INFLUENCE OF SUPPLEMENTARY FOLIAR SPRAY OF UREA AND BORON ON THE GROWTH AND YIELD OF CHICKPEA VARIETIES

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MY BELOVED PARENTS

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CERTIFICATE

This is to certify that the thesis entitled **“Influence of supplementary foliar spray of urea and boron on the growth and yield of chickpea varieties”** 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 **Tahmina Ahmed Meem,** Registration No. **11-04349** 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: June, 2017
Dhaka, Bangladesh

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INFLUENCE OF SUPPLEMENTARY FOLIAR SPRAY OF UREA AND BORON ON THE GROWTH AND YIELD OF CHICKPEA VARIETIES

ABSTRACT

A field experiment was conducted at the Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, during the period from November, 2016 to April, 2017 to study the influence of supplementary foliar spray of urea and boron on the growth and yield of chickpea varieties. The experiment was carried out in split plot design considering two varieties *i.e*. BARI Chola-5 and BARI Chola-8 in the main plot and five levels of supplementary foliar spray 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 in the sub plot replicated three times. Variety BARI Chola-8 (V_2) gave the highest above ground dry matter plant^{-1} (11.95 g), pods plant^{-1} (26.11), 1000 seed weight (273.87 g) and seed yield (1.47 t ha^{-1}). In the case of supplementary foliar spray, highest above ground dry matter plant^{-1} (12.82 g), pods plant^{-1} (28.27), seeds pod^{-1} (1.92), 1000 seed weight (220.90 g) and seed yield (1.69 t ha^{-1}) was produced by T_3 treatment (RF + 2% Urea FS at FI). Regarding combined effects, the highest pods plant^{-1} (29.17), 1000 seed weight (298 g) and seed yield (1.75 t ha^{-1}) were observed from V_2T_3 (BARI Chola-8 along with RF + Urea (2%) FS at FI) when V_1T_3 (BARI Chola-5 along with RF + Urea (2%) FS at FI) was significantly at par for pods plant^{-1} and seed yield. So, BARI Chola-8 or BARI Chola-5 cultivation with recommended fertilizer plus additional 2% urea spray at flower initiation may be a way of maximizing yield of chickpea.

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LIST OF ACRONYMS

AEZ	Agro- Ecological Zone
@	At the rate of
AGDM	Above ground dry matter
B	Boron
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BARC	Bangladesh Agricultural Research Council
BR	Brassinosteroid
Cm	Centimeter
CGR	Crop growth rate
CV	Coefficient of Variance
cv.	Cultivar (s)
$CaCl_2$	Calcium chloride
Cu	Copper
DAS	Days after sowing
DAP	Di-ammonium phosphate
dm^2	Diameter square
dw	Dry weight
^0C	Degree celsius
et al.	And others
FAO	Food and Agriculture Organization
Fe	Iron
$FeSO_4$	Ferrous sulphate
Fed.	Feddan (4200 m^2)
g	Gram (s)
$g\ m^{-2}\ d^{-1}$	Gram per meter square per day
HI	Harvest Index
Hr	Hour(s)
ha	Hectare
IAA	Indole acetic acid
i. e.	That is
kg	Kilogram (s)
K	Potassium

LIST OF ACRONYMS

KNO_3	Potassium nitrate
LSD	Least Significant Difference
LAI	Leaf area index
l^{-1}	Per litre
M	Meter
m^2	Meter squares
Mm	Millimeter
Mg	Milligram
Mn	Manganese
Mo	Molibdenum
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Non-significant
NAA	Napthalic acetic acid
Na_2MoO_4	Sodium molibdate
%	Percentage
P	Phosphorus
PGR	Plant growth regulator
ppm	Parts per million
q	Quintal
RGR	Relative growth rate
SAU	Sher-e- Bangla Agricultural University
SRDI	Soil Resources Development Institute
S	Sulphur
t ha^{-1}	Ton per hectare
TSP	Triple Super Phosphate
TDM	Total dry matter
USDA	United States Department of Agriculture
USG	Urea super granule
viz.	Videlicet (namely)
var.	Variety
Zn	Zinc
$ZnSO_4$	Zinc sulphate

CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the leading pulse crops in Bangladesh belongs to the family Fabaceae, subfamily Papilionaceae which is known as Chola or boot in Bangladesh. Today chickpea is the third most important pulse crop after grasspea and lentil. About 15% of the world's total pulse productions belong to this crop and its production in the world is 13.11 million tons from an acreage of 13.57 million hectares with the productivity of 9.6 q/ha (FAO, 2013). Chickpea is a temperate crop though it is well adapted in tropical and sub-tropical conditions (Kay, 1979). In this region, chickpea is normally sown in the post monsoon i.e. during rabi season. In Bangladesh, chickpea is grown on well drained alluvial to clay loam soils having pH ranging from 6.0 to 7.0. Among the major pulses that grown in Bangladesh chickpea ranked fifth in area and production but second in consumption priority. It crosses 15000 hectares with a producion of 15000 metric tons (BARI, 2014). The area of chickpea cultivation is decreasing due to increase in area under boro rice, maize, wheat and potato cultivation (BBS, 2010). Economically cultivation is not profitable comparing high valued crop as opined by farmers in Bangladesh.

Chickpea is an important source of protein for millions of people in the developing countries, particularly in South Asia, who are largely vegetarian either by choice or because of economic reasons. Chickpea is rich in protein content (20.47g/100g), carbohydrate (62.95g/100g), fibre (12.2g/100g), phosphorous (252mg/l00g), high amount of minerals such as calcium (57mg/100g), magnesium (79mg/100g), iron (4.31mg/l00g) and zinc (15mg/100g), low in fat content and most of it is polyunsaturated (Wallace *et al*., 2016). Chickpea meets 80% of its nitrogen (N) requirement from symbiotic nitrogen fixation and can fix up to 140 kg N ha^{-1} from air. It leaves substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improve soil health and fertility. According to the FAO (2013) yield of chickpea in Bangladesh is miserably low (761 kg ha^{-1}) as compared to that of other countries like India (833 kg ha^{-1}), Myanmar (1,106 kg ha^{-1}), Israel (1813 kg ha^{-1}), Russian Federation (2,400 kg ha^{-1}), Kazakhstan (3,000 kg ha^{-1}) and China (6,000 kg ha^{-1}). Such low yield, however, is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons, viz., Unavailability of quality seeds of high yielding varieties, delayed sowing after the harvest of boro rice, non judicial supplementary foliar spray, disease and insect infestation. Yield gap can be abridged by adopting the advanced variety and optimum supplementary foliar spray.

