 and 4 % kg^{-1} seed) as seed treatments on the growth and yield of groundnut cv. KRG–1. He concluded that the micronutrient showed significant effect on growth parameters. The Zn at 4% + Mo at 2 % kg^{-1} seed treatment recorded the highest root length (13.66 cm) and its dry weight (887.0 mg) over the control.

Kalyanasundaram (2002) conducted a field experiments and found that foliar application of macronutrient (N, P, K etc) and micronutrient (Zn, B, Mn etc) at 50 ml ha^{1} along with plantozyme (liquid biofertilizer) recorded an additional grain yield of 214 Kg ha^{1} (24.4%) in blackgram. Foliar application of 2% DAP was also followed.

Manonmani and Srimathi (2009) conducted an experiment to study the effects of the foliar application of ZnSO4 (1.0%; T_1), Borax (1.0%; T_2), FeSO4 (1.0%; T_3), MnSO4 (1.0%; T_4), Na_2MoO_4 (1.0%; T_5), DAP [Diammonium phosphate] (2.0%; T_6), urea (1.0%; T_7) and KCl (1.0%; T_8) on blackgram (cv. APK 1) seed yield and quality were studied in Bhavanisagar, Tamil Nadu, India. DAP, followed by urea, resulted in the greatest germination (92 and 88%) and vigour index (3690 and 3256). The resultant seeds were stored under ambient conditions (28+2°C and 70+5% relative humidity) for 12 months. Treatment with DAP and urea maintained the storability of seeds, which were characterized by high germination rates (74 and 70%) and vigour index (2088 and 1820), up to 10 months of storage, whereas the control seeds maintained their viability only up to 8 months of storage.

Goldbach and Wimmer (2007) observed that B and Zn potentiated the seed germination compared with that of control seeds. The B and Zn supplementation individually or together in pot experiments alleviated the salinity (100 mM NaCl) effect on germination, the optimum response was like as in case of petridish culture at 3×10^{-3} mM of B and 3×10^{-4} mM of Zn.

Ali and Mahmoud (2013) carried out an experiment to evaluate the effect of B and Zn foliar application in mungbean on seed yield and yield components under sandy soil conditions. Foliar spray by B, Zn and their interaction had a significant ($p\leq0.05$) effect on number of pods plant^{-1}, number of seeds pod^{-1} and 1000 seed weight traits in the two growing seasons. The maximum seed yields ha^{-1} (2000 and 2030 kg ha^{-1} in first and second seasons, respectively) were found when mungbean plants sprayed with 150 ppm B and 500 ppm Zn with no significant differences between this interaction and obtained seed yield from sprayed mungbean plants with 150 ppm B and 400 ppm Zn in the two growing seasons. This is to be logic since the highest values of yield components and consequently seed yield ha^{-1} gained with the same interaction.

Nalini and Bhavana (2012) showed that B deficiency response on reproductive yield and recovery through foliar application of B was determined in black gram, an important edible legume in India. Results showed that foliar spray of B (0.01 and 0.5% borax) improved not only the flowering, yield parameters like number, size and weight of pods and seeds. Foliar application of 0.5% borax after bud formation was most beneficial not only for reproductive yield but also seed B content.

Roy *et al.* (2011) carried out an experiment where foliar or soil plus foliar methods of B fertilization increased yield attributes including seed pod^{-1}, pod plant^{-1}, 1000 seed weight, both seed and straw yield and uptake of B in green gram over control irrespective of genotypes. The maximum increase in all parameters studied was found in the soil plus foliar application method.

Chitdeshwari and Poongothai (2004) carried out an experiment to evaluate the response of groundnut to the soil application of Zn, B and S and Mo, and also the seed treatment with Zn, B and S. A substantial yield increase was obtained with the soil application of Zn @5 kg ha^{-1} in combination with B @ 1.0 kg ha^{-1} and S at 40 kg ha^{-}

$^{-1}$. The yield increase over the control was 24.2% for TMV 7 and 14.8% for JL 24. Zinc had the most pronounced effect on yield, followed by S and B.

Paul (2009) conducted a pot experiment to study the effect of N, Mo, B and Bradyrhizobium inoculant on growth, nodulation, yield and yield contributing characters nitrogen uptake of black gram. Bradyrhizobium inoculation in presence of Mo and B recorded the highest root and shoot length, seed and stover yield, yield attributes, N and protein content of black gram compared to non–inoculated control. Molybdenum and B performed better results. This result showed that the use of Bradyrhizobium inoculation with Mo and B appeared to be an effective method for successful black gram production.

Islam (2005) showed that seed yield of chickpea (cv. BARI Chola-5) increased significantly due to application of 1 to 1.5 kg B ha^{-1}. In these contexts, application of B and Mo in addition to essential major elements along with a maintenance dose of cowdung has gaining practical significance for boosting up the yield of chickpea.

Ali *et al.* (2002) stated that yield in chickpea losses by varying magnitude, e.g., 22–50% due to Fe up to 100% due to B and 16–30% due to S. Genotypic differences in response to application of Fe, B and S have also been found among chickpea genotypes.

Mishpra *et al.* (2001) carried out an experiment to evaluaate the effect of nutrient management and plant growth regulators on the yield and economics of chickpea in Madhya Pradesh, India during the rabi season of 1998–99. Seeds and stover yields were higher in B and cephalexin treatments compared to the other growth regulator treatments. Boron and P with S treatments gave the highest net returns.

Anita *et al.* (2012) was conducted an experiment to evaluate the optimum concentration of B and Zn needed for early establishment of seedlings including seed germination to mitigate the harmful effect of salinity. *Vigna radiata* L. Wilczek var. Pusa Vishal were germinated and grown under different levels of B (1×10^{-3} mM – 5×10^{-3} mM) and Zn (1×10^{-3} mM – 10×10^{-3} mM) of sterilized seeds under controlled conditions. The decrease was reverted with specific optimal concentration of B (3×10^{-3} mM) and Zn (4×10^{-3} mM). The optimum concentration of B and Zn were thus taken for further sand culture experiments based on maximum germination percentage.

Moghazy *et al.* (2014) carried out an experiment to evaluate the influence of a foliar application with boron and five levels of combinations between compost manure and mineral nitrogen fertilizer as well as their interaction on growth, yield and chemical composition of pea. They found that foliar spray for improving quality and increasing yield with boron (boric acid 17 % B) at 50 ppm and application of nitrogen fertilizer in compost form at 2.5 ton fed^{-1} and inorganic N- fertilizer at 60 kg fed^{-1} in pea field were the most effective treatment.

Salih (2013) conducted pot experiment under greenhouse conditions at Khabat, Iraqi Kurdistan during 2011 and 2012 growth season to evaluate the effect of Fe, B and Zn foliar application on nutrient concentration and seed protein of cowpea (*Vigna Unguiculata*). This experiment was conducted with three concentrations (0, 1 and 2 ppm) of micronutrient solutions were applied. Fe, B and Zn were sprayed every 15 days. The results showed thst foliar application with micronutrients (Fe, B and Zn) might be play critical role in crop growth, involving in photosynthesis processes, respiration and other biochemical and physiological activates and thus their importance in achieving higher yields.

Kaur and Nelson (2014) carried out a field reporting to observe the response of corn to foliar B applications at V_4–V_6 (4–6 leaves with visible collars) and VT (tasseling) growth stages on fine textured soils at four sites from 2008 to 2010 in Northeast Missouri. The treatments included a non-treated control; V_4–V_6 applied B at 0.56, 1.12 and 2.24 kg·ha^{-1}; and VT applied B at 0.28, 0.56 and 1.12 kg·ha^{-1}. They concluded that B applications at VT increased ear leaf tissue B concentration compared to V4–V6 applications and non-treated control, but no significant effect on corn yields. B application of 2.24 kg·ha^{-1} at V_4–V_6 decreased the severity of gray leaf spot and increased the severity of northern leaf blight compared to the non-treated control and at V_4–V_6 at 2.24 kg·ha^{-1} was the most beneficial timing and concentration estimated in these fine textured soils.

Gowthami and Rao (2014) carried out an experiment at Agricultural College Farm, Bapatla during *Kharif* 2013-14 to evaluate the effect of foliar application of potassium, boron and zinc on growth and seed yield of soybean. They observed that foliar application of potassium nitrate @ 2 % + boric acid @ 50 ppm + zinc sulphate @ 1 % (T_7) at 30 and 60 DAS was found to be superior in increasing plant height, number of branches, number of leaves, leaf area, total drymatter, number of pods per plant, test weight and seed yield followed by potassium nitrate @ 2 % + boric acid @ 50 ppm at 30 and 60 DAS (T_4), boric acid @ 50 ppm + zinc sulphate @ 1 % at 30 and 60 DAS (T_6) and potassium nitrate @ 2 % + zinc sulphate @ 1 % at 30 and 60 DAS (T_5) where as minimum results were found in control.

Das and Jana (2015) carried out at experiment at Pulses and Oilseeds Research Station, Berhampore, Murshidabad, West Bengal during *pre kharif, kharif and rabi* seasons of 2011-12, 2012-13 and 2013-14 to evaluate the effect of water soluble fertilizer spray on growth and yield of greengram, blackgram, lathyrus, lentil and chickpea. Five sets of experiments were carried out with three replications *viz.* two levels of basal fertilizer application (F_0 - No basal dose of fertilizer, F_1- Basal dose of fertilizer application @ 20, 40, 40 kg N, P_2O_5, K_2O ha^{-1}.) as one factor and seven levels of foliar spray of water soluble fertilizers at pre flowering stage (no spray, 0.5% NPK, 1% NPK, 2% NPK, 3% NPK, 2% DAP, 2% Urea) as another factor. They found that application of 2% urea significantly increased the seed yield over basal dose of fertilizer application and lowest seed yield was found with no basal fertilizer and spray. Highest seed yield was recorded without basal dose of fertilizer application, with 3% NPK application. Under basal dose of fertilizer application, the results stated thar a gradual increase in yield with the increase in concentration of NPK fertilizer spray up to 2%, among the fertilizer spray treatments irrespective of basal dose of fertilizer application, application of urea was significantly better than all other treatments.

From above discussion it was concluded that foliar application of different fertilizers at different stages improving the growth and yield contributing character of field crops.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka-1207 to study the effect of nitrogen and boron on growth and yield of blackgram. Materials used and methodologies followed in the present investigation have been described in this chapter-

3.1 Description of the experimental site

3.1.1 Site and soil

Geographically the experimental field was located at 23° 77' N latitude and 90° 33' E longitudes at an altitude of 9 m above the mean sea level. The soil under the Agro-ecological Zone - Modhupur Tract (AEZ -28). The topography of land was medium high and soil texture was silty clay with pH 6.1. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-I.

3.1.2 Climate and weather

The climate of the locality is subtropical that is characterized by high temperature and heavy rainfall during Kharif season (April-September) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature. The prevailing weather conditions during the study period have been presented in Appendix-II.

3.2 Plant materials

Seeds of BARI Mash-2 and BARI Mash-3 were used as planting material. BARI Mash-2 was released and developed by BARI in 1996. Plant height of the cultivar ranges from 33 to 35 cm. Average yield of this cultivar is about 1.4-1.5 t ha^{-1}. The seeds of BARI Mash-2 for the experiment were collected from Bangladesh Agricultural Research Institute, Joydepur and Gazipur. The seeds were drum-shaped and blackish and free from mixture of other seeds, weed seeds and extraneous materials. BARI Mash-3 developed by Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh. It was introduced from India and released in 1996. BARI Mash-3 is erect growth habit and attains a height of 35 -38 cm, flowers 35-40 days after emergence and reaches physiological maturity 70-75 days after emergence. Average yield is 1.5-1.6 t ha^{-1}. The seeds of BARI Mash-3 for the experiment were collected from Bangladesh Agricultural Research Institute, Joydepur and Gazipur.

3.3 Treatments of the experiment

The experiment consisted of eight applications 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

T_6= Urea (2%) FS at FI

T_7= Boron (1%) FS at FI

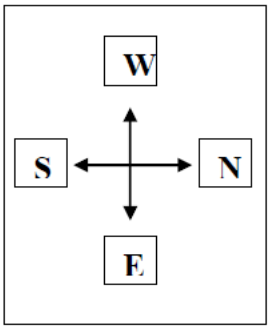
$T_{8=}$ Urea (2%) + Boron (1%) FS at FI

The varieties of BARI Mash-2 and BARI Mash-3 were selected for this study.The distance between the plot and replication was maintained 1m and 1.5 m respectively. The experiment was laid out in split-plot design with three replications.

3.4 Experimental design and layout

The experiment was laid out in a Split-plot Design with three replications. Variety was in main plot and foliar spray in sub plot. The experiment was divided into three blocks and consisted of 16 plots in each plot. Each unit plot in from of raised bed was 5.04 m^2 (2.1m ×2.4 m) in size. Altogether there were 48 unit plots in experiment and required 448.26 m^2 lands. Row to row and plant to plant distance were 30 and 10 cm respectively.

Legend



Treatments:

Factor A: Variety

V_1 = BARI Mash-2

V_2 = BARI Mash-3

Factor B: Fertilizer management

T_1 = RF + Foliar spray (FS) with water at flower initiation (FI)

T_2 = RF + Urea (2%) FS at FI

T_3 = RF + Boron (1%) FS at FI

T_4 = RF + Urea (2%) + Boron (1%) FS at FI

T_5 = Urea (2%) FS at FI

T_6 = Boron (1%) FS at FI

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

T_8 = RF + Foliar spray (FS) with water at flower initiation (FI)

Experiment layout:

Plot size = 2.4m×2.1m, Plot to plot distance = 1 m, Block to block distance = 1.5m

Total land size = 18.60m × 24.10m. Replication = 3

R_1		R_2		R_3	
V_1T_1	V_2T_5	V_2T_7	V_1T_3	V_2T_8	V_1T_5
V_1T_2	V_2T_6	V_2T_8	V_1T_4	V_2T_1	V_1T_6
V_1T_3	V_2T_7	V_2T_1	V_1T_5	V_2T_2	V_1T_7
V_1T_4	V_2T_8	V_2T_2	V_1T_6	V_2T_3	V_1T_8
V_1T_5	V_2T_1	V_2T_3	V_1T_7	V_2T_4	V_1T_1
V_1T_6	V_2T_2	V_2T_4	V_1T_8	V_2T_5	V_1T_2
V_1T_7	V_2T_3	V_2T_5	V_1T_1	V_2T_6	V_1T_3
V_1T_8	V_2T_4	V_2T_6	V_1T_2	V_2T_7	V_1T_4

Figure 1: **Experimental plot design and layout**

3.5 Land preparation

The land, which was selected to conduct the experiment, was opened on 2nd March by power tiller plough. After opening the land with a power tiller, it was ploughed and crossploughed six times with a power tiller and laddering to break up the soil clods to obtain level the land followed each ploughing.

3.6 Manures and fertilizer application

As per recommendation following doses per hectare of manures and fertilizer were applied:

Recommended Fertilizers and Treatment Doses

Fertilizer	Dose (per ha)
Cowdung	10 ton
Urea	40 kg
TSP	80 kg
MP	40kg
Boric Acid	As per treatment

Source: Krishi Projukti Hat Boi

Treatments	Doses/plot
T_1 =Recommended Fertilizer(RF)	RF
T_2 =RF+ Foliar Spray (FS) of water at flower ignition(FI)	RF
T_3 =RF+ Urea2% FS at FI	RF+2g
T_4 =RF+ Boron 1% FS at FI	RF+1g
T_4 =RF+ Urea2% + Boron1% FS at FI	RF+2g+1g
T_6=Urea2% FS at FI	2g
T_7=Boron 1% FS at FI	1 g
T_8=Urea2% + Boron1% FS at FI	2g+1g

3.7 Seed Treatment

The Blackgram Seeds ware treated by Forastin 50 wp @15 g per 1.5 kg seed.

3.8 Seed Sowing

Seed was sowing on the field in line by line method. Row to row and plant to plant distance were 30 cm and 10 cm, respectively. Water was supplied every line before sowing of Blackgram seed. The seed sowing time was 4th March 2016. 80% of seeds were germinated on the 3rd day after sowing.

3.9 Intercultural operations

3.9.1 Weeding and Thinning

1st Weeding, Thinning and Drainage were completed on 20 DAS after sowing on 19th March 2016. 2nd weeding was completed after 15 DAS of first weeding. 3rd weeding was complited at 60 DAS.

3.9.2 Application of irrigation water

Two irrigations were applied to each plot, 1st irrigation was done 15 days after sowing (DAS) and 2nd irrigation was done at 40 DAS.

3.9.3 Plant protection measures

To protect the crops from birds, there had used a trap which made by Tin and Bamboo.

3.10 Harvesting

The crop was harvested plot wise when about 80 percent pod became mature at 75 DAS. The harvested pods were sorted into individual bags for each plot. They were taken to the threshing floor and sun dried for three days. Afterwards the seeds and stover were separately weighed. 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 Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.12 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.13 Recording of data

The data were recorded on the following parameters

i. Plant height (cm)
ii. Leaves plant^{-1} (no.)
iii. Branches plant^{-1}(no.)

iv. Above ground dry weight plant^{-1} (g)
v. Nodules plant^{-1} (no.)
vi. Pods plant^{-1} (no.)
vii. Seeds pod^{-1}(no.)
viii. Pod length (cm)
ix. 1000 seeds weight (g)
x. Seed yield (t ha^{-1})
xi. Stover yield (t ha^{-1})
xii. Biological yield (t ha^{-1})
xiii. Harvest index (%)

3.14 Procedure of recording data

Five plants were randomly selected from inner rows of each plot at 15, 30, 45, 60, 75 DAS and harvest to which different growth data of plant. Yield contributing and yield data were taken at harvest from ten randomly selected plants.

i. Plant height (cm)

The height of the selected plants was measured from the ground level to the tip of the plant and average value determined. Plant height recorded data on total number of 5 plants from every treatment plot and the average was calculated. The height was measured from the ground level to the tip of the plant by a meter scale.

ii. Leaves plant^{-1} (no.)

Leaves plant^{-1} was counted from each plant sample. Leaves plant^{-1} and weight were the first recorded data on 19th March 2016 for the total number of 5 plants from every treatment plot and the average was calculated.

iii. Branches plant^{-1} (no.)

It was done by counting total number of branches of all sampled plants. Number of Branches and weight were the first recorded data on 19th March 2016 for the total number of 5 plants from every treatment plot and the average was calculated.

iv. Nodule plant^{1} (no.)

Total number of nodule per plant^{1} was counted from three randomly selected plants per treatment. It was done on 3rd, 18th April and 3rd May 2016.

V. Above ground dry matter content plant^{-1}

5 randomly collected plant from each plot at 15, 30, 45, 60, 75 and at harvest were collected for taking dry matter content. Fresh sample of plant from each plot were put into envelop and placed in oven maintained at 70^0 for 72 hours and then transferred into desiccators and allowed to cool down at room temperature. The final dry weight of the sample was taken and recorded in gram.

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

Five plants from each plot was uprooted carefully with soil at 30, 45 and 60 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.

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

Numbers of total pods of 10 plants from each plot were counted and the mean numbers were expressed as plant^{-1} basis.

Viii. 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.

ix. Pod length (cm)

Pod length was recorded from randomly selected 20 pods and the mean length was expressed on pod^{-1} basis.

x. Weight of 1000-seeds (g)

Thausand seeds were counted, which were taken from the seeds sample of each plot separately, then weighed in an electrical balance and data were taken.

xi. Seed yield (t ha^{-1})

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

xii. Stover yield (t ha^{-1})

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}.

xiii. Biological yield (t ha^{-1})

The summation of seed yield and above ground stover yield was the biological yield. Biological yield = seed yield + Stover yield.

xiv. Harvest index (%)

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

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

Here, Biological yield = Seed yield + stover yield

3.14 Data analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Present study was undertaken to determine the performance of foliar spray method of urea and boron used in blackgram cultivation. Data on different yield contributing characters and yield related traits were recorded to find out the response of two varieties of blackgram to foliar application of urea and boron. The results of the experiment have been presented, discussed and possible interpretations have been made in this chapter.

4.1 Plant height (cm)

4.1.1 Effect of variety

Plant height increased gradually from 15 days after sowing (DAS) to harvest. Plant height varied significantly at 30, 45, 60, 75DAS and at harvest due to varietal variation of blackgram (Fig. 2). At 15 DAS the longest plant was (7.46 cm) observed at V_1 and the shortest plant (7.00cm) from V_2. At 30 DAS and 45 DAS the longest plant (15.51cm, 34.89cm) was recorded from (V_1) which was statistically similar with blackgram V_2 (14.70cm and 33.48cm) respectively. At 60 DAS the longest plant (41.77cm) was recorded from V_1 and the shortest plant (38.89cm) from V_2. At 75 DAS and harvest the longest plant (45.03cm, 49.47cm) was recorded from (V_1) which was statistically similar with V_2 (43.85cm and 47.79cm) respectively. This result might be due to the genetic variation of different blackgram varieties.

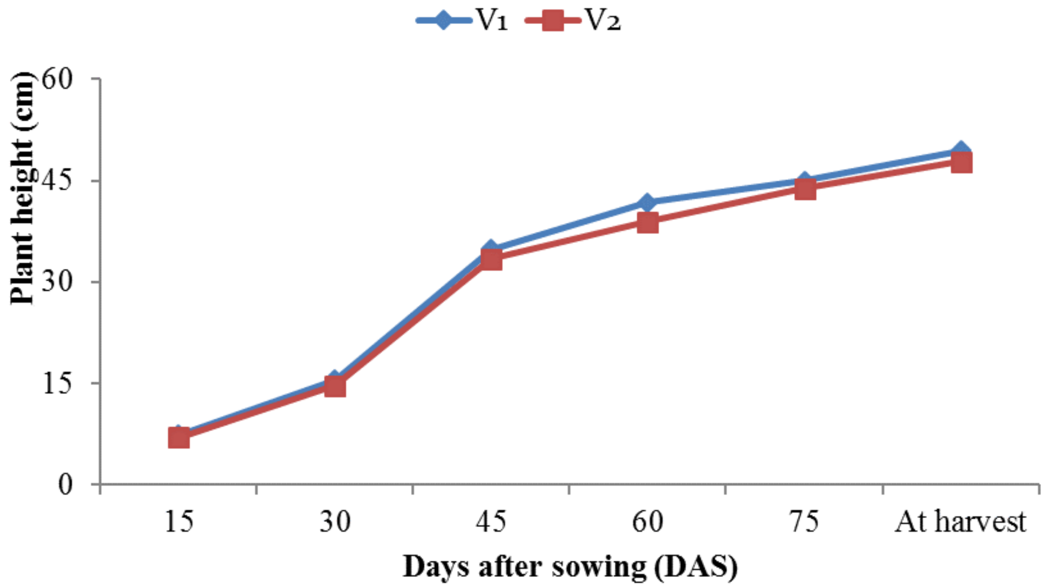


Figure 2. Effect of variety on the plant height of blackgram at different days after sowing (LSD $_{(0.05)}$ = 0.34, NS, NS, 2.86, NS and NS at 15, 30, 45, 60, 75 DAS and at harvest, respectively)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.1.2 Effect of foliar application

Significant variation was observed on the plant height of blackgram when added foliar spray was applied. Statistically significant variation was observed in terms of plant height of blackgram at 15, 30,45,60,75 and harvest treatment management under the present trial (Fig. 3). At 15 DAS the longest plant height (7.54cm) was observed in T_2 which is statistically similar with all other treatment except T_7 and the shortest plant height (6.75cm) was observed in T_7 which is statistically similar with all other treatment except T_2. At 30 DAS the longest plant height (16.14cm) was observed in T_4 which is statistically similar with T_1, T_2, T_5, T_6 and T_8 respectively and the shortest plant height (13.97cm) was observed in T_3 which is statistically similar with T_1, T_2, T_5, and T_7 respectively. At 45 DAS the longest plant height (36.88cm) was observed in T_5which is statistically similar with T_1, T_2, T_3 and T_4 and the shortest plant height (31.22 cm) was observed in T_7which is statistically similar with T_6 and $T_{8.}$ At 60 DAS the longest plant (44.12 cm,) was gained from T_5 which similar with $T_3$and T_8 whereas the shortest plant height (38.71 cm) was from T_7 which was statistically similar with only T_6 not the other treatment. At 75 DAS the tallest plant (49.83cm) was showed by T_5 which is statistically similar with T_1 and T_3 on the other hand the shortest plant

(38.71cm) was observed in T_7 which is statistically similar only T_6. The highest plant height (53.19 cm) was at T_5 which is similar with T_1, T_3, T_4 and T_8 at harvest was found.

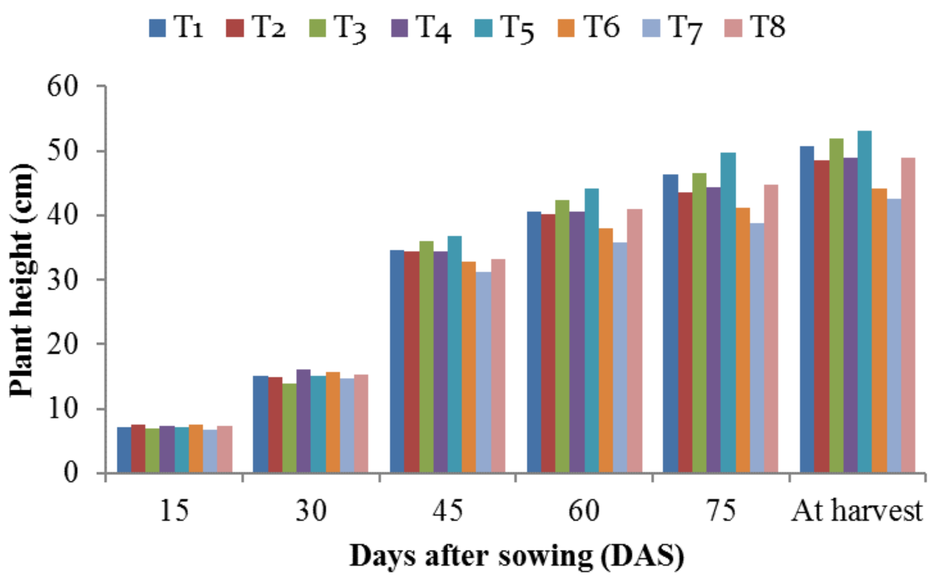


Figure 3. Effect of added foliar application on the plant height of blackgram at different days after sowing (LSD $_{(0.05)}$ = 0.71, 1.29, 2.92, 3.41, 4.00 and 4.41 at 15, 30, 45, 60, 75 DAS and harvest, respectively

T_1= Recommended Fertilizer (RF), T_5= RF+ Urea (2%) + Boron (1%) FS at FI,

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI), T_6= Urea (2%) FS at FI,

T_3= RF+ Urea (2%) FS at FI, T_7= Boron (1%) FS at FI,

T_4= RF+ Boron (1%) FS at FI, $T_{8=}$ Urea (2%) + Boron (1%) FS at FI

4.1.3 Combined effect of variety and foliar application on plant height

Combined effect of variety and foliar spray viewed significant variation in terms of plant height of blackgram at 15, 30, 45, 60, 75 DAS and at the harvest period (Table1). The highest plant height (8.32cm) at 15 DAS was observed at V_1T_2 followed by V_1T_1, V_1T_5, V_1T_8 and V_2T_4 where as the lowest plant height (6.53cm) was in V_2T_7 which was statistically similar with all the treatments except V_1T_2, V_1T_6 and V_2T_1. At 30 DAS the longest plant (16.67cm) was recorded from V_1T_8 which was statistically similar with V_1T_1, V_1T_2, V_1T_4, V_1T_5, V_1T_6 and V_2T_4. At the same DAS, the shortest plant was recorded from V_1T_3 (13.37 cm) which was statistically similar with V_1T_7, V_2T_1, V_2T_2, V_2T_3, V_2T_5, V_2T_6, and V_2T_7. Combined of V_1T_5 scored the highest plant height (37.40 cm) at 45 DAS which was statistically similar with V_1T_2, V_1T_3, V_1T_4,

V_1T_5, V_1T_6, V_2T_1, V_2T_3, V_2T_4 and V_2T_5.On the other hand, the lowest plant height (30.07 cm) was obtained from the combination of V_2T_7 which was statistically similar with V_1T_6, V_1T_7, V_1T_8, V_2T_2, V_2T_4, V_2T_6 and V_2T_8. At 60 DAS, highest plant height (44.87 cm) was recorded from the combination V_1T_5 which was statistically similar with V_1T_1, V_1T_2, V_1T_3, V_1T_4, V_1T_8, V_2T_3 and V_2T_5. The shortest plant height (34.24 cm) was recorded from the combination V_2T_7 which was statistically similar with V_1T_7, V_2T_1, V_2T_2, V_2T_4 and V_2T_6. At 75 DAS longest plant (52.48cm) was observed at V_1T_5 which is statistically dissimilar with all other treatment except V_1T_3 and V_2T_5 whereas the shortest plant (37.01 cm) was at V_2T_7 which is similar only with V_1T_6, V_1T_7 and V_2T_6. At harvest, treatment combination V_1T_5 scored the highest plant height (54.27cm) which was statistically similar with all other combination except V_1T_6, V_1T_7, V_2T_2, V_2T_6, V_2T_7 and V_2T_8. On the other hand, combination V_2T_7gave the lowest plant height (41.09 cm) which was statistically similar with V_1T_6, V_1T_7, V_2T_6 and V_2T_8 treatment combinations at harvest.