Variety plays an important role in producing high yield of chickpea because different varieties responded differently for their genotypic characters, input requirements, growth process and the prevailing environment during growing season. High yielding cultivars usually have extensive root system, taller in height, relatively more number of pods and grains pod^{-1}, and good quality seed produces higher yield (Ullah *et al.,* 2002). If we just replace our present varieties with high yielding varieties which are very response to heavy fertilization and may enhance our yield per unit area up to 8-12% (Palta *et al.,* 2005).

Nitrogen fixation in chickpea ranges from 10 to 176 kg ha^{-1} season^{-1}, depending on method of cultivation, cultivar, presence of appropriate *rhizobia* and favorable environment at variable (Bcek *et al.,* 1991). There are evident that nitrogen application becomes helpful to increase the seed yield (Chaudhari *et al.,* 1998). To produce one unit of seeds, chickpea needs as much as three times more nitrogen than that needed by cereals like rice. Chickpea needs much more nitrogen at the reproductive stage than it does in the vegetative stage. In a study Mitra *et al.* (1988) found that a moderate yielding chickpea crop requires 27.86 mg N g^{-1} photosynthetic product during the first 20 days of the pod and seed development. 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, dry matter, pods per plant and 1000 seed weight of grain legumes compared to no N. Nitrogen is most useful element for pulse crops as a component of protein, amino acids in chickpea, its deficiency causes reduced growth, chlorosis, easly scenescence and yield reducton (BARC, 2012). However, legume plants start to support their reproductive units with dry matter rather than the *rhizobia*. As a result nitrogen fixation at that time is ceased that may be a back drop of pulse production (Uddin, 2010). Plant grown with lower basal application of nitrogen to a certain stage when vegetative stage is supported by maximum use of fixed nitrogen present in the nodules. Thus nitrogen becomes very limiting during onset of pod filling, reported 20-50% flower and pod dropping which limits seed yield in chickpea (Vikman and Vessey, 1992). In this situation nitrogen given as basal to the crop is not sufficiently available to the plant. So, nitrogen management is required synchronizing this demand of plant growth stages and before flowering to attempt yield improvements of pulse (Deolankar, 2005; Mukesh, 2006).

Boron is one of the most important micronutrients for crops. B deficiency causes loss of membrane integrity and cell wall stability flower drop, subsequently poor podding of chickpeas (Srivastava *et al*., 1997) and poor yields. Boron may cause yield losses up to 100%, it is estimated that each ton of chickpea grain removes 35 g of B from the soil (Ahlawat *et al*., 2007). The availability of B decreases when the pH is higher than 6.5-7.0, unfavourable weather conditions (drought, high precipitation) and soil conditions (B leaching, calcareous soils: B fixation) (Sims, 2000). Chickpea while grown in sandy soil with low organic matter and boron gave poor yield (Srivastava *et al*., 1997). In comparison with others crops, the response of the crop to the application of B is higher in chickpea than in some cereals (Wankhade *et al*., 1996). Ahlawat *et al*. (2007) reported that soil having less than 0.3 mg B kg^{-1} is deficit for such nutrient and to be corrected by applying boron. Seed yield of chickpea increased with the application of boron @ 1.5-2.5 kg ha^{-1} (Shil *et al*., 2007). The application of boron resulted in a higher production of dry matter which translocated to the seeds resulted in higher yield.

Foliar fertilization is one of the most important methods of fertilizer application practices in agriculture because 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). It also reduces the obstacles of macro & micro nutrient absorbtion by root in high pH, low osmotic potential & water availability in critical stage (Zeidan, 2003 ; Anandhakrishnaveni *et al.*, 2004).

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). It has been found effective in increasing the nitrogen availability for seed filling in chickpea (Palta *et al.*, 2005). Urea is one of the most widely used foliar N-fertilizers, characterized by high leaf penetration rate and low cost and most plants can absorb rapidly and hydrolyze in the cytosol (Witte *et* *al*., 2002). Moreover, direct application of N-fertilizers to leaves, especially urea, can be a potential alternative to support plant to nourish its reproductive units when N_2-fixation has been suppressed (Aliloo *et al*., 2012). Therefore, foliar nutrition through urea may be a practical solution to enhance N or protein concentration in the grain.

Ali and Mishra (2001) also found a significant response when foliar applications of B were carried out. Foliar applications of B to annual crops are superior to broadcast applications, and equivalent or slightly more effective than banded applications (Gupta and Cutcliffe, 1978; Marteens and Westermann, 1991).

The above observations have been created the scope of the present study with following objectives-

I. To compare the growth and yield of different varieties of chickpea.
II. To study the effect of supplementary foliar spray in chickpea cultivation.
III. To explore the combined effect of variety and supplementary foliar spray on the performance of chickpea.

CHAPTER II

REVIEW OF LITERATURE

In Bangladesh and in many countries of the world chickpea is an important pulse crop. The crop has conventional less attention by the researchers on various aspects because normally it grows without/less care or management practices. Based on this, a very few research work related to foliar spray of important nutrient such as urea, boron and their effect on growth and yield of chickpea have been carried out in our country. Foliar added nitrogen and boron play an important role in improving chickpea growth and yield during its flower onset when symbiosis process is likely be stopped. However, there is evidence that the yield of chickpea can be increased substantially by using fertilizers (Katare *et al.*, 1984). However, some of the important and informative works and research findings related to the variety, nitrogen and boron so far been done at home and abroad have been reviewed in this chapter under the following headings -

2.1 Varietal performance of chickpea in relation to growth and yield

Increasing chickpea yield can be achieved by breeding high yielding cultivars. Significant differences in chickpea cultivars have been shown by many workers (Hafiz, 2000; Akay, 2011).

2.1.1 Plant height (cm)

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its vicinity.

Karasu *et al.* (2009) conducted an experiment to determine the effect of bacterial inoculation and different nitrogen doses on yield and yield components of some chickpea genotypes in Mustafakemalpa province. While maximum plant height was recorded on popular local genotype named Yerli (58.7cm), Canıtez-87 cultivar and ILC-114 line had shorter plant height (54.7 and 53.7 cm, respectively).

Aliloo *et al.* (2012) conducted an experiment in chickpea to study the effects of foliar spraying of aqueous solutions 2 and 4% urea at two stages (before and after flowering) and 20 kg/ha urea application in soil (three-week after sowing) on growth, yield and yield components of cultivars (Azad and ILC 482) under rainfed conditions. Plant height of Azad cultivar (102.5cm) was significantly higher than that of ILC 482(100.5cm).

Khatun *et al*. (2010) reported that the tallest plant height (49.6 cm in 2004-05 and 49.9 cm in 2005-06) was recorded by BARI Chola-5 at 100 DAS. The lowest plant height (12.6 cm in 2004-05 and 13.0 cm in 2005-06) was noted in BARI Chola-8 at 20 DAS.