Table 1. Combined effect of variety and added foliar application on the plant height of blackgram at different days after sowing

Treatment combinations	Plant height (cm) at different days after sowing (DAS)					
	15	**30**	**45**	**60**	**75**	**At harvest**
V_1T_1	7.42 a-e	15.67 a-e	34.72 a-c	42.73 a- c	46.07 b-d	50.00 a-d
V_1T_2	8.32 a	15.43 a-e	35.57 a-c	41.73 a-d	43.27 b-e	49.27 a-e
V_1T_3	6.73 de	13.37 f	36.47 ab	43.33 ab	47.25 ab	52.92 ab
V_1T_4	7.00 c-e	16.43 a-c	35.44 a-c	42.72 a-c	43.35 b-e	49.59 a-e
V_1T_5	7.41 a-e	15.33 a-e	37.40 a	44.87 a	52.48 a	54.27 a
V_1T_6	8.03 ab	16.60 ab	33.89 a-d	39.58 b-e	41.53 c-f	44.92 c-f
V_1T_7	6.96 c-e	14.60 d-f	32.37 b-d	37.35 d-f	40.40 ef	43.98 d-f
V_1T_8	7.79 a-c	16.67 a	33.27 b-d	41.87 a-d	45.91 b-e	50.83 a-c
V_2T_1	6.97 c-e	14.33 d-f	34.51 a-c	38.40 c-f	46.51 bc	51.45 ab
V_2T_2	6.77 de	14.40 d-f	33.22 b-d	38.67 b-f	44.01 b-e	47.86 b-e
V_2T_3	7.23 b-e	14.57 d-f	35.60 a-c	41.31 a-e	46.05 b-e	50.77 a-c
V_2T_4	7.66 a-d	15.93 a-d	33.37 a-d	38.60 b-f	45.56 b-e	48.45 a-e
V_2T_5	6.95 c-e	14.70 c-f	36.37 ab	43.36 ab	47.19 ab	52.11 ab
V_2T_6	6.86 c-e	14.80 b-f	31.63 cd	36.60 ef	40.84 d-f	43.52 ef
V_2T_7	6.53 e	14.83 b-f	30.07 d	34.24 f	37.01 f	41.09 f
V_2T_8	7.01 c-e	14.03 ef	33.05 b-d	39.93 b-e	43.59 b-e	47.09 b-f
LSD $_{(0.05)}$	**1.01**	**1.83**	**4.13**	**4.82**	**5.65**	**6.23**
CV (%)	**8.33**	**7.24**	**7.23**	**7.14**	**7.60**	**7.66**

V_1= BARI Mash-2, V_2=BARI Mash-3

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,

T_6= Urea (2%) FS at FI,

T_7= Boron (1%) FS at FI,

$T_{8=}$ Urea (2%) + Boron (1%) FS at FI

4.2 Leaves plant^{-1} (no.)

4.2.1 Effect of variety

Blackgram varieties presented data obtained from 30,45,75 and at harvest leaves plant^{-1} at different days after sowing (Fig. 4). At 15 and 30 DAS maximum leaves plant^{-1} (2.58 and 5.52, respectively) was recorded in V_1 which is statistically similar with V_2. At 45 DAS V_1 showed the maximum leaves plant^{-1} (13.08) than V_2 (12.26). At 60 DAS the highest leaves plant^{-1}(16.21) was in V_1 whereas the lowest leaves plant^{-1}(14.38) was observed at V_2. V_1 gave the maximum leaves plant^{-1}(17.40) at 60 DAS which is statistically similar with V_2 (17.34). At the time of harvest maximum leaves plant^{-1}(29.47) was observed in V_2 which is statistically similar with V_1.

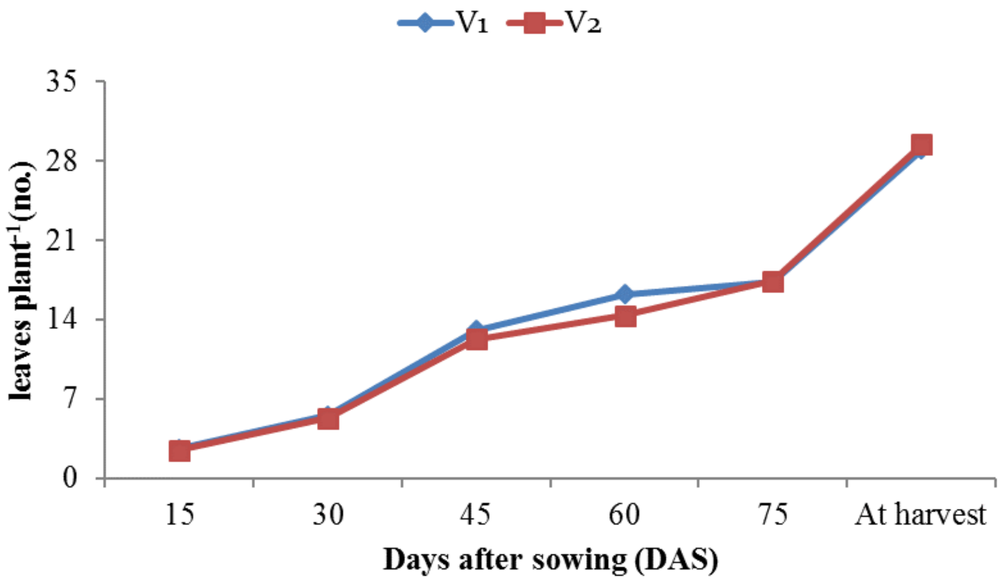


Figure 4. Effect of variety on leaves plant^{-1}(no.) of blackgram at different days after sowing (LSD $_{(0.05)}$ = NS, NS, 0.80, 1.16, NS and NS at 15, 30, 45, 60, 75 DAS and harvest, respectively)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.2.2 Effect of foliar application

The difference was observed in leaves plant^{-1} of blackgram due to different foliar application throughout the growing season (Fig. 5). At 15 DAS T_6 gave maximum leaves plant^{-1} (2.63) which is statistically similar with all other treatment except T_1 which showed the lowest leaves plant^{-1} (2.40). T_5 gave the maximum leaves plant^{-1} (6.27, 15.20, 17.53, 19.60 and 37.07 at 30,45,60,75 DAS and at harvest, respectively) which was statistically at par with T_3 at 30, 45 and 60 DAS and also statistically similar with T_1 and T_3 at 75 DAS. At 30 DAS lowest leaves plant^{-1} (4.88) was showed at T_7 which is statistically similar with T_1, T_2, T_6 and T_8. Lowest leaves plant^{-1} (9.977and 12.23) was observed at T_7 which is statistically dissimilar with all other treatment at 45 and 60 DAS respectively. In T_6 minimum no of leaves plant^{-1} (15.02) was observed at 75 DAS which is statistically dissimilar with all other treatment except T_7. Finally, at harvest lowest leaves plant^{-1} (22.50) was observed at T_7 which is statistically dissimilar with all other treatment except T_6.

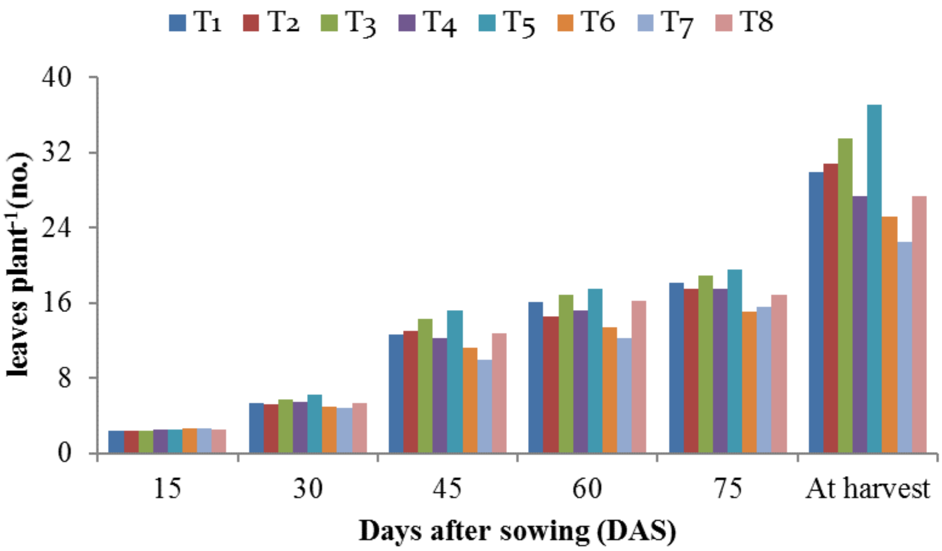


Figure 5. Effect of added foliar application on leaves plant^{-1}(no.) of blackgram at different days after sowing (LSD $_{(0.05)}$ = 0.23, 0.52, 0.87, 1.09, 1.69 and 2.70 at 15, 30, 45, 60, 75 DAS and harvest, respectively)

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,

T_6= Urea (2%) FS at FI,

T_7= Boron (1%) FS at FI,

T_8= Urea (2%) + Boron (1%) FS at FI

4.2.3 Combined effect of variety and foliar application

Leaves plant^{-1} gradually increase with the increase of DAS (Table 2). Leaves plant^{-1} in V_1T_6 showed the highest value at 15 DAS (2.93**)** which is statistically similar with V_1T_2, V_1T_7 and V_2T_4 and the lowest leaves plant^{-1} (2.20) was found in V_2T_2 which is statistically similar with V_1T_1, V_1T_3, V_1T_4, V_1T_5, V_2T_1, V_2T_1, V_2T_5, V_2T_6 and V_2T_7. At 30, 45 and 60 DAS the highest leaves plant^{-1} (6.53, 15.53 and 18.80 respectively**)** was observed at V_1T_5 which is statistically dissimilar with all other treatment except V_1T_3 andV_2T_5 at 30, 45 DAS and V_1T_8 at 60 DAS whereas the lowest leaves plant^{-1} at 30, 45 and 60 DAS(4.83, 9.80, 11.73, respectively) was observed in V_2T_7 that is statistically similar with all the treatment except V_1T_3, V_1T_4, V_1T_5 and V_2T_5 at 30 DAS, $V_1T_7$and V_2T_6at 45 DAS and V_1T_7 andV_2T_6at 60 DAS respectively. At 75 DAS leaves plant^{-1} in V_2T_5 showed the maximum (20.07) that is statistically similar with V_1T, V_1T_4, V_1T_5, V_2T_1 and V_2T_3 and minimum leaves plant^{-1} (15.01) gave in V_1T_6 which is statistically similar with V_1T_2, V_1T_7, V_1T_8, V_2T_4, V_2T_6, V_2T_7 and V_2T_8. The maximum leaves plant^{-1} (37.40) at highest was found in V_2T_5 which is statistically different with all the treatment except $V_1T_3$and V_1T_5 whereas minimum number of leaves plant^{-1} (22.00) gave in V_1T_7 which is statistically different with all the treatment except V_1T_6, $V_1T_8$and V_2T_7 at harvest stage.

Table 2. Combined effect of variety and added foliar application on leaves plant^{-1}(no.) of blackgram at different days after sowing

Treatment combinations	Leaves plant^{-1}(no.) at different days after sowing (DAS)					
	15	30	45	60	75	At harvest
V_1T_1	2.47 c-f	5.47 b-d	13.09 c-e	17.53 ab	17.67 b-e	28.73 e-g
V_1T_2	2.67 a-c	5.27 b-d	14.07 bc	15.27 c-e	17.40 b-f	32.27 c-e
V_1T_3	2.33 d-f	6.00 ab	14.60 ab	18.40 a	18.93 a-c	33.83 a-c
V_1T_4	2.27 ef	5.60 bc	12.53 d-f	15.60 c	17.87 a-d	27.27 gh
V_1T_5	2.47 c-f	6.53 a	15.53 a	18.80 a	19.13 ab	36.73 ab
V_1T_6	2.93 a	5.07 cd	11.60 fg	13.87 ef	15.01 f	24.40 h-j
V_1T_7	2.87 ab	4.93 cd	10.15 h	12.73 fg	15.60 d-f	22.00 j
V_1T_8	2.60 b-d	5.27 b-d	13.10 cd	17.47 ab	17.10 b-f	26.80 g-i
V_2T_1	2.33 d-f	5.13 cd	12.20 d-f	14.73 c-e	18.53 a-c	31.20 c-f
V_2T_2	2.20 f	5.27 b-d	11.93 d-g	14.00 d-f	17.60 b-e	29.53 d-g
V_2T_3	2.53 c-e	5.53 b-d	14.13 bc	15.47 cd	18.87 a-c	33.20 b-d
V_2T_4	2.87 ab	5.27 b-d	11.87 e-g	14.83 c-e	17.07 b-f	27.40 f-h
V_2T_5	2.47 c-f	6.00 ab	14.87 ab	16.27 bc	20.07 a	37.40 a
V_2T_6	2.33 d-f	4.93 cd	10.93 gh	12.97 fg	15.03 f	26.00 g-i
V_2T_7	2.33 d-f	4.83 d	9.80 h	11.73 g	15.47 ef	23.00 ij
V_2T_8	2.53 c-e	5.47 b-d	12.33 d-f	15.00 c-e	16.60 c-f	28.00 f-h
LSD $_{(0.05)}$	**0.33**	**0.74**	**1.23**	**1.54**	**2.39**	**3.82**
CV (%)	**7.74**	**8.16**	**5.78**	**6.02**	**8.23**	**7.81**

V_1= BARI Mash-2, V_2=BARI Mash-3

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,

T_6= Urea (2%) FS at FI,

T_7= Boron (1%) FS at FI,

T_8= Urea (2%) + Boron (1%) FS at FI

4.3 Branches plant^{-1} (no.)

4.3.1 Effect of variety

Significant variation of branches plant^{-1} was observed due to varietal variation of blackgram. The highest branches plant^{-1}(2.93, 3.33, 3.75 DAS and 4.45 at 45, 60, 75 DAS and at harvest) was found in V_1 and lowest branches plant^{-1}(2.58, 2.89, 3.47 and 3.98 at 45, 60, 75 and at harvest) was showed in V_2which is not statistically similar with each other (Fig. 6).

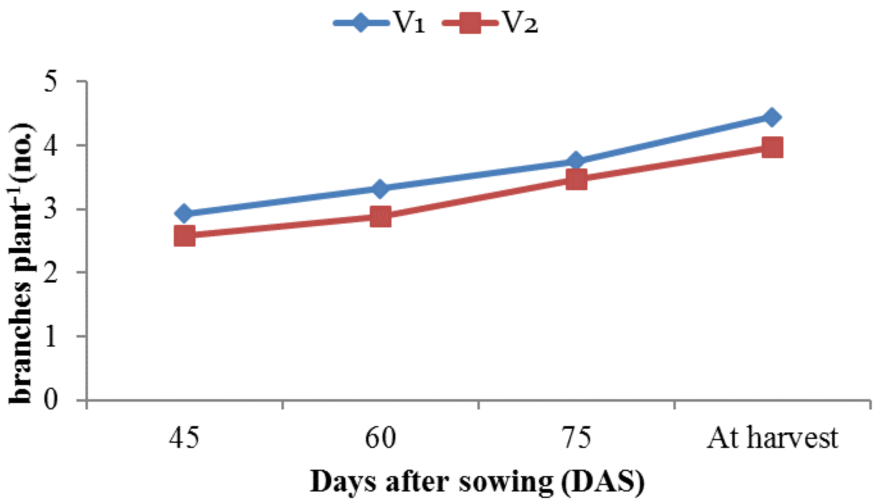


Figure 6. Effect of variety on branches plant^{-1}(no.) of blackgram at different days after sowing (LSD $_{(0.05)}$ = 0.12, 0.10, 0.17 and 0.42 at 45, 60, 75 DAS and at harvest, respectively)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.3.2 Effect of foliar application

Number of branches plant^{-1}of blackgram was observed significant variation in case of different treatment. In T_5 treatment showed highest branches plant^{-1} (3.67, 3.80, 4.23 and 4.87 at 45, 60, 75 DAS and at harvest, respectively). The lowest branches plant^{-1} (2.13, 2.50, 2.97 and 3.27 at 45, 60, 75 DAS and at harvest, respectively) was recorded in T_7 treatment (Fig. 7).

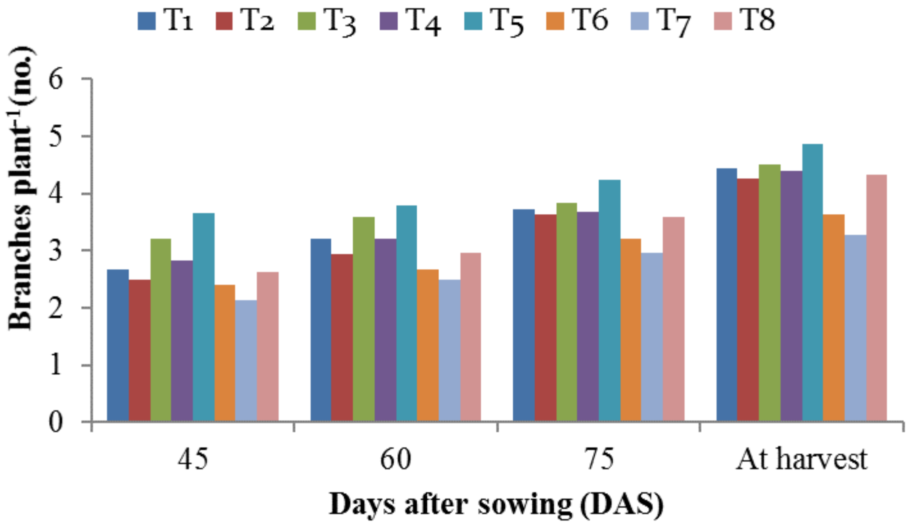


Figure 7. Effect of added foliar application on branches plant^{-1} (no.) of blackgram at different days after sowing (LSD $_{(0.05)}$ = 0.25, 0.27, 0.32 and 0.39 at 45, 60, 75 DAS and at harvest, respectively)

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,
T_6= Urea (2%) FS at FI,
T_7= Boron (1%) FS at FI,
T_8= Urea (2%) + Boron (1%) FS at FI

4.3.3 Combined effect of variety and foliar application

Combined effect of variety and fertilizer management through foliar application showed significant differences on branches plant^{-1} at 45, 60, 75 and at harvest. At 45,60,75 and at harvest the highest branches plant^{-1}(3.93,4.07,4.27 and 4.87 respectively) was recorded in V_1T_5 which is not statistically similar with all other treatment except V_1T_3 60 DAS, V_1T_1, V_1T_3, $V_1T_4$and V_2T_5at 75 DAS and V_1T_1, V_1T_2, V_1T_3, V_1T_4, $V_1T_8$and V_2T_5 at harvest. The lowest branches plant^{-1}(1.93) was observed in V_2T_7 that is not statistically similar with any other treatment at 45 DAS. At 60 DAS the lowest branches plant^{-1}(2.33) was recorded in V_2T_7 that is statistically similar with V_1T_7 and V_2T_6 not any other treatment. The minimum branches plant^{-1}(2.87) was observed in V_2T_7 that is statistically similar with V_1T_6, $V_1T_7$and V_2T_6. Finally, at harvest the lowest branches plant^{-1}(3.13) was recorded in V_2T_7 that is statistically similar with $V_1T_7$and V_2T_6 (Table 3).

Table 3. Combined effect of variety and added foliar application on branches plant^{-1} (no.) of blackgram 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	2.73 de	3.60 b	3.87 a-d	4.67 ab
V_1T_2	2.60 ef	2.93 de	3.73 c-e	4.53 a-c
V_1T_3	3.40 b	3.73 ab	4.07 a-c	4.80 a
V_1T_4	3.27 bc	3.53 bc	3.97 a-d	4.73 ab
V_1T_5	3.93 a	4.07 a	4.27 a	4.87 a
V_1T_6	2.47 ef	2.87 de	3.27 f-h	3.87 de
V_1T_7	2.33 f	2.67 efg	3.07 gh	3.40 ef
V_1T_8	2.67 def	3.20 cd	3.80 b-e	4.73 ab
V_2T_1	2.60 ef	2.80 ef	3.60 d-f	4.20 b-d
V_2T_2	2.40 ef	2.93 de	3.53 d-f	4.00 cd
V_2T_3	3.00 cd	3.47 bc	3.60 d-f	4.20 b-d
V_2T_4	2.40 ef	2.87 de	3.40 e-g	4.07 cd
V_2T_5	3.40 b	3.53 bc	4.20 ab	4.87 a
V_2T_6	2.33 f	2.47 fg	3.17 f-h	3.40 ef
V_2T_7	1.93 g	2.33 g	2.87 h	3.13 f
V_2T_8	2.60 ef	2.73 ef	3.40 e-g	3.93 de
LSD (0.05)	**0.35**	**0.38**	**0.46**	**0.54**
CV (%)	**7.57**	**7.31**	**7.58**	**7.71**

V_1= BARI Mash-2, V_2=BARI Mash-3

T_1= Recommended Fertilizer (RF), T_5= RF+ Urea (2%) + Boron (1%) FS at FI,

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI), T_6= Urea (2%) FS at FI,

T_3= RF+ Urea (2%) FS at FI, T_7= Boron (1%) FS at FI,

T_4= RF+ Boron (1%) FS at FI, T_8= Urea (2%) + Boron (1%) FS at FI

4.4 Above ground dry weight plant^{-1} (g)

The trend increase of above ground dry matter was very slow at early stage then it was increased rapidly from 50 to 60 DAS

4.4.1 Effect of variety

In different blackgram variety the above ground dry weight plant^{-1} was significantly influenced (Fig. 8). There was some significant difference between V_1 and V_2 at 15 DAS. At 30 DAS most above ground dry weight plant^{-1} (2.45) was recorded in V_1 and minimum was in V_2. V_2 gave maximum above ground dry weight plant^{-1} (6.42) at 45 DAS which is statistically similar with V_1 (5.65). Results showed that highest above ground dry weight plant^{-1} (11.05) was found from V_1 which is statistically similar with V_2 at 60 DAS. V_2 showed the highest above ground dry weight plant^{-1} (15.66) which is non- significant with V_1at 75 DAS. And at harvest the highest above ground dry weight plant^{-1} (20.875) and the lowest above ground dry weight plant^{-1} (16.875). Genetic variation of blackgram might be due to this result. These result also found in Sharma *et al.* (2012), Dasgupta and Das (1991) and Reddy *et al.* (1990).

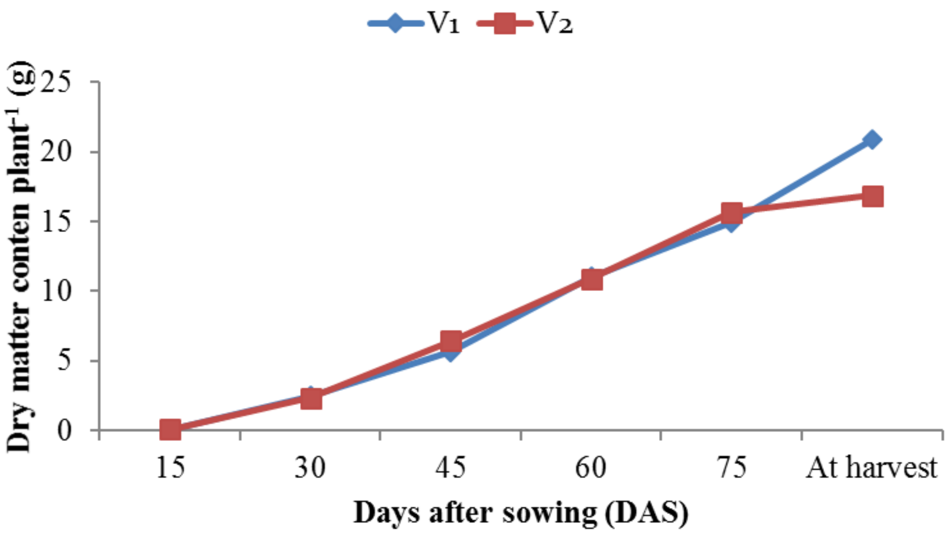


Figure 8. Effect of variety on the dry matter content plant^{-1} of blackgram at different days after sowing (LSD $_{(0.05)}$ = NS, 0.09, NS, NS, NS and 3.46 at 15, 30, 45, 60, 75 DAS and harvest, respectively

V_1= BARI Mash-2, V_2=BARI Mash-3

4.4.2 Effect of foliar application

Above ground dry weight plant^{-1} was statistically significant at 30, 45, 60, 75 and at harvest but at 15 DAS showed statistically non-significant variation (Fig. 9). Result showed that highest above ground dry weight plant^{-1} (2.75, 7.11, 12.63, 19and 24.67 at 30,45,60,75 and at harvest respectively) at T_5 followed by T_2 and T_3. The lowest above ground dry weight plant^{-1} (2.04, 4.62, 9.178, 12.03 and 14.17 at 30, 45, 60, 75 and at harvest respectively) at T_7 followed by T_6.

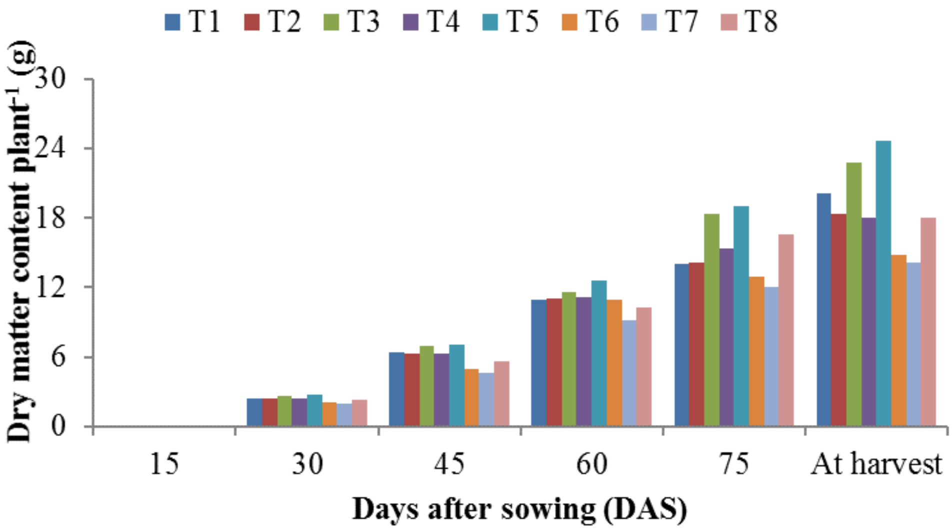


Figure 9. Effect of added foliar application on the dry matter content plant^{-1} of blackgram at different days after sowing (LSD $_{(0.05)}$ = 0.04, 0.28, 0.56, 1.00, 1.30 and 1.87 at 15, 30, 45, 60, 75 DAS and at harvest, respectively)

T_1= Recommended Fertilizer (RF), T_5= RF+ Urea (2%) + Boron (1%) FS at FI,

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI), T_6= Urea (2%) FS at FI,

T_3= RF+ Urea (2%) FS at FI, T_7= Boron (1%) FS at FI,

T_4= RF+ Boron (1%) FS at FI, T_8= Urea (2%) + Boron (1%) FS at FI

4.4.3 Combined effect of variety and foliar application

Combined effect of variety and foliar application showed significant variation on above ground dry weight plant^{-1} at all growth stages except 15 DAS. The maximum above ground dry weight plant^{-1} (2.78 g) at 30 DAS was obtained from V_2T_5 and lowest above ground dry weight plant^{-1} (1.91) was obtained from V_2T_7. At 45 DAS maximum above ground dry weight plant^{-1} (7.45 g) was obtained from V_2T_5 the lowest above ground dry weight plant^{-1} (4.13) was obtained from V_1T_7. It was found that the highest above ground dry weight plant^{-1} (12.70, 20.92 and 28.33 at 60, 75DAS and harvest respectively) was observed at V_1T_5 followed by V_1T_3 V_1T_5 V_2T_3 V_2T_5 at 60 DAS, V_1T_3at 75 DAS. Lowest above ground dry weight plant^{-1} (8.59, 9.99 at 60 and 75DAS respectively) was observed at V_1T_7 which was statistically similar with V_2T_7at 60 DAS and V_1T_6 at 75DAS. Finally, at harvest Lowest above ground dry weight plant^{-1} (12.67) which was statistically similar with $V_2T_4$and V_2T_6 (table 4).

Table 4. Combined effect of variety and added foliar application on the dry matter content plant^{-1} of blackgram at different days after sowing

Treatment combinations	Dry matter content plant^{-1} at different days after sowing (DAS)					
	15	30	45	60	75	At harvest
V_1T_1	0.052	2.46 a-e	6.29 c-e	10.82 b-d	13.36 de	20.33 c
V_1T_2	0.053	2.35 b-e	6.08 c-e	11.13 b-d	12.15 ef	19.67 c
V_1T_3	0.060	2.57 a-c	6.69 a-c	11.71 ab	19.90 a	25.33 b
V_1T_4	0.061	2.55 a-d	5.79 d-f	11.68 ab	14.75 cd	21.00 c
V_1T_5	0.051	2.71 ab	6.77 a-c	12.70 a	20.92 a	28.33 a
V_1T_6	0.061	2.18 c-f	4.51 hi	11.64 ab	11.42 fg	16.33 d
V_1T_7	0.050	2.16 d-f	4.13 i	8.59 e	9.99 g	15.67 de
V_1T_8	0.061	2.61 ab	4.95 gh	10.13 cd	17.21 b	20.33 c
V_2T_1	0.055	2.44 a-e	6.62 bc	10.99 b-d	14.69 cd	20.00 c
V_2T_2	0.055	2.62 ab	6.42 b-d	11.07 b-d	16.12 bc	17.00 d
V_2T_3	0.053	2.64 ab	7.16 ab	11.44 a-c	16.88 b	20.33 c
V_2T_4	0.059	2.36 b-e	6.83 a-c	10.76 b-d	15.90 bc	15.00 d-f
V_2T_5	0.055	2.78 a	7.45 a	12.56 a	17.08 b	21.00 c
V_2T_6	0.065	1.92 f	5.51 e-g	10.16 cd	14.50 cd	13.33 ef
V_2T_7	0.054	1.91 f	5.11 f-h	9.77 de	14.06 d	12.67 f
V_2T_8	0.063	2.08 ef	6.27 c-e	10.34 b-d	16.03 bc	15.67 de
LSD $_{(0.05)}$	**NS**	**0.39**	**0.79**	**1.42**	**1.83**	**2.65**
CV (%)	**9.07**	**9.83**	**7.79**	**7.74**	**7.16**	**8.40**

V_1= BARI Mash-2, V_2=BARI Mash-3
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,
T_6= Urea (2%) FS at FI,
T_7= Boron (1%) FS at FI,
T_8= Urea (2%) + Boron (1%) FS at FI

4.5 Nodule plant^{-1}(no.)

4.5.1 Effect of Variety

Number of nodules plant^{-1} showed significant variation in growth period due to the varietal variation (Fig. 10). V_1 gave most amount of nodule plant^1 (53.371**)** where V_2 gave the lowest amount of nodule plant^1 (43.45**)** at 30 DAS. At 45 DAS maximum nodule plant^1 (97.979) was observed at V_1 and minimum nodule plant^1 (79.167) at V_2. The number of nodule plant^1 at 60 DAS was recorded (96.13) and (94.04) from V_1 and V_2 and there was no significant variation.