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

Gagandeep *et al.* (2015) concluded that 2.0 percent urea spraying at green floral bud stage of inflorescence followed by another spray 2 days after the first spraying pigeonpea recorded higher number of branches (36), when compared to control (25).

Mahmud (2013) conducted an experiment at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2011 to March, 2012 to find out the influence of the different micronutrient application to chickpea crops for increased seed yield. BARI Chola-9 (V_2) produced 27.86 %, 22.33 %, 22.82 %, 16.57 % and 16.13 % more branches at 40, 60 80, 100 DAS and harvest, respectively than BARI Chola-6 (V_1).

An experiment was conducted by Gurha *et al*. (2001) on chickpea cultivars BG 256, BG 1095, BGD 122, BGD 123, CSJ 126, H 96-112, and RSG 807 in Kanpur, Uttar Pradesh, India to determine the effect of stunt disease on chickpea characteristics and yield components. The reduction in the production of main branches was 28.5% in CSJ 126 and 50% in BG 1095 and H 96-112.

2.1.3 Dry matter weight plant^{-1} (g)

Fallah *et al*. (2005) in Khorram-abad (Lorestan, Iran) reported that chickpea genotype Greet produced dry matter compared with other genotypes (Greet and Hasem).

Quader (2013) reported that at 80, 100 DAS and harvest, BARI Chola-6 showed significantly the highest (4.35 g, 6.32 g and 6.95 g) plant dry weight, which was statistically similar with BINA Chola-6 (4.26 g, 6.25 g and 6.77 g). On the other hand BARI Chola-5 showed significantly the lowest (3.92 g, 5.47 g and 5.94 g) plant dry weight at 60, 80, 100 DAS and harvest.

Roy (2013) stated that dry matter content plant^{-1} of BARI Chola-8 and BARI Chola-9 at 60, 75, 90 and 105 DAS varied significantly. The maximum dry matter content plant^{-1} (4.37 g, 5.33 g, 5.78 g and 6.03 g) was found from V_2 (BARI Chola-9), while the minimum dry matter content plant^{-1} (3.83 g, 4.61 g, 5.14 g and 5.43 g) was recorded from V_1 (BARI Chola-8) at 60, 75, 90 and 105 DAS, respectively.

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

Mahmud (2013) reported that BARI Chola-6 produced 35.2%, 28.88 %, 17.33%, and 20.79 % more nodule plant^{-1} at 60, 80, 100 DAS and at harvest respectively than BARI Chola-9.

Quader (2013) observed that BARI Chola-5 had highest (17.58 and 13.61) nodules plant^{-1} and was at par with BARI Chola-6 (15.94 and 13.47) at 80 and 100 DAS, respectively. BINA Chola-6 showed lowest (12.17, 15.72, 13.19 and 10.81, respectively) nodules plant^{-1} at different growth stages.

Alam *et al.* (2017) carried out an experiment to study the yield of chickpea as affected by boron application. Five varieties of chickpea namely BARI Chola-5, BARI Chola-6, BARI Chola-7, BARI Chola-8 and BARI Chola-9 and four levels of boron (0, 1, 2, 3 kg B ha^{-1}) were used in this experiment. The highest number of nodules plant^{-1} (25.98) was produced by BARI Chola-8 than rest of the varieties.

2.1.5 Nodule dry weight per plant $^{-1}$ (g)

Das *et al.* (2009) conducted an experiment to study the effects of applied phosphorus fertilizer doses on the nodulation and yield in chickpea (*Cicer arietinum* L.) and showed variation in nodule dry weight plant^{-1} in the different varieties was observed. The dry weight of nodule plant^{-1} was 8.49 mg and 6.63 mg in BARI Chola-7 and 4.17 mg in the BU Chola-1 respectively.

Quader (2013) reportd that at 60, 80 and 100 DAS BARI Chola-5 showed significantly highest (0.653 g, 0.575 g and 0.298 g, respectively) nodule dry weight followed by BARI Chola-6 (0.598 g, 0.547 g and 0.294 g, respectively) and BINA Chola-6 (0.501 g, 0.431 g and 0.211 g , respectively).

2.1.6 Leaf area index

Golldani and Moghaddam (2006) found that Karaj (12-60-31) with 3 times irrigations showed highest leaf area index and ILC 482 had the lowest.

Hoque (2005) conducted an experiment in field of Bangladesh Agricultural University to investigate the foliar applicatipn of different concentration of GABA on chickpea. BINA Chola-3 and HyproChola produced higher leaf area (472.2 and 447.7cm^2) than BINA Chola-2 (360.5cm^2).

Mansur *et al*. (2006) conducted an experiment to investigate the effect of leaf area, canopy width & dry matter production in chickpea genotypes as influenced by plant densities & phosphorus levels. While significantly higher leaf area was recorded by BG-267 at 30 DAS (4.23 dm^2/plant) & harvest (4.83 dm^2/plant) compared to ICCV-2.

2.1.7 Crop growth rate ($g\ m^{-2}\ d^{-1}$) and relative growth rate ($g\ g^{-1}\ d^{-1}$)

Golldani and Moghaddam (2006) conducted an experiment in Mashhad, Iran with 4 irrigation levels and three kabuli chickpea cultivars (Jam, Karaj 12-60-31 and ILC482). Karaj 12-60-31 had the highest crop growth rate and relative growth rate.

Hoque (2005) stated that relative growth rate was found higher in BINA Chola-3 (0.172 $g\ g^{-1}\ d^{-1}$) than BINA Chola-2 at 70-80 DAS and the lowest RGR of 0.0095 $g\ g^{-1}\ d^{-1}$ at 100-110 DAS. BINAChola-3 maintained higher CGR almost all the growing period by variety of HyproChola and lowest in BINA Chola-2.

2.1.8 Dry matter partitioning (%)

Karim and Fattah (2007) conducted an experiment to evaluate the effect of foliar spray of potassium naphthenate (KNap) and naphthalene acetic acid (NAA) on the growth of BARI Chola-6. Irrespective of treatment differences stem dry matter accounted for 38.4, 44.9 and 37.9% and leaf dry matter accounted for 61.5, 51.7 and 20.8% at vegetative, pod setting and maturity stages, respectively. Pod accounted for 3.4 and 41.3% dry matter at pod setting and maturity stages, respectively.

Tatar *et al.* (2013) reported that the highest total dry matter reduction in chilling conditions was found in genotype HH-2 (43 %) whereas the lowest one in Cevdetbey-98 (25.3 %). This can be due to the differential partitioning of dry matter in both genotypes under chilling conditions. The genotype HH-2 reduces dry matter content of roots and stems and not of leaves whereas the genotype Cevdetbey-98 diminishes the dry matter in leaves and translocated assimilates to pods.