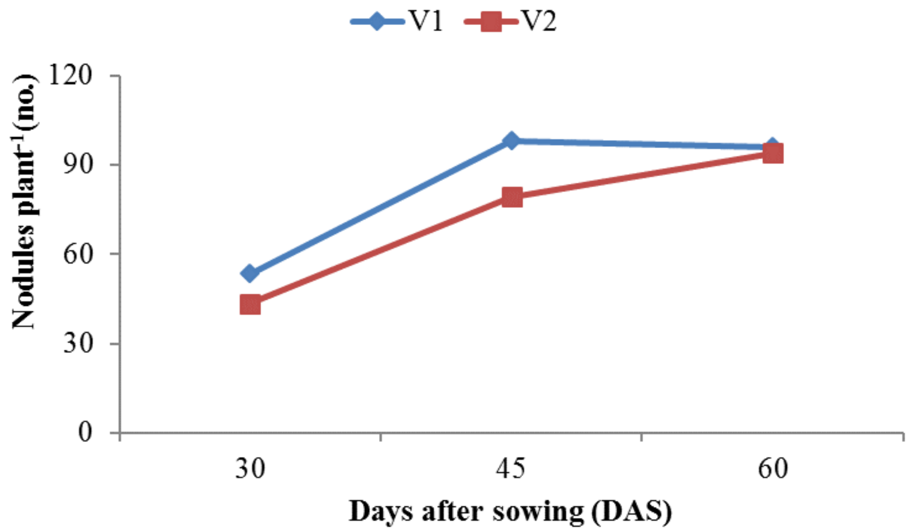


Figure 10. Effect of variety on nodules plant^{-1}(no.) of blackgram at different days after sowing (LSD $_{(0.05)}$ = 8.54, 3.96 and NS at 30, 45 and 60 DAS, respectively)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.5.2 Effect of foliar application

Significant variation was observed on number of nodule plant^{-1} due to effect of different foliar application on blackgram. At 30 DAS, the highest number of nodule plant^{-1} (66.10) was recorded from T_3 treatment and the lowest number of nodule plant^1 (29.65) was recorded from T_7 which was statistically dissimilar with any other treatments. At 45 DAS, the highest number of nodule plant^1 (121.0) was recorded from T_5 treatment. On the other hand, the lowest number of nodule plant^1 (54.83) was recorded from T_7 which was statistically not similar with other treatments. The highest number of nodule plant^{1} (161.8) at 60 DAS gained from T_5 treatment and the lowest number of nodule plant^{-1} (65.67) was recorded from T_6 which was statistically similar with T_7 treatment (Fig. 11).

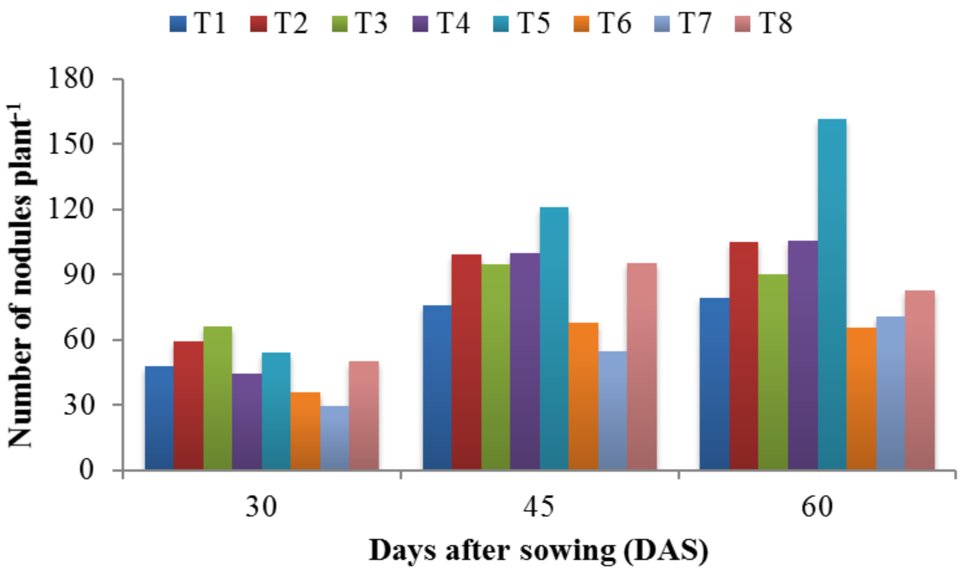


Figure 11. Effect of added foliar application on nodules plant^{-1}(no.) of blackgram at different days after sowing (LSD $_{(0.05)}$ = 4.23, 8.96 and 9.41 at 30, 45 and 60 DAS, respectively)

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,
T_6= Urea (2%) FS at FI,
T_7= Boron (1%) FS at FI,
$T_{8=}$ Urea (2%) + Boron (1%) FS at FI

4.5.3 Combined effect of variety and foliar application

The Blackgram varieties responded differently to foliar spraying in terms of nodule number plant^{-1}. At 30 DAS, the combined effect V_1T_3 was achieved the highest number of nodule plant^{-1} (82.87) and the lowest (28.43) was obtained from the V_1T_7 which was statistically similar with V_2T_7 combination. At 45 DAS, the highest number of nodule (136.0) plant^{-1}was recorded from V_1T_5 combination. On the other hand, the lowest number of nodule (52.67) plant^{-1}was recorded from V_2T_7 combination which was statistically similar with V_1T_7, V_2T_1 and V_2T_6 combinations. At 60 DAS, V_2T_5 showed the highest number of nodule (170.7) plant^{-1} and the lowest number of nodule (62.67) plant^{-1} obtained from V_2T_7combination which was statistically similar with V_1T_1, V_1T_6 and V_2T_6 combinations (Table 5).

Table 4. Combined effect of variety and added foliar application on the dry matter content plant^{-1} of blackgram at different days after sowing

Treatment combinations	Dry matter content plant^{-1} at different days after sowing (DAS)					
	15	30	45	60	75	At harvest
V_1T_1	0.052	2.46 a-e	6.29 c-e	10.82 b-d	13.36 de	20.33 c
V_1T_2	0.053	2.35 b-e	6.08 c-e	11.13 b-d	12.15 ef	19.67 c
V_1T_3	0.060	2.57 a-c	6.69 a-c	11.71 ab	19.90 a	25.33 b
V_1T_4	0.061	2.55 a-d	5.79 d-f	11.68 ab	14.75 cd	21.00 c
V_1T_5	0.051	2.71 ab	6.77 a-c	12.70 a	20.92 a	28.33 a
V_1T_6	0.061	2.18 c-f	4.51 hi	11.64 ab	11.42 fg	16.33 d
V_1T_7	0.050	2.16 d-f	4.13 i	8.59 e	9.99 g	15.67 de
V_1T_8	0.061	2.61 ab	4.95 gh	10.13 cd	17.21 b	20.33 c
V_2T_1	0.055	2.44 a-e	6.62 bc	10.99 b-d	14.69 cd	20.00 c
V_2T_2	0.055	2.62 ab	6.42 b-d	11.07 b-d	16.12 bc	17.00 d
V_2T_3	0.053	2.64 ab	7.16 ab	11.44 a-c	16.88 b	20.33 c
V_2T_4	0.059	2.36 b-e	6.83 a-c	10.76 b-d	15.90 bc	15.00 d-f
V_2T_5	0.055	2.78 a	7.45 a	12.56 a	17.08 b	21.00 c
V_2T_6	0.065	1.92 f	5.51 e-g	10.16 cd	14.50 cd	13.33 ef
V_2T_7	0.054	1.91 f	5.11 f-h	9.77 de	14.06 d	12.67 f
V_2T_8	0.063	2.08 ef	6.27 c-e	10.34 b-d	16.03 bc	15.67 de
LSD $_{(0.05)}$	**NS**	**0.39**	**0.79**	**1.42**	**1.83**	**2.65**
CV (%)	**9.07**	**9.83**	**7.79**	**7.74**	**7.16**	**8.40**

V_1= BARI Mash-2, V_2=BARI Mash-3

T_1= Recommended Fertilizer (RF), T_5= RF+ Urea (2%) + Boron (1%) FS at FI,

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI), T_6= Urea (2%) FS at FI,

T_3= RF+ Urea (2%) FS at FI, T_7= Boron (1%) FS at FI,

T_4= RF+ Boron (1%) FS at FI, T_8= Urea (2%) + Boron (1%) FS at FI

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

4.6.1 Effect of variety

There was no significant variation was observed in pods plant^{-1} of blackgram due to varietal variation (Fig. 12). The highest pods plant^{-1} (21.70) was observed in V_1. The lowest pods plant^{-1} (20.23) was observed from the V_2.

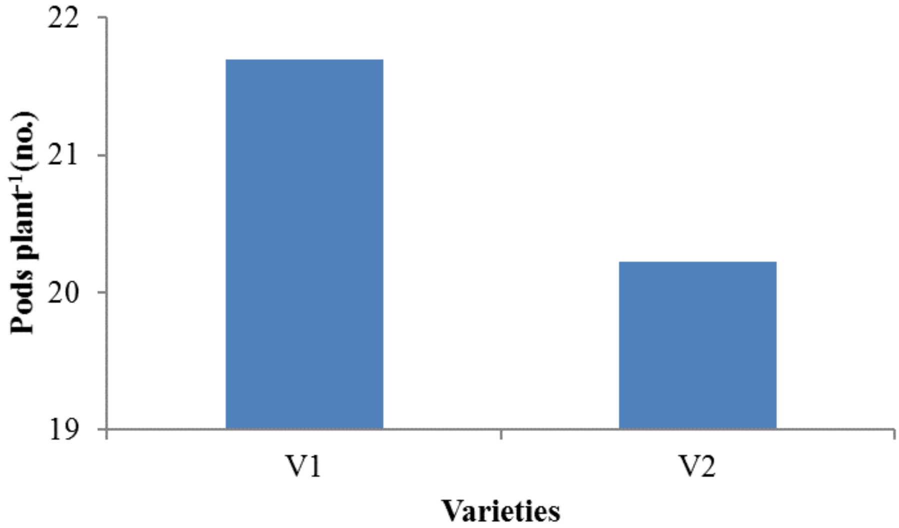


Figure 12. Effect of variety on pods plant^{-1}(no.) of blackgram (LSD $_{(0.05)}$ = NS)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.6.2 Effect of foliar application

There was significant variation recorded for number of pods plant^{-1}. Result revealed that higher number of pods plant^{-1}(28.85) was recorded from T_5 and the lowest pods plant^{-1} (14.57) was recorded from the T_7 (Fig. 13).

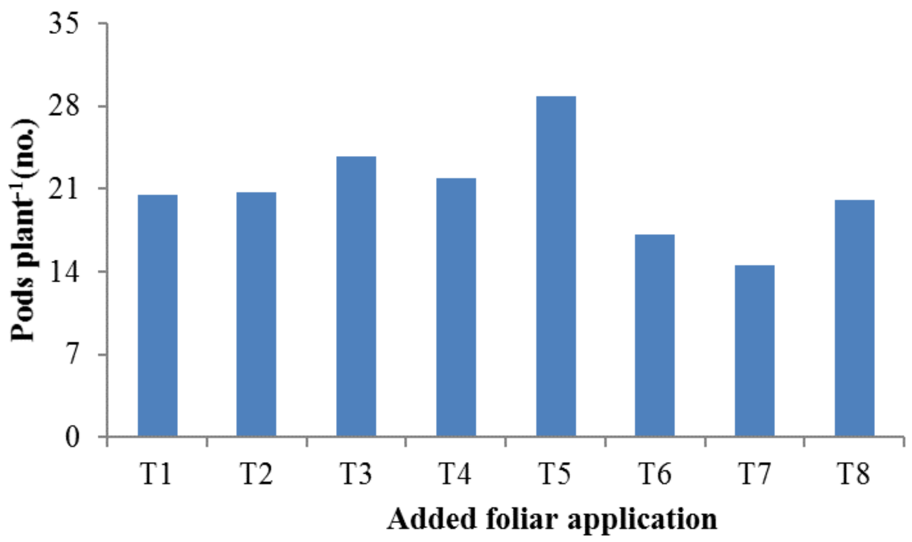


Figure 13. Effect of added foliar application on pods plant^{-1}(no.) of blackgram (LSD $_{(0.05)}$ = 1.55)

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,

T_6= Urea (2%) FS at FI,

T_7= Boron (1%) FS at FI,

$T_{8=}$ Urea (2%) + Boron (1%) FS at FI

4.6.3 Combined effect of variety and foliar application

The sinteraction effect of variety and foliar spray was significantly varied for pods plant^{-1} of blackgram. The highest pods plant^{-1} (31.70) was found from V_1T_5 and the lowest pods plant^{-1} (14.07) was recorded from the V_1T_7 which was statistically significant with V_2T_7 (Table 6).

4.7 Pod length

4.7.1 Effect of variety

Pod length of blackgram showed statistically non-significant variation due to variety of blackgram (Fig. 14). From result the highest pod length (4.19) was observed in V_1 and the lowest pod length (4.18) was observed in V_2.

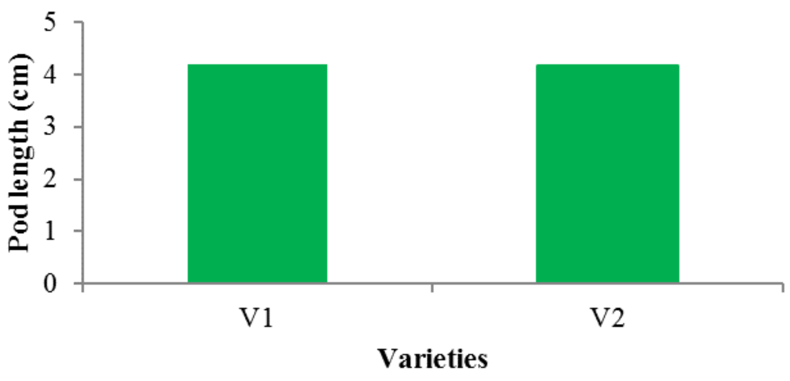


Figure 14. Effect of variety on the pod length of blackgram (LSD $_{(0.05)}$ = NS)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.7.2 Effect of foliar application

Statistically significant variation was observed due to foliar application. Results showed that highest pod length (4.535) was observed in T_5 which is not statistically similar with any other treatment whereas the lowest pod length (3.992) was observed in T_7 which was statistically similar with T_4 and T_6 (Fig.15).

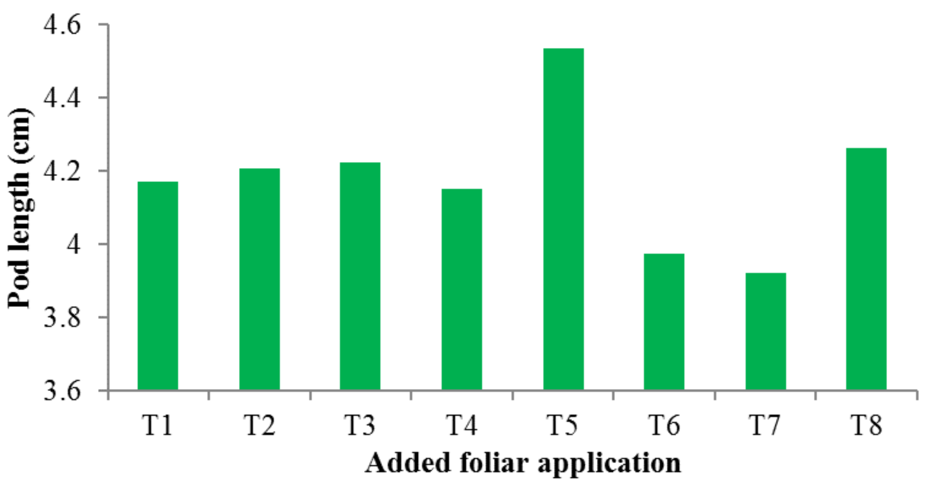


Figure 15. Effect of added foliar application on the pod length of blackgram (LSD $_{(0.05)}$ = 0.24)

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,

T_6= Urea (2%) FS at FI,

T_7= Boron (1%) FS at FI,

T_8= Urea (2%) + Boron (1%) FS at FI

4.7.3 Combined effect of variety and foliar application

Combined effect of variety and foliar spray was significantly influenced pod length of blackgram. Results showed that highest pod length (4.58) was observed in V_1T_5 which is statistically similar with V_1T_4, V_1T_8, V_2T_1, $V_2T_3$and V_2T_5 whereas the lowest pod length (3.93) was observed in V_1T_7 which was statistically similar with all other treatment except V_1T_4, V_1T_5, V_1T_8, V_2T_1, V_2T_3 and V_2T_5 (Table 6).

4.8 seeds pod^{-1}(no.)

4.8.1 Effect of variety

Number of seeds pod^{-1} was not significantly affected by varietal variation of blackgram (Fig. 16). The highest number of seeds pod^{-1} (5.77) was observed from V_2 and the lowest number of seeds pod^{-1} (5.62) was observed from V_1. Similar results were found in Sharma *et al.* (2012); Reddy *et al.* (1990) and Dasgupta and Das (1991) who reported that seeds pod $^{-1}$ varies might have been due to genetic variation of blackgram varieties.

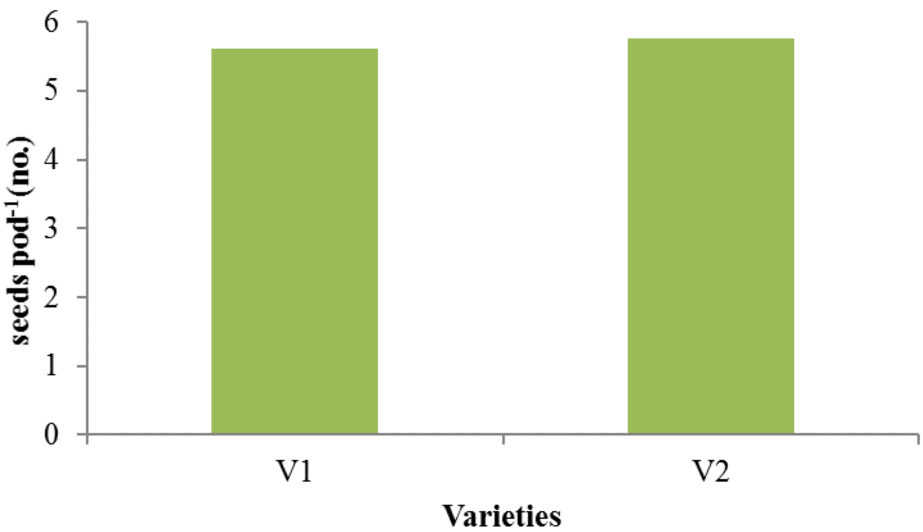


Figure 16. Effect of variety on the seeds pod^{-1} (no.) of blackgram (LSD $_{(0.05)}$ = NS)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.8.2 Effect of foliar application

Statistically significant variation was observed in number of seeds pod^{-1} due to foliar application among the different treatment T_5 gave highest (6.19) seeds pod^{-1} which was statistically similar with T_1 T_2, and T_3. The lowest number of seeds pod^{-1} (9.21) was gave by T_7 which was statistically similar with T_4 and T_6 (Fig. 17).

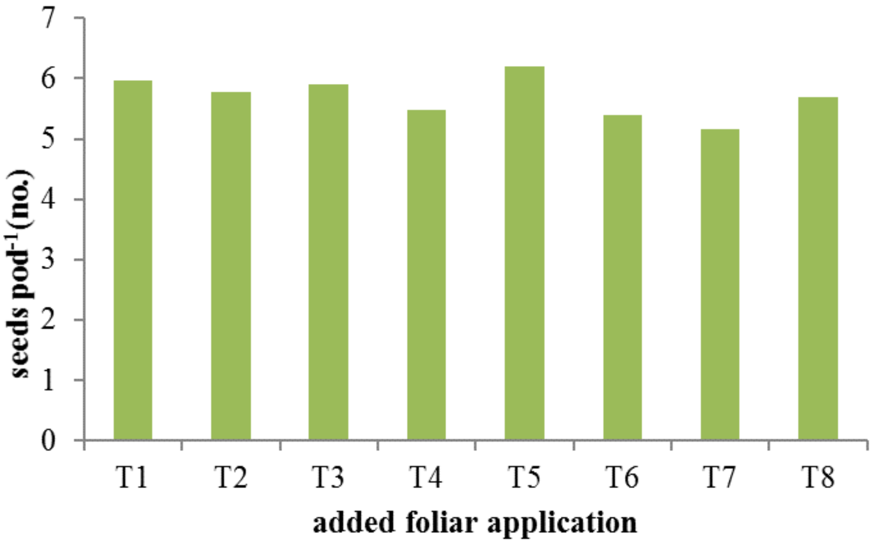


Figure 17. Effect of different fertilizers on seeds pod^{-1}(no.) of blackgram (LSD $_{(0.05)}$ = 0.42)

T_1= Recommended Fertilizer (RF), T_5= RF+ Urea (2%) + Boron (1%) FS at FI,

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI), T_6= Urea (2%) FS at FI,

T_3= RF+ Urea (2%) FS at FI, T_7= Boron (1%) FS at FI,

T_4= RF+ Boron (1%) FS at FI, $T_{8=}$ Urea (2%) + Boron (1%) FS at FI

4.8.3 Combined effect of variety and foliar application

Blackgram was significantly influenced by combined effect of varieties and foliar application on seeds pod^{-1} (Table 6). The highest seeds pod^{-1} (6.27) was recorded with the treatment combination of V_2T_5 which was statistically similar with V_1T_1, V_1T_2, V_1T_3, V_1T_5, V_2T_1, V_2T_2, V_2T_3 and V_2T_8. The lowest seeds pod^{-1} (5.10) was found in V_1T_7 treatment which was statistically similar with V_1T_4, V_1T_6, V_1T_8, V_2T_4, V_2T_6 and V_2T_7.

4.9 1000 seeds weight (g)

4.9.1 Effect of variety

The 1000 seeds weight of blackgram was statistically non- significant due to variety of blackgram (Fig. 18). It was found that the highest 1000 seed weight (34.96 g) was observed from V_1 and the lowest was recorded (33.75 g) in the V_2.

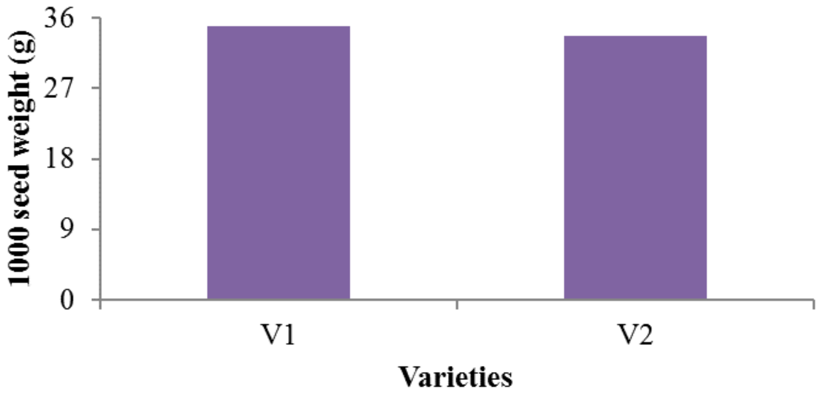


Figure 18. Effect of variety on the 1000 seed weight of blackgram (LSD $_{(0.05)}$=NS)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.9.2 Effect of foliar application

Different treatment showed significant variations in respect of the 1000 seeds weight of blackgram. Results revealed that the highest 1000 seed weight (38.50 g) was recorded from T_5 which was not statistically similar with any other treatment. The minimum 1000 seed weight (31.50 g) was observed in T_7 followed by $T_1$and T_6 (Fig. 19). Effect was found in foliar spray of both macro (N, P, K, S) and micro (B, Mn. Mg) nutrients during flowering and podding of lupin did not increase grain yield (Seymour and Brennan, 1995).

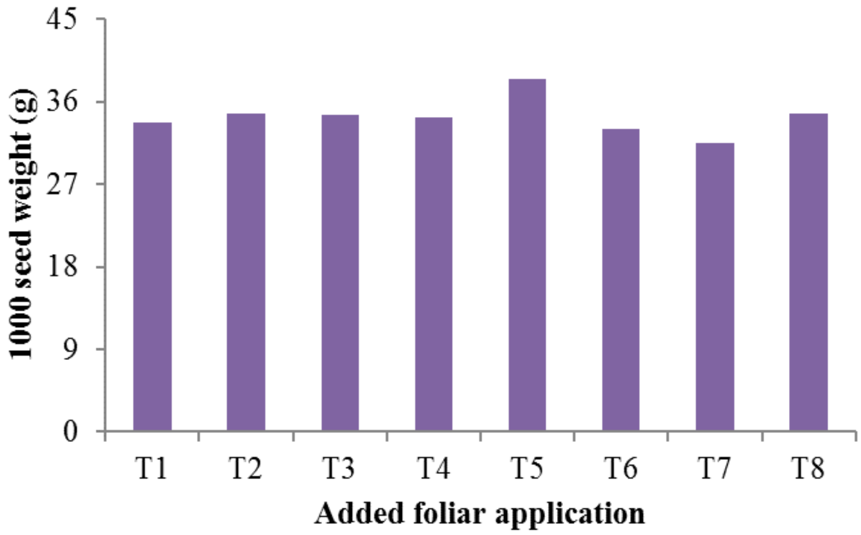


Figure 19. Effect of added foliar application on the 1000 seed weight (g) of blackgram (LSD $_{(0.05)}$ = 2.80)

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,

T_6= Urea (2%) FS at FI,

T_7= Boron (1%) FS at FI,

T_8= Urea (2%) + Boron (1%) FS at FI

4.9.3 Combined effect of variety and foliar application

Combined effect of variety and foliar application exerted significant effect on the 1000 seeds weight of blackgram. It was found that the highest 1000 seed weight (56.67 g) was recorded from the treatment combination of V_1T_5 followed by V_2T_5. The lowest 1000 seeds weight (30.00 g) was found in V_2T_7treatment which was statistically identical with V_1T_1, V_1T_7, V_2T_1 and V_2T_6 (Table 6).

Table 6. Combined effect of variety and added foliar application on the pods plant^{-1}, pod length, seeds pod^{-1} and 1000 seed weight of blackgram

Treatment combinations	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	1000 seed weight (g)
V_1T_1	20.93 cd	4.04 d-f	6.07 ab	33.67 b-e
V_1T_2	20.73 cd	4.17 b-f	5.72 a-e	35.33 bc
V_1T_3	25.67 b	4.14 c-f	5.75 a-e	34.00 b-d
V_1T_4	24.40 b	4.28 a-e	5.40 d-f	34.00 b-d
V_1T_5	31.70 a	4.58 a	6.11 ab	39.67 a
V_1T_6	16.67 fg	3.97 ef	5.35 d-f	34.67 b-d
V_1T_7	14.07 h	3.93 f	5.10 f	33.00 c-e
V_1T_8	19.40 de	4.39 a-c	5.43 d-f	35.33 bc
V_2T_1	20.13 cd	4.30 a-e	5.87 a-d	33.67 b-e
V_2T_2	20.73 cd	4.24 b-f	5.85 a-d	34.00 b-d
V_2T_3	21.87 c	4.31 a-d	6.03 a-c	35.00 b-d
V_2T_4	19.53 de	4.02 d-f	5.57 b-f	34.67 b-d
V_2T_5	26.00 b	4.49 ab	6.27 a	37.33 ab
V_2T_6	17.67 ef	3.98 d-f	5.44 c-f	31.33 de
V_2T_7	15.07 gh	3.92 f	5.20 ef	30.00 e
V_2T_8	20.80 cd	4.10 c-f	5.93 a-d	34.00 b-d
LSD $_{(0.05)}$	**2.19**	**0.33**	**0.59**	**3.97**
CV (%)	**6.23**	**4.76**	**6.22**	**6.90**

V_1= BARI Mash-2, V_2=BARI Mash-3

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,

T_6= Urea (2%) FS at FI,

T_7= Boron (1%) FS at FI,

T_8= Urea (2%) + Boron (1%) FS at FI

4.10 Seed yield t ha^{-1}

4.10.1 Effect of variety

Statistically significant variation was observed seed yield ha^{-1} of blackgram due to variety (Fig. 20). The highest seed yield (1.06 t ha^{-1}) was obtained from V_1 and the lowest one (1.00 t ha^{-1}) was recorded from V_2. similar result was found by Jagannath *et al.* (2014), Yadahalli and Palled (2004) and Rao and Konda (1988) who reported that TAU-1 recorded significantly highest grain yield over rest of the varieties which could be attributed due to higher values of yield components namely pods $plant^{-1}$, grains pod^{-1}, 1000 seeds weight. Differences in production potential for different varieties of blackgram are also recorded by Panotra *et al.* (2016), Sharma *et al.* (2000) and Sing and Sing (2000).