Ali and Ahmed (2016) reported that under drought stress condition most of the genotypes of lentil transferred more than 40% assimilates to the seed although some of the genotypes produced lower amount of total dry matter. BLX-99033-19 showed highest dry matter partitoning to pod and BARI Mosur-4 showed the lowest value.

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

Hasanuzzaman *et al.* (2007) conducted an experiment at the experimental field of Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh, during the period from November, 2005 to March, 2006 and showed that BARI Chola-4 produced maximum number of pods per plant (33.35) and BARI Chola-1 produced lowest pod. The maximum production of pod was 44% greater than the lower pod production.

An experiment was carried out by Mirzakhani *et al*. (2013) with water deficit and three cultivars of chickpea (Arman, Azad and ILC-482). Based on the results obtained from the analysis of variances the Arman cultivar had the maximum number of pods in branch, the weight of seeds in multiple seed pods than the Azad and ILC-482.

Aliloo *et al.* (2012) reported that pods/plant of Azad cultivar (28.35) was significantly higher than that of ILC 482 (25.53).

Roy *et al*. (2016) stated that maximum number of pods plant^{-1} (27.58) was found from BARI Chola-9, while the minimum (26.03) was observed from BARI Chola-8. Pods plant^{-1} varied for different varieties might be due to genetical and environmental influences as well as management practices.

Khatun *et al.* (2010) reported that number of pods plant was directly related to seed yield. BARI Chola-5 produced higher pods/plant, which resulted in higher seed yield, though number of pods/plant did not differ significantly among the varieties.

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

Roy *et al.* (2016) stated that different varieties responded differently for number of seeds pods to input supply and the prevailing environment during the growing season.

The maximum seeds pod (1.65) was recorded from BARI Chola-9 and the minimum (1.54) was recorded from BARI Chola-8.

Khatun *et al.* (2010) reported that number of seeds/pod significantly differed among the varieties.the highest seeds/pod obtained in BARI Chola-5 (1.69) and lowest in BARI Chola-8 (1.54).

Mahmud (2013) repoted that BARI Chola-6 produced the highest (2.02) number of seeds pod^{-1} and BARI Chola-9 produced the lowest (1.91) number of seeds pod^{-1}.

2.1.11 1000-seed weight (g)

Karasu *et al.* (2009) reported that maximum 1000 seed weight was obtained from Canıtez- 87 cultivar (498.2 g) and popular local genotype Yerli (497.9 g), ILC-114 line had fewer 1000 seed weight (446.8 g).

BINA (2012) conducted an experiment to determine the optimum irrigation water requirement of chickpea developed at BINA. The experiment was conducted at BINA sub-stations, Magura and Ishurdi during the Rabi season of 2010-2011. In Magura, highest 1000 seed weight produced form BINA Chola-6 (148.05 g).

A field experiment was conducted by Singh and Sekhon (2006) in Ludhiana, Punjab, India, during the winter (rabi) season to study the effect of row spacings (30 and 45 cm) and seed rates (30, 40 and 50 kg/ha) on the performance of genotypes GPF 2 and GNG 469 of desi chickpea (*Cicer arietinum*). Bold-seeded genotype, i.e. GNG 469 recorded higher 100-seed weight (22.81 g) and lower pods per plant than the small-seeded (14.85 g) genotype GPF 2.

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

Bhuiyan *et al.* (2009) conducted a trial at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal, Bangladesh and found that seed yields of the BARI Chola-5 and BARI Chola-6 (1.80 t/ha and 1.85 t/ha, respectively) were increased by 20.0% and 19.4% over uninoculated treatments for two consecutive rabi seasons in 2002-03 and 2003-04.

Hasanuzzaman *et al.* (2007) showed among the varieties, BARI Chola-5 gave the maximum seed yield (1.81 t ha^{-1}), which was 36.09% more over BARI Chola-1, which produced the lowest seed yield (1.33 t ha^{-1}).

Khatun *et al.* (2010) reported that thousand-seed weight of three chickpea varieties differed significantly. Maximum seed weight (192 g in 2004-05 and 189 g in 2005-06) was obtained in BARI Chola-8 whereas minimum seed weight (130g in 2004-05 and 135g in 2005-06) was obtained in BARI Chola-5.

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

Ali *et al.* (2010) found in their study that chickpea genotype 97086 produced higher biological (7658 kg/ha) than other genotypes.

Mahmud (2013) observed that the BARI Chola-6 produced the highest (2.20 t ha^{-1}) stover yield and BARI Chola-9 produced the lowest (1.92 t ha^{-1}) stover yield. Result showed that BARI Chola-6 produced 14.69 % more stover yield than BARI Chola-9.

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

Roy (2013) conducted an experiment during the period from 11 December, 2012 to 30 March 2013 to study the influence of supplementary nitrogen, irrigation and hormones on flower droppings, growth and yield of chickpea. The higher biological yield (4.41 t ha^{-1}) was recorded from BARI Chola-9, while the lower (3.90 t ha^{-1}) was found from BARI Chola-8.

Tickoo *et al.* (2006) carried out an experiment on mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 m spacing and supplied with 36-46 and 58-46 kg NP ha^{-1} in a field experiment conducted in Delhi, India. Cultivar Pusa Vishal recorded higher biological yield (3.66 t ha^{-1}) compared to cv. Pusa 105 (1.63 t ha^{-1}).

2.1.15. Harvest index (%)

Das *et al.* (2009) stated that the highest harvest index (37.68 %) was found in the variety BARI Chola-7 and the lowest (36.28 %) in the variety BARI Chola-6.

Mukesh (2006) reported that K-850 chickpea variety proved better in terms of seed yield, whereas Radhey proved better in terms of harvest index in relation to nitrogen application.

Mahmud (2013) observed that BARI Chola-9 produced the highest (43.64 %) harvest index numerically while BARI Chola-6 produced the lowest (42.46 %) harvest index numerically. This result showed that BARI Chola-6 produced 0.41% more harvest index than BARI Chola-9.

Quader (2013) conducted an experiment at the research field of Sher-e-Bangla Agricultural University, Dhaka to find out the effect of the time of application of nitrogenfertilizer to chickpea crops. The highest (43.97%) harvest index was found in BARI Chola-6, which was followed by BINA Chola-6 (43.80%). On the other hand BARI Chola-5 showed significantly the lowest (42.29%) harvest index the varieties.