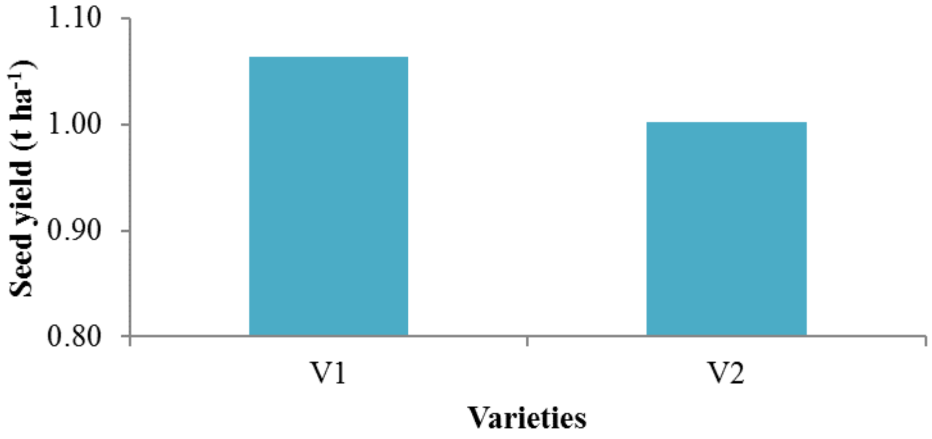


Figure 20. Effect of variety on the seed yield of blackgram (LSD $_{(0.05)}$ = 0.01)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.10.2 Effect of foliar application

Statistically significant variation was recorded in respect of seed yield of blackgram. It was observed that the highest seed yield (1.24 t ha^1) was observed in T_5 treatment which was statistically different from any other treatments. The lowest seed yield (0.84 t ha^1) was recorded from T_7 treatment which was statistically not similar with any other treatments (Fig. 21).

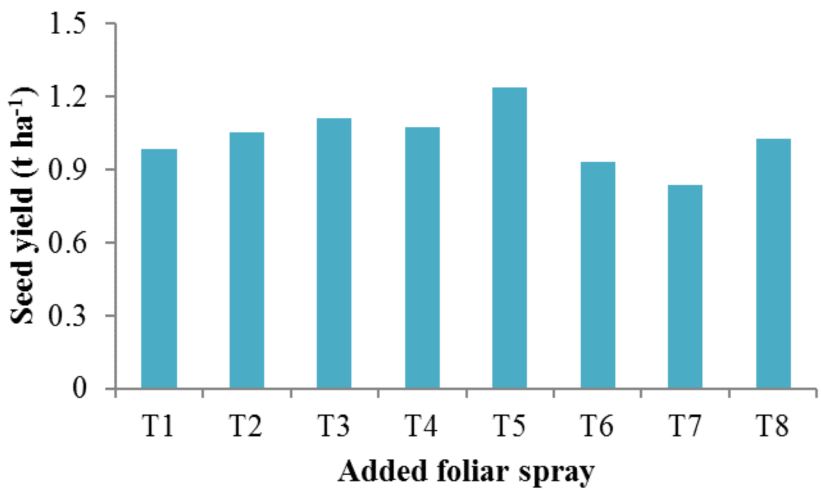


Figure 21. Effect of added foliar application on the seed yield of blackgram ($LSD_{(0.05)}$ =0.07)

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,
T_6= Urea (2%) FS at FI,
T_7= Boron (1%) FS at FI,
$T_{8=}$ Urea (2%) + Boron (1%) FS at FI

4.10.3 Combined effect of variety and foliar application

Combined effect of variety and foliar application gaved significant variation on seed yield. The result revealed that, the highest seed yield (1.29 t ha) was recorded from the combination of V_1T_5 which was statistically not similar with any other treatment. The lowest seed yield (0.82 t ha^{-1}) was recorded from the combination V_2T_7 which was statistically similar with $V_1T_7$and V_2T_6 combination (Table 7).

4.11 Stover yield

4.11.1 Effect of variety

Stover yield of blackgram was observed statistically significant variation due to varietal variation it was found that the highest stover yield (1.38 t ha^{-1}) was recorded from V_1 and the lowest stover yield (1.24 t ha^{-1}) was recorded from V_2 (Fig. 22).

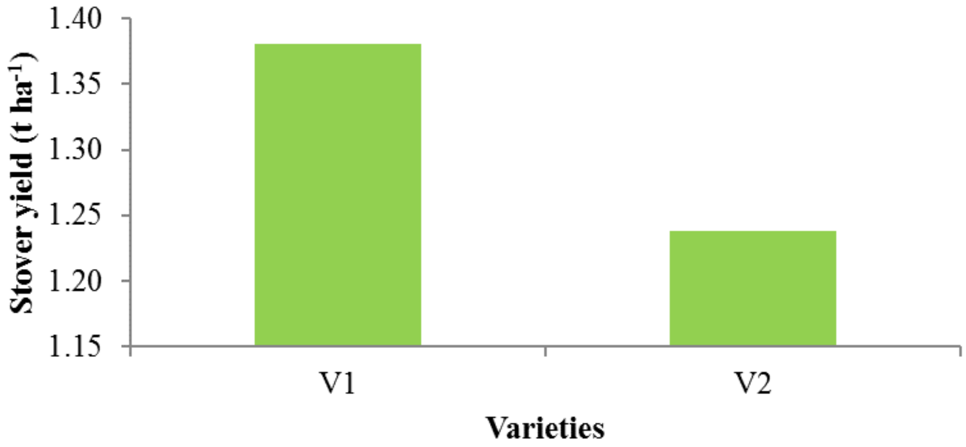


Figure 22. Effect of variety on the stover yield of blackgram (LSD $_{(0.05)}$ = 0.10)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.11.2 Effect of foliar application

Due to different foliar application significant variations was observed in respect of stover yield of blackgram. Among different treatments T_5 gave the highest stover yield (2.79 t ha^{-1}) followed by T_3. On the other hand, the lowest stover yield (1.07 t ha^{-1}) was observed with T_7treatment followed by T_6 (Fig. 23).

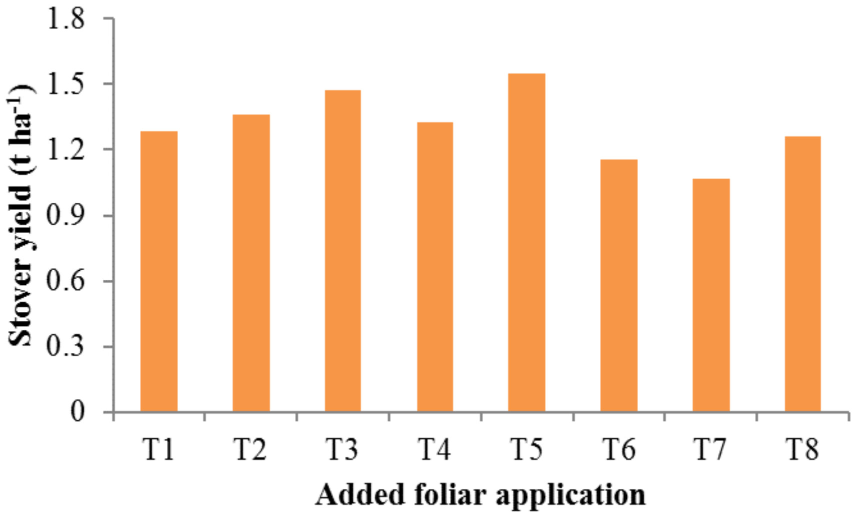


Figure 23. Effect of added foliar application on the stover yield of blackgram ($LSD_{(0.05)}$ = 0.12)

T_1= Recommended Fertilizer (RF), T_5= RF+ Urea (2%) + Boron (1%) FS at FI,

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI), T_6= Urea (2%) FS at FI,

T_3= RF+ Urea (2%) FS at FI, T_7= Boron (1%) FS at FI,

T_4= RF+ Boron (1%) FS at FI, T_8= Urea (2%) + Boron (1%) FS at FI

4.11.3 Combined effect of variety and foliar application

Combined effect of variety and foliar application on stover yield ha^{-1} was significantly influenced. It was recorded that the highest stover yield (1.64 ha^{-1}) was found from the treatment combination of V_1T_5 followed by V_1T_3. On the contrary, the lowest stover yield (1.01t ha^{-1}) was recorded from V_2T_6 which was similar to $V_1T_7$and V_2T_7 (Table 7).

4.12 Biological yield

4.12.1 Effect of variety

Significant variation was recorded on the biological yield of blackgram due to varietal difference. It was found that the highest biological yield of blackgram (2.45 t ha^{-1}) was observed in V_1. On the contrary, the lowest biological yield (2.24 t ha^{-1}) was observed in the V_2 (Fig. 24).

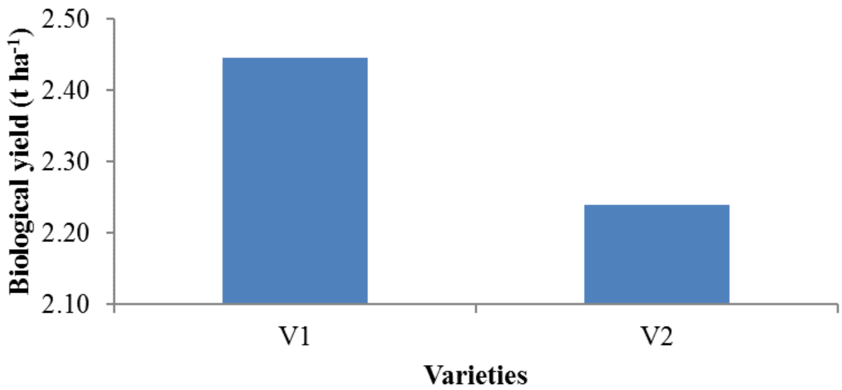


Figure 24. Effect of variety on the biological yield of blackgram (LSD $_{(0.05)}$ = 0.11)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.12.2 Effect of foliar application

There were significant variations in respect of biological yield of blackgram due to foliar application. T_5 gave the highest biological yield (2.79t ha^{-1}) among the different treatment, and the lowest biological yield (1.91 t ha^{-1}) was observed with T_7 treatment (Fig. 25).

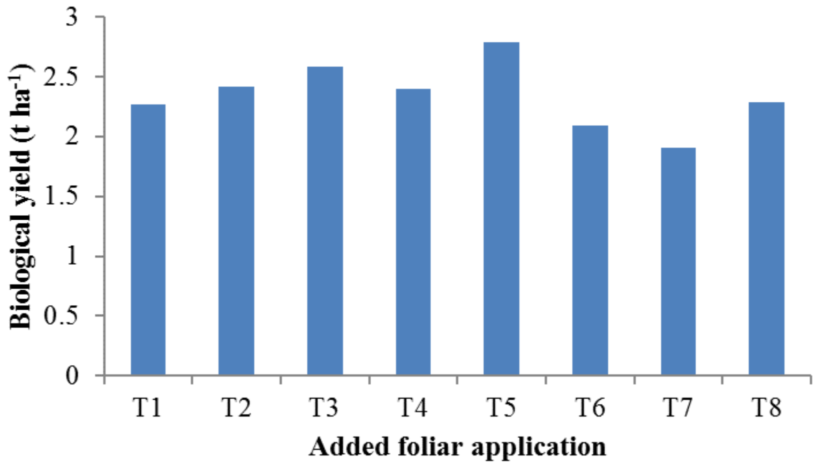


Figure 25. Effect of added foliar application on the biological yield of blackgram (LSD $_{(0.05)}$ = 0.16)

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,

T_6= Urea (2%) FS at FI,

T_7= Boron (1%) FS at FI,

T_8= Urea (2%) + Boron (1%) FS at FI

4.12.3 Combined effect of variety and foliar application

The combined effect of different variety and foliar application on the biological yield of blackgram was significantly varied (Table 7). The maximum biological yield (2.93t ha^{-1}) was observed with the interaction of V_1T_5 which were statistically similar with V_1T_3. On the other hand, the minimum biological yield (1.84 t ha^{-1}) was recorded in V_2T_7 treatment combination which was statistically similar with V_1T_7 and V_2T_6 treatments.

4.13 Harvest index (%)

4.13.1 Effect of variety

Statistically no significant variation was observed in harvest index due to variety of blackgram. Numerically the highest harvest index (44.77%) was observed from V_2 and the lowest harvest index (43.55%) was observed from V_1 ((Fig. 26).

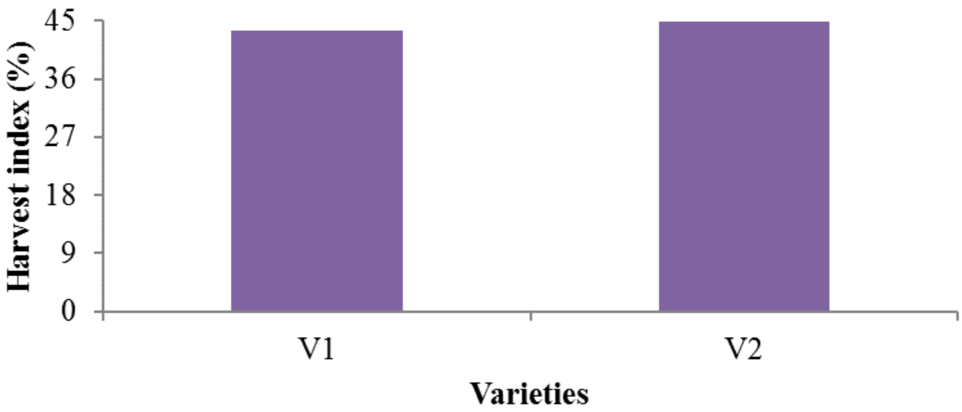


Figure 26. Effect of variety on the harvest index of blackgram (LSD $_{(0.05)}$ = NS)

V_1= BARI Mash-2, V_2=BARI Mash-3

4.13.2 Effect of foliar application

There was no significant variation among the foliar application on the harvest index of blackgram. Among different treatment T_8 gave highest harvest index (44.96%). The lowest harvest index (43.22%) was observed from T_2 (Fig. 27).

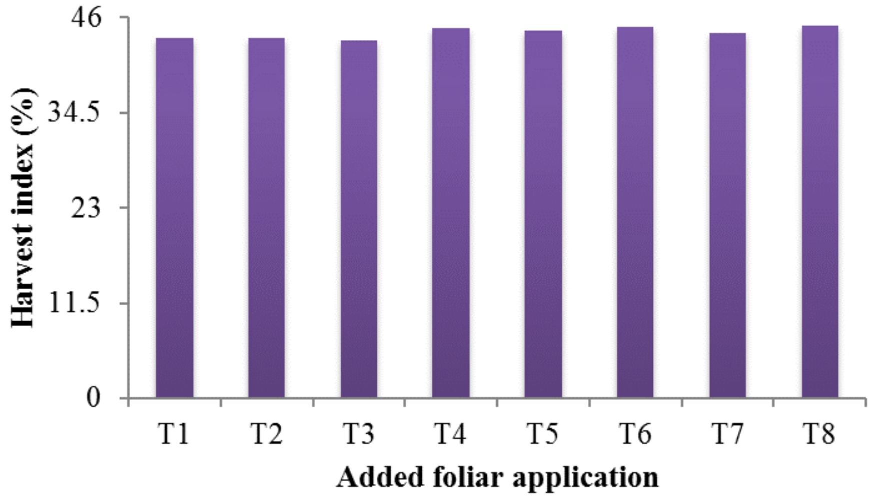


Figure 27. Effect of added foliar application on the harvest index of blackgram (LSD $_{(0.05)}$ = NS)

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,
T_6= Urea (2%) FS at FI,
T_7= Boron (1%) FS at FI,
$T_{8=}$ Urea (2%) + Boron (1%) FS at FI

4.13.3 Combined effect of variety and foliar application

Combined effect of variety and foliar application on harvest index was significantly influenced in blackgram. It was found that the highest harvest index (44.05%) was recorded from the treatment combination of V_2T_6 which was statistically similar with all other treatment except V_1T_1, V_1T_2, V_1T_3, V_1T_6 and V_1T_7.The lowest harvest index (42.11%) was found from V_1T_3 followed by V_1T_1, V_1T_2, V_1T_3, V_1T_6 and V_1T_7 treatment combination(Table 7).

Table 7. Combined effect of variety and added foliar application on the seed yield, stover yield, biological yield and harvest index of blackgram

Treatment combinations	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1T_1	1.04 c-e	1.36 c-e	2.40 de	43.46 b
V_1T_2	1.05 c-e	1.40 cd	2.45 c-e	42.90 b
V_1T_3	1.15 bc	1.58 ab	2.73 ab	42.11 b
V_1T_4	1.13 bc	1.38 cd	2.51 b-d	45.16 ab
V_1T_5	1.29 a	1.64 a	2.93 a	44.07 ab
V_1T_6	0.97 e-g	1.31 c-e	2.28 ef	42.77 b
V_1T_7	0.86 hi	1.12 fg	1.98 gh	43.44 b
V_1T_8	1.01 d-f	1.27 d-f	2.28 ef	44.51 ab
V_2T_1	0.93 f-h	1.21 ef	2.14 fg	43.57 ab
V_2T_2	1.06 c-e	1.33 c-e	2.38 de	44.27 ab
V_2T_3	1.08 b-d	1.36 c-e	2.44 c-e	44.33 ab
V_2T_4	1.02 d-f	1.27 d-f	2.29 d-f	44.33 ab
V_2T_5	1.18 b	1.46 bc	2.64 bc	44.78 ab
V_2T_6	0.89 g-i	1.01 g	1.90 h	46.83 a
V_2T_7	0.82 i	1.02 g	1.84 h	44.68 ab
V_2T_8	1.04 c-e	1.25 d-f	2.30 d-f	45.41 ab
LSD $_{(0.05)}$	**0.11**	**0.17**	**0.22**	**3.35**
CV (%)	**6.42**	**7.47**	**5.75**	**4.54**

V_1= BARI Mash-2, V_2=BARI Mash-3

T_1= Recommended Fertilizer (RF), T_5= RF+ Urea (2%) + Boron (1%) FS at FI,

T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI), T_6= Urea (2%) FS at FI,

T_3= RF+ Urea (2%) FS at FI, T_7= Boron (1%) FS at FI,

T_4= RF+ Boron (1%) FS at FI, $T_{8=}$ Urea (2%) + Boron (1%) FS at FI

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy Research Field of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from March to June, 2016 to observed the effect of foliar application of urea and boron in blackgram cultivation in Kharif 1 season under the Modhupur Tract (AEZ-28). The field experiment was conducted with two varieties of foliar fertilization *viz.* BARI Mash-2 (V_1), BARI Mash-3 (V_2) and eight treatments *viz.* T_1= Recommended Fertilizer (RF), T_2= RF+ Foliar Spray (FS) with water at flower ignition (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, T_6= Urea (2%) FS at FI, T_7= Boron (1%) FS at FI, $T_{8=}$ Urea (2%) + Boron (1%) FS at FI. Split-plot design with three replications was laid out in the experiment where variety was assigned in the main plots and foliar fertilization was assigned in the sub-plots.

Data were recorded on crop growth parameters like plant height, leaves plant^{-1}, branches plant^{-1}, nodules plant^{-1}and above ground dry matter plant^{-1} at different growth stages. Other yield and yield contributing character like pods plant^{-1}, seeds pod^{-1}, pod length, 1000-seeds weight, seed yield plant^{-1}, seed yield ha^{-1}, stover yield biological yield and harvest index were recorded after harvest. Recorded data were analyzed using MSTAT-C package. Among the treatments the mean differences were compared by least significant difference test at 5% level of significance.

From results it was observed that two varieties of blackgram had significant difference. Plant height gradually increase up to harvest and the highest plant height (49.47 cm) was accounted for V_1 and the lowest one (47.79 cm) was from V_2. The maximum leaves plant^{-1} (29.47) was recorded from V_2 at harvest and lowest one (29.00) from V_1. The maximum branches plant^{-1} (4.45) where produced from V_1 minimum branches plant^{-1} (3.98) was recorded from V_2 at harvest. V_1 produced maximum (20.875) above ground dry weight plant^{-1} and V_2 produce minimum (16.875). The highest nodule plant^{-1}(96.13) was observed from V_1 and the lowest was (94.04) observed from V_2. The highest pods plant^{-1}(21.70), pod length (4.19cm) from V_1, seeds pod $^{-1}$(5.77) from V_2 ,1000 seed weight (34.96 g), seed yield t ha^{-1} (1.06), stover yield t ha^{-1}(1.38), biological yield (2.45) at V_1 harvest index (44.77%) was recorded from V_2 whereas the minimum pods plant^{-1} (20.23), pod length (4.18) from

V_1, seeds pod $^{-1}$(5.77) from V_2, 1000 seed weight (33.75 g), seed yield t ha^{-1} (1.00), stover yield t ha^{-1}(1.24), biological yield (2.24) at V_2.

Foliar application also significantly influenced all growth and yield attributes except harvest index. The results showed that the highest plant height (53.19 cm) was found in the T_5 whereas the lowest one (42.54 cm) was from T_7 at harvest. At harvest, the T_5 produced maximum leaves plant^{-1} (37.07), branches plant^{-1} (4.87), above ground dry weight plant^{-1} (24.67 g) and nodule plant^{-1}(161.8) and T_7 produce the lowest leaves plant^{-1} (22.50), branches plant^{-1} (3.27), above ground dry weight plant^{-1} (18.00 g) was observed in T_8. Minimum nodule plant^{-1}(161.8) was observed from T_5 and lowest was (65.67) observed from T_6. T_5 produced highest pods plant^{-1}(28.85), pod length (4.53cm), seeds pod^{-1} (6.19), 1000 seed weight (38.50g) whereas lowest pods plant^{-1}(14.57), pod length (3.92cm), seeds pod^{-1} (5.15), 1000 seed weight (31.50g). At harvest T_5 gave highest seed yield (1.24 t ha^{-1}), stover yield (1.55 t ha^{-1}), biological yield (2.79 t ha^{-1}) and the lowest one seed yield (0.84 t ha^{-1}), stover yield t ha^{-1}(1.07), biological yield (1.91 t ha^{-1}) and there is no significant effect on harvest index of foliar application.

Combined effect of varieties and different foliar application also significantly affected growth as well as yield and yield contributing characters of blackgram. The tallest plant height (54.27 cm) was found in the combination of V_1T_5 at harvest and the shortest plant height (41.09 cm) was found in the V_2T_7. The maximum leaves plant^{-1} (37.40) was found from treatment interaction V_2T_5 whereas the lowest leaves plant^{-1} (22.00) was observed in treatment combination V_1T_7 at harvest. The maximum branches plant^{-1} (4.87) was recorded from V_2T_5 and the minimum branches plant^{-1} (3.13) was recorded from V_2T_7 at harvest. At harvest the highest (28.33 g) above ground dry weight plant^{-1} at harvest was found from interaction of V_1T_5 and the lowest (12.67 g) above ground dry weight plant^{-1} was found in V_2T_7. The maximum nodule plant^{-1} (170.7) was counted for treatment combination V_1T_5 whereas the minimum nodule plant^{-1} (62.33) was counted for treatment combination V_1T_6 at harvest 60 DAS. The highest pods plant^{-1}(31.70), pod length (4.58) at the interaction of V_1T_5 and the minimum pods plant^{-1}(14.07) at V_1T_7, pod length (3.92) at V_2T_7 was observed. The highest Seeds pod^{-1}(6.27) was at V_2T_5 and 1000-seeds wt. (39.67 g) at $V_1T_5$was found the lowest Seeds pod^{-1}(5.10) was at V_1T_7, 1000-seeds wt. (30.00 g) at

V_2T_7 was observed at harvest. The maximum seed yield (1.29 t ha^{-1}), stover yield t ha^{-1}(1.64), biological yield (2.93 t ha^{-1}), was found from V_1T_5, where as the lowest seed yield (0.82 t ha^{-1}) from V_2T_7, stover yield (1.01 t ha^{-1}) from V_2T_6, biological yield (1.84 t ha^{-1}) was found from V_2T_7. The maximum harvest index (46.83%) recorded from V_2T_6 and minimum (42.11%) was recorded from V_1T_3

From the discussion it may be concluded that extra foliar application of urea (2%)+ boron (1%) at flowering stage along with recommended fertilizer giving better growth and higher yield in blackgram.

RECOMMENDATION

Such study may be conducted at different blackgram growing areas of Bangladesh for justification of the treatment variability towards improvement of the crop.

CHAPTER V

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APPENDICES

Appendix I. 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, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Land type	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	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	**Value**
pH	6.1
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total weeding (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

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

Appendix II. Monthly record of air temperature, relative humidity and total rainfall of the experimental site during the period from March to June 2016

Month (2016)	Air temperature (degrees Celsius)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
March	32.10	20.56	45.11	4
April	32.79	23.38	63.48	166
May	34.07	25.42	67.83	185
June	32.75	26.70	74.57	375

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

Appendix III. Analysis of variance of the data on Plant height of blackgram as influenced by combined effect of variety and foliar application

Source of variation	df	Mean square of plant height at different days after sowing (DAS)					
		15	30	45	60	75	At harvest
Replication	2	0.087	1.869	9.361	11.663	17.691	52.847
Variety (A)	1	2.521*	7.922 NS	23.970 NS	99.850 NS	16.934 NS	33.818 NS
Error	2	0.076	0.713	3.914	5.292	1.853	27.770
Foliar spray (B)	7	0.403*	2.638*	19.597*	38.029*	69.979*	79.142*
Variety(A) X Foliar spray (B)	7	0.854*	2.118*	1.309*	1.553*	8.833*	3.518*
Error	28	0.362	1.197	6.106	8.299	11.417	13.890

*Significant at 5% level of significance

NS Non significant

Appendix IV. Analysis of variance of the data on leaves plant^{-1} of blackgram as influenced by combined effect of variety and foliar application

Source of variation	df	Mean square of leaves plant^{-1} at different days after sowing (DAS)					
		15	30	45	60	75	At harvest
Replication	2	0.030	0.016	4.544	5.126	0.161	12.538
Variety (A)	1	0.188 ^{NS}	0.542 ^{NS}	8.184*	40.333*	0.051 ^{NS}	2.572 ^{NS}
Error	2	0.108	0.158	0.416	0.866	1.466	1.734
Foliar spray (B)	7	0.047*	1.158*	16.145*	19.391*	14.605*	129.955*
Variety(A) X Foliar spray (B)	7	0.248*	0.092*	0.460*	1.299*	0.545*	3.796*
Error	28	0.038	0.195	0.537	0.847	2.042	5.221

*Significant at 5% level of significance

^{NS} Non significant

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

Source of variation	df	Mean square of branches plant^{-1} at different days after sowing (DAS)			
		45	60	75	At harvest
Replication	2	0.078	0.004	0.114	0.081
Variety (A)	1	1.401*	2.253*	0.963*	2.707*
Error	2	0.010	0.006	0.019	0.114
Foliar spray (B)	7	1.402*	1.160*	0.881*	1.579*
Variety(A) X Foliar spray (B)	7	0.107*	0.091*	0.048*	0.092*
Error	28	0.043	0.052	0.075	0.106

*Significant at 5% level of significance

^{NS} Non significant

Appendix VI. Analysis of variance of the data on above ground dry weight plant^{-1} of blackgram as influenced by combined effect of variety and foliar application

Source of variation	df	Mean square of above ground dry weight plant^{-1} at different days after sowing (DAS)					
		15	30	45	60	75	At harvest
Replication	2	0.00	0.012	0.137	3.683	1.418	1.750
Variety (A)	1	0.00 ^{NS}	0.135*	7.053 ^{NS}	0.320 ^{NS}	5.755 ^{NS}	192.000*
Error	2	0.00	0.005	0.615	0.733	4.199	7.750
Foliar spray (B)	7	0.00*	0.369*	4.689*	5.965*	37.847*	78.179*
Variety(A) X Foliar spray (B)	7	0.00*	0.095*	0.204*	0.947*	14.196*	7.238*
Error	28	0.00	0.055	0.221	0.720	1.201	2.512

*Significant at 5% level of significance

^{NS} Non significant

Appendix VII. Analysis of variance of the data on nodules plant^{-1} of blackgram as influenced by combined effect of variety and foliar application

Source of variation	df	Mean square of nodules plant^{-1} at different days after sowing (DAS)		
		30	45	60
Replication	2	6.751	56.818	17.583
Variety (A)	1	1181.075*	4246.922*	52.083 ^{NS}
Error	2	47.291	10.172	18.583
Foliar spray (B)	7	842.484*	2668.517*	5626.857*
Variety(A) X Foliar spray (B)	7	359.568*	242.493*	198.512*
Error	28	12.802	57.340	63.345

*Significant at 5% level of significance

^{NS} Non significant

Appendix VIII. Analysis of variance of the data on yield contributing characters of blackgram as influenced by combined effect of variety and foliar application

Source of variation	df	Mean square value of			
		Pods plant^{-1}	Pod length	Seeds pod^{-1}	1000 seed weight
Replication	2	0.684	0.031	0.292	1.646
Variety (A)	1	25.960 ^{NS}	0.002 ^{NS}	0.287 ^{NS}	17.521 ^{NS}
Error	2	1.669	0.021	0.414	2.15
Foliar spray (B)	7	109.183*	0.210*	0.683*	23.878*
Variety(A) X Foliar spray (B)	7	12.409*	0.050*	0.059*	4.045*
Error	28	1.707	0.040	0.126	5.622

*Significant at 5% level of significance

^{NS} Non significant

Appendix IX. Analysis of variance of the data on yield contributing characters of blackgram as influenced by combined effect of variety and foliar application

Source of variation	df	Mean square value of			
		Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.025	0.032	0.104	5.199
Variety (A)	1	0.045*	0.247*	0.502*	17.897 ^{NS}
Error	2	0.000	0.006	0.008	2.238
Foliar spray (B)	7	0.086*	0.145*	0.450*	2.659 ^{NS}
Variety(A) X Foliar spray (B)	7	0.005*	0.012*	0.062*	3.193*
Error	28	0.004	0.010	0.018	4.016

*Significant at 5% level of significance

^{NS} Non significant

PLATES

Plate 1: Preparing land for seed sowing

Plate 2: Blackgram plant after germination

Plate 3: Vagetative stage of blackgram

Plate 4: Nodule data collection

Plate 5: Flowering stage and foliar application

Plate 6: Reproductive stage

Plate 7: Harvesting stage