2.2 Effect of supplementary foliar spray of urea on growth and yield of chickpea

2.2.1 Plant height (cm)

Aliloo *et al.* (2012) conducted a field experiment to study the effects of foliar spraying of aqueous solutions 2 and 4% urea at two stages (before and after flowering) and 20 kg/ha urea application in soil (three-week after sowing) on growth, yield and yield components of chickpea cultivars (Azad and ILC 482). Highest plant height was produced by 20 kg urea application. However, difference among 20 kg urea application, 2% and 4% urea spraying before flowering was not statistically significant.

Verma *et al.* (2009) evaluated that physiological traits and productivity of rainfed chickpea in relation to urea spray and genotype and reported that 1.0 per cent urea at flowering and pod development stage resulted in higher plant height (47.7 cm) that control.

Gagandeep *et al*. (2015) reported that in pigeonpea maximum enhancement in these traits were observed with 2% urea application which was approximately 13% more plant height at flowering stage of development as compared to control. Increase in plant height and number of branches could be the result of increased metabolic and divisional activities in the shoot apical meristems in response to urea applications.

Rao *et al.* (2016) conducted a field experiment during rabi season of 2012-13 at Regional Agricultural Research Station, Lam, Guntur, with an aim to find out effect of foliar nutrition on physiological and biochemical parameters of mung bean (*vigna mungo*) under irrigated conditions. Among foliar nutrients urea @ 2% recorded the highest plant height (21.29 cm), control recorded lower plant height (16.54 cm), followed by water spray.

Bahr (2007) reported that treatments of 1% urea foliar application at pod filling stage of chickpea gave the tallest plants (129.00 cm) whereas smallest plant (97.00 cm) in control.

Atram (2007) conducted an experiment to find out the response of foliar application of nitrogen in chickpea. Effect of foliar spray of nutrients on plant height, urea spray 2% at flower initiation stage and 10 days thereafter recorded the maximum plant height (44.7cm) which was significantly higher than the plant height obtained with water spray only (31.3 cm).

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

Tanwar *et al.* (2014) observed that the foliar application of 2% urea solution significantly improved the branches/plant (4.49) with two sprays of urea at flower initiation and 10 days thereafter in chickpea.

Venkatesh and Basu (2012) reported that the branching of chickpea enhanced significantly due to foliar spray of urea and DAP and the highest branches/plant (6.93) was recorded with urea spray at 75 DAS which was statistically at par with DAP spray at 75 DAS but significantly higher over control and water spray and urea/DAP spray at 105 DAS.

Gagandeep *et al.* (2015) reported that spraying 2.0 % urea at green floral bud stage of inflorescence of pigeonpea followed by another spray 2 days after the first spray resulted in approximately 58% in number of branches at flowering stage of development as compared to control. This increase with 2% urea application, at podding stage was approximately 40% in number of branches this might be due to more availability of nitrogen, which plays a vital role in cell division.

Atram (2007) conducted an experiment to find out the response of foliar application of nitrogen in chickpea. The effect of foliar spray of nutrients on number of branches per plant, urea spray 2% at flower initiation stage and 10 days thereafter gave significantly higher number of branches (6. 75) than water spray (4.22).

2.2.3 Above ground dry matter (AGDM) plant^{-1} (g)

Thakur *et al.* (2017a) stated that due to presence of various nutrients and PGR in pulse magic (10 per cent nitrogen, 40 per cent phosphorous, 3 per cent micronutrient and 20 PPM plant growth regulator) might have governed the various physiological characters that ultimately increased the dry matter production at various stages of crop growth by increasing the various growth indices and it was more at harvest (23.74 g plant^{-1}) due to more dry matter accumulation in pods.

Venkatesh and Basu (2012) reported that dry weight of plants after spray application was significantly increased and highest dry weight of 6.78 and 14.25 g plant^{-1} was recorded with urea spray application after ten days of 1st spray (75 DAS) and 2nd spray (105 DAS), respectively.

Palta *et al.* (2005) concluded that the potential to increase yields of chickpea by application of foliar nitrogen near flowering in environments in which terminal droughts reduce yield.

Mondal *et al.* (2011) conducted an experiment to study effect of foliar application of nitrogen and micronutrients on growth and yield in mungbean and opined that 1.5 per cent urea alone or combination of nitrogen and various micro nutrients like boron, molybdenum, zinc, calcium and iron @ 0.1 per cent with four sprays at 4 days interval from flowering to pod development stage gave higher total dry mass per plant (10.2 g) than control (6.38g).

Yadav *et al*. (2011) reported that in chickpea 2% diammonium phosphate, urea and potassium chloride @ 2% each at flowering and branching stage recorded the highest dry matter accumulation (114.9 g) at harvest and the lowest at control (86.3 g).

Sritharan *et al.* (2015) stated that 2% urea at 25 days after sowing and 15 days after first spray in blackgram recorded higher dry matter production (24.84 g plant^{-1}) at pod filling stage than other treatments & lowest at control (9.82 g plant^{-1}). Foliage applied macro nutrients at critical stages of the crop were effectively engrossed and translocated to the developing pods, producing more number of pods and better filling in soybean was reported by Jayabel *et al*. (1999).

Surendar *et al.* (2013) reported that in blackgram, spraying 2.0% urea and 0.1 ppm brassinolide at 25 days after sowing resulted in higher total dry matter plant^{-1} at vegetative stage (2.12 g), flowering stage (4.85 g), pod filling stage (10.57 g) and harvest stage (17.13 g) per plant, respectively than other treatments and lowest result found at control in all the vegetative and reproductive stages.

Bisne (2015) reported that chickpea seed priming for 4 hrs in $Cacl_2$ + foliar spray of 2% urea at 1st flower + foliar spray of 100ppm salicylic acid 1st pod initiation and 10 days later gave highest dry matter (16.58) superseded other treatments for the same trait.

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

Kumar (2018) conducted an experiment to study the effect of foliar application of nutrients on growth and development of black gram (*Vigna mungo* (L.) Hepper) under rain fed condition and reported that application of urea 2% spray at flowering gave maximum number of root nodules/plant (14.33) at 30 DAS. At 45 DAS the application of DAP 2% spray at flowering and 15 days later recorded maximum number of root nodules/plant (15.60), the minimum number of root nodules/ plant was recorded of 11.67 in control treatment.

Aggarwal *et al.* (2015) reported that foliar spray of 2% urea at vegetative + flower initiation rerecorded highest leghaemoglobin content & nodule number (40) and was statistically at par with 2% urea spray at vegetative stage alone but significantly higher than all other treatments which improved nodulation.

Abbasi *et al.* (2013) recorded that application of 50 kg urea/ha produced the highest number (17.33) of nodules per plant and the lowest values (9 .67) at control condition in chickpea.

Bisne (2015) stated that seed priming for 4 hrs in $CaCl_2$ + foliar spray of 2% urea at 1st flower + foliar spray of 100 ppm salicylic acid 1st pod initiation and 10 days later (0.25) superseded other treatments for nodules dry weight. The lowest magnitude was noted in control (0.13).

Quader (2013) reported that nodule dry weight showed significant variation for different nitrogen application at 40, 60, 80 and 100 DAS. At 80 DAS, the maximum nodules plant^{-1} was recorded from basal application of 20 kg N ha^{-1} and additional 20 kg N ha^{-1} at flower initiation (20.44) and was statistically similar with (20.33) basal application of 20 kg N ha^{-1} and additional 20 kg N ha^{-1} at branch initiation and basal application of 20 kg N ha^{-1} and additional 20 kg N ha^{-1} at branch initiation (20.17).

2.2.5 Nodules dry weight $plant^{-1}$ (g)

Kumar (2018) reported that treatment application of DAP 2% spray at flowering and 15 days later recorded maximum dry weight of root nodules/plant (18.50) at 45 DAS, which was significantly superior than rest of treatments except application of urea phosphate 2% spray at flowering of blackgram. The minimum dry weight of per plant was recorded of 7.22 mg in control treatment.

Maurya *et al.* (1987) studied the effect of N levels (0, 30, 60 or 90 kg ha^{-1}) on the rate of growth and yield performance of chickpea at Dilhi, India in 1988. They noted that applied N at the levels above 40 kg ha^{-1} reduced the nodule dry weight and the seed yield consequently.

Quader (2013) stated that nodule dry weight showed significant variation for different nitrogen application at 40, 60, 80 and 100 DAS. The highest nodule dry weight of chickpea at 80 and 100 DAS was recorded from basal application of 40 kg N ha^{-1} (0.65 g and 0.35 g, respectively). The lowest nodule dry weight were recorded from no fertilizer (0.33 g and 0.14 g, respectively).

Aggarwal *et al.* (2015) conducted an experiment to elucidate the response of chickpea to foliar application of N through urea at different growth stages under irrigated conditions of Punjab, India. Highest nodule dry weight (137.3mg/plant) found at foliar spray of 2% urea at vegetative + flower initiationand the lowest in control (105.5 mg/plant).

2.2.6 Leaf area index (LAI)

Surendar *et al.* (2013) reported that the normal recommended dose of nitrogen along with foliar spray of urea 2% and Brassinosteriod 0.1 ppm resulted in a remarkable improvement in LAI with 35 and 40 per cent increase during flowering and pod filling stages of blackgram. Higher leaf area index (0.34, 0.82, 1.89, and 1.65) at vegetative stage, flowering stage, post flowering stage and harvest stage, respectively than control.

Sritharan *et al.* (2015) stated that 2.0% urea at 25 days after sowing and 15 days after first spray in blackgram recorded higher leaf area (966.5 cm^2 $plant^{-1}$) at pod filling stage and lowest at control (529.10).

Gagandeep *et al.* (2015) reported that maximum increase in leaf area and LAI was noted with 2% urea application in pigeonpea which was 26% at flowering and 19% at podding stage of development as compared to control.

Rao *et al*. (2016) reported that among foliar nutrients urea @ 2% recorded highest leaf area (520.83 cm^2 $plant^{-1}$) followed by KNO_3 in pigeonpea. Control recorded lower leaf area (345.97 cm^2 $plant^{-1}$).

Namvar *et al.* (2011) stated that the maximum values of LAI in inoculated and non-inoculated chickpea plants were observed in application of 75 (23.45% increase over control) and 100 kg urea ha^{-1} (20.67% increase over control), respectively. Plants that were treated with 0 kg urea ha^{-1}showed the lowest LAI at both levels of inoculation.

Atram (2007) stated that foliar application of nutrients in chickpea affected LAI at 45 and 60 days after sowing. Foliar spray of 2% urea at flowering initiation stage and 10 days thereafter gave higher LAI (1.38) as compared to other treatments.

Mondal *et al.* (2012) conducted a field experiment at the field laboratory of the Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh during the period from July to November 2010 to investigate the effect of foliar application of urea on growth and yield of soybean. Application of 1.5% urea thrice from the beginning of flowering to pod development stage with an interval of 10 days showed superiority in leaf area index than control.

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

Crop production is determined by crop growth rate as a function of light interception by the leaf area of a crop.

Sritharan *et al.* (2015) stated that 2% urea at 25 days after sowing and 15 days after first spray in blackgram recorded higher crop growth rate (24.6 g m^{-2} d^{-1}) between 30-60 days after sowing (48.0 days) and lowest at control (14.7 g m^{-2} d^{-1}).

Surendar *et al.* (2013) reported that in blackgram, spraying 2% urea and 0.1 ppm brassinolide at 25 days after sowing resulted in effective in registering higher crop growth rate (0.78, 1.84, 1.36 g m^{-2} day^{-1}) than control (0.54, 1.22, 1.02 g m^{-2} day^{-1}). This enhancement in CGR was due to fast development of the sources as well as sink.

Rajendran (1991) observed that foliar application of 1 % urea significantly increased the number of leaves from 7.9 to 9.0 in greengram than control.

Namvar *et al.* (2011) stated that application of 75 and 100 kg urea ha^{-1} showed the highest CGR in inoculated (35.06% increase over control) and non-inoculated (31.33% increase over control) chickpea plants, respectively. The lowest CGR was recorded in non-fertilized and non-inoculated plants. Higher CGR may be due to higher production of dry matter owing to greater LAI and higher light in-terception (Zajac *et al.,* 2005; Yasari and Patwardhan, 2006).

Atram (2007) conducted an experiment to find out the response of foliar application of nitrogen in chickpea. Foliar application of 2% urea at flower initiation stage (3.46) and 10 days thereafter (5.04) was also found significant to increase the CGR.

Thakur *et al.* (2017b) conducted a field experiment to investigate the effect of foliar nutrition on growth and yield of rainfed blackgram. Higher CGR (0.095 g $dm^{-2}day^{-1}$at 35-55 DAS and 0.239 g $dm^{-2}day^{-1}$ at 55 DAS-Harvest) was obtained with foliar application of combination of nutrients and PGR and in blackgram.Salim (1992) stated that foliar spraying of 1percent urea significantly increased the crop growth rate in soybean.

2.2.8 Relative growth rate (g g^{-1} d^{-1})

Kumar (2018) conducted an experiment to study the effect of foliar application of nutrients on growth and development of blackgram (*Vigna mungo* (L.) Hepper) under rainfed condition and reported that application of 19:19:19 (NPK) 2% spray at flowering stages produced maximum RGR (0.066 g/g/day) followed by foliar application of DAP 2% spray at flowering stage and 15 days later (0.062 g/g/day) at 45-60 days interval.

Gagandeep *et al.* (2015) conducted an experiment to determine the effect of foliar application of mineral nutrients on growth attributes of two pigeonpea varieties (PAU 881 and AL 201) for two successive seasons (2012-2013). They opined that at flowering stage, maximum enhancement in RGR was noticed with 2% urea which was 21.71 (PAU 881) and 25.71% (AL 201) high over controls. At this stage, all the treatments significantly enhanced RGR over controls but there was non-significant difference among the treatments. However, at podding stage, maximum RGR (0.454 g g^{-1} dw day^{-1}in PAU 88 and 0.414 g g^{-1} dw day^{-1} in AL 201) was obtained with 2% urea which was 27.69 (PAU 881) and 23.17 (AL 201) percent higher over their control. Increase in RGR in treated plants can be attributed to increased leaf longevity in these plants as compared to their controls.

Ali *et al*. (2014) stated that the relative growth rate between 75 DAS and harvest recorded significant difference with concentrations of foliar application of water soluble fertilizers in chickpea. Significantly higher RGR (0.816 g g^{-1} day^{-1})was recorded with 2.0 per cent water soluble fertilizer at flowering and pod development stage which was on par with 1.5 % WSF flowering and pod development stage (0.814 g g^{-1} day^{-1}). Significantly lower RGR of 0.657 g $g^{-1}day^{-1}$ was recorded with control.

Aktar (2013) reported that statistically significant variation was recorded for relative growth rate (RGR) of chickpea at 20-40 DAS, 40-60 DAS, 60-80 DAS and 80-100 DAS for the application of prilled urea and urea super granules. At 80-100 DAS, the highest RGR was found from USG placed at 20 cm distance (0.025 g g^{-1} day^{-1}), while the lowest RGR was found from USG placed at 40 cm distance (0.012 g g^{-1} day).

2.2.9 Dry matter partitioning (%)

Rawsthorne *et al.* (1985) observed that nitrate fed chickpea plants partitioned more dry matter into the branches and leaves during early vegetative growth compared to those dependent on nitrogen fixation. After anthesis, proportionately more dry matter and nitrogen is partitioned into pod wall development and chickpea up to 60% of all the dry matter accumulated after anthesis is allocated into the seed (Khanna-Chopra and Sinha, 1987).

Duan *et al.* (2014) reported that the contribution of post-anthesis assimilates to grains under different N rates ranged from 58.5% to 80.1%, with the higher ones being obtained at 150 and 180 kg ha^{-1}. Taken together, N rates of 150 and 180 kg N ha^{-1} were most effective in promoting post-anthesis assimilates and dry matter accumulation in wheat grains and ultimately the grain yield.

Kulsum *et al.* (2007) evaluated the performance of blackgram under various levels of nitrogen at the Bangbandhu Sheikh Mujibur Rahman Agricultural University during

March to June 2002. In the beginning of the growth cycle, the differences in TDM between the varieties due to fertilizer N application were less conspicuous but over the time the differences widened. The treatment with 80 kg N ha^{-1} was found superior to other treatments in accumulation of DM in these components. Leaf and stem dry weight continued to increase until mature stage then decreased irrespective of N treatments. Decreasing leaf and stem dry weight may be due to remobilization of assimilates towards grain.

2.2.10 Pods/plant (no.)

Venkatesh *et al.* (2012) conducted a field experiment that to study the response of chickpea to foliar application of nitrogenous fertilizres under rainfed conditions. The highest pods per plant (45.3) were recorded in 2% urea spray at 75 DAS which was 23.7 and 21.3% higher than control and water spray respectively.

Surendar *et al*. (2013) reported that the treatmental combination (N 25 kg ha^{-1}+ Urea 2% + BR 0.1 ppm) caused more than 50 percent improvement in setting of pods in blackgram. Treatment combination (N 25 kg ha^{-1}+ BR 0.1 ppm + Urea 2%) was found to be the most effective treatment in improving the grain yield by 27 percent over control.

Sritharan *et al.* (2015) reported that the number of pods per plant was increased due to the foliar spray of 2% urea (44.72) and had the significant yield increment in blackgram when compared to control (21.31).

Mondal *et al.* (2011) stated that 1.5% urea alone or combination of nitrogen and various micro-nutrients like boron, molybdenum, zinc, calcium and iron @ 0.1 percent with four sprays at 4 days interval from flowering to pod development stage resulted in higher pods per plant (15.2) than other treatments in mungbean. The lowest pods per plant was found in control (11.8).

Roy (2013) stated that maximum pods plant^{-1} in chickpea (28.52) was observed from supplemental irrigation along with aqueous N before flowering, which was statistically similar (27.57 and 26.75, respectively) with supplemental irrigation before flowering, PRH (phytohormon) spray before flowering and kinetine spray before flowering whereas the minimum (25.00) was recorded from control i.e., no spray at flowering and afterwards.

Atram (2007) reported that foliar nutrition affected the number of pods significantly in chickpea. Significantly higher numbers of pods (43.95) were recorded with the treatment urea spray 2% at flower initiation stage and 10 days thereafter. All the treatments gave higher number of pods as compared to water spray.

Aggarwal *et al.* (2015) reported that foliar application of urea brought significant improvement in number of pods/plant and 2% urea spray at vegetative stage + flower initiation stage produced highest pods per plant which was significantly higher than 2% urea spray at vegetative stage and unsprayed control.

Tanwar *et al.* (2014) observed that the foliar application of 2 % urea solution at flower initiation was significantly improved the highest pods/plant (54.28) in chickpea.

Thakur *et al.* (2017a) reported that higher number of pods per plant in blackgram (38.0) were absorved in pulse magic (10 per cent nitrogen, 40 per cent phosphorous, 3 per cent micronutrient and 20 PPM plant growth regulator) foliar spray than other treatement and it is due to the application of nutrients at reproductive stage has helped in more translocation of photosynthates to the developing pods.

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

Mondal *et al*. (2011) stated that 1.5% urea alone or combination of nitrogen and various micro-nutrients like boron, molybdenum, zinc, calcium and iron @ 0.1 % with four sprays at 4 days interval from flowering to pod resulted in seeds per pod (9.40).

Venkatesh and Basu (2012) reported that the highest seeds /pod in chickpea recorded in 2% urea spray at 75 DAS which was 1.90 and it was higher than control (1.72) and water spray (1.75), respectively.

Roy *et al.* (2016) reported that maximum seeds pod (1.67) was found from supplemental irrigation along with aqueous N before flowering, whereas the minimum (1.51) was observed from control treatment in pigeonpea.

Aggarwal *et al.* (2015) conducted a study to elucidate the response of chickpea to foliar application of N through urea at different growth stages under irrigated conditions of Punjab, India. Highest seeds/pod obtained in 2% urea spray at flower initiation stage + pod initiation stage (1.87) which were significantly higher than all other treatments.

Nigamananda and Elamathi (2007) conducted an experiment in Uttar Pradesh, India to evaluate the effect of N application time as basal urea spray and use of plant growth regulator (NAA at 40 ppm) on the yield and yield components of greengram cv. K-851. Treatments were as included: 1/2 basal N + foliar N as urea at 25 or 35 days after sowing (DAS); 1/2 basal N + 1/4 at 25 DAS + 1/4 at 35DAS as urea; and 1/2 basal N +1/2 foliar spraying as urea + 40 ppm NAA. 2% foliar spray of urea and NAA, applied at 35 DAS, resulted in the highest seeds/pod (7.67)

2.2.12 1000 seed weight (g)

Shirani *et al.* (2015) investigated the the effects of foliar application of zinc, manganese and nitrogen on yield, yield components and grain quality of chickpea (*Cicer arientinum* L.). Foliar application of nitrogen increased the grain yield by 6.2% compared to control.

Mondal *et al.* (2011) stated that 1.5% urea alone or combination of nitrogen and various micro-nutrients like boron, molybdenum, zinc, calcium and iron @ 0.1 % with four sprays at 4 days interval from flowering to pod resulted in 100 seed weight (5.19 g) in mungbean.

Venkatesh and Basu (2012) concluded that The 100 seed weight of chickpea was significantly increased with 2% urea spray at 75 DAS (16.9) being at par with other treatments except control.

Bahr (2007) stated that foliar application of 1% urea sprayed at pod filling of chickpea gave the best results for yield and all yield attributes. The heaviest 100 seed in gram was found 36 at 1% urea sprayed at pod filling and 26.8g at control.

Roy *et al.* (2016) reported that maximum 1000-seed weight in chickpea (274.00 g) was recorded from supplemental irrigation along with aqueous N before flowering; whereas the minimum (234.89 g) was found from control treatment.

Verma *et al.* (2009) reported that the 100 seed weight significantly improved upto 1.00% urea spray in chickpea.

Tanwar *et al.* (2014) observed that the foliar application of 2% urea solution significantly improved 100 seed weight during both the years over water spray in chickpea.

An experiment was conducted by Abbasi *et al.* (2013) with nitrogen rates at four levels (0, 25, 50 and 75 kg urea ha^{-1}). The result revealed that 100 grains weights were significantly affected by nitrogen rates and seed inoculation in chickpea varieties.

Namvar and Sharifi (2011) stated that increasing of nitrogen application rate significantly decreased the weight of 100-grain in chickpea. The highest 100-grain weight was recorded in the control while the lowest rate of this trait was obtained from 100 kg urea ha^{-1}. Application of 100 kg urea ha^{-1} decreased the 100-grain weight by 7.51% compared to the control.

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

Brijnandan *et al.* (2014) reported that significant increase in seed yield of chickpea enhanced by seed priming and foliar application of urea at flower initiation and 10 days thereafter. Among the various treatments seed yield maximum in seed priming followed by urea spray 2 percent at flowering and 10 days thereafter (1197.74 kg/ha) recording an increase of 58.55 per cent over non-seed priming + water spray (865.18 kg/ha).

Gagandeep *et al*. (2015) reported that an increase in seed yield/plant was recorded following mineral nutrients application and maximum increase was observed with 2% urea application which was 1.66 (PAU 881) and 1.77 (AL 201) fold over controls followed by 1% urea (1.45 fold in PAU 881 and 1.65 fold in AL 201). The improvement in leaf characteristics (LA and LAI) as observed in their study might have contributed towards enhanced production of assimilates through improved photosynthetic efficiency.

Rao *et al.* (2016) conducted a field experiment during Rabi season of 2012-13 at Regional Agricultural Research Station, Lam, Guntur, with an aim to find out effect of foliar nutrition on physiological and biochemical parameters of mungbean (vigna mungo (L.) Hepper) under irrigated conditions. Among foliar nutrients urea @ 2% recorded significantly higher seed yield (792.17 kg ha^{-1}) followed by KNO_3@ 1%

(770.27 kg ha^{-1}). Lower seed yield was observed in control (609.0 kg ha^{-1}) followed by water spray (643.50 kg ha^{-1}).

Thimmegowda (1983) concluded that 0.4% urea at flower initiation of greengram recorded higher seed yield (1229 kg ha^{-1}) than control.

Sritharan *et al.* (2015) reported that foliar spray of 2% urea exhibited higher yield (900 kg/ha) with 20% yield increment over control followed by T_3 (100 ppm salicylic acid + 2% DAP + 0.2% Boric acid + 0.5% FeSO4 + 0.5% ZnSO4 + 0.05% Na_2MoO_4) which yield 860 kg/ha.

Verma *et al.* (2011) reported that Urea @ 2.0 % at 40 days after sowing of blackgram resulted in an increase of 27.4 to 31.0 percent in grain yield.

Bahr (2007) conducted a field experiment in private farm at Al Beheira Governorate, Egypt to study the effect four urea foliar application treatments 1% urea sprayed at flowering, at pod set, pod filling and (control) unsprayed of chickpea. Treatments of 1% urea foliar application at pod filling gave the highest seed yield (1461kg/fed.) whereas lowest seed yield (633kg/fed.) in control.

Palta *et al*. (2005) investigated the effect of foliar application of isotopically labelled nitrogen (15N-urea) at 4 stages during flowering and podding on the uptake and utilisation of nitrogen by chickpea (*Cicer arietinum* L.) under conditions of terminal drought was in a glasshouse study. Foliar applications of urea at 50% pod set and at the end of podding did not affect the yield primarily because the uptake of nitrogen was limited by the leaf senescence that occurred with the development of terminal drought. The results indicate the potential to increase yields of chickpea by application of foliar nitrogen near flowering in environments in which terminal droughts reduce yield.

Das and Jana (2015) carried out five sets of experiment at Pulses and Oilseeds Research Station, Berhampore, Murshidabad, West Bengal to evaluate the effect of water soluble fertilizer spray on growth and yield of greengram, blackgram, lathyrus, lentil and chickpea. 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.

Nigamananda and Elamathi (2007) conducted an experiment to evaluate the effect of N application time as basal urea spray and use of plant growth regulator (NAA at 40 ppm) on the yield and yield components of greengram cv. K-851.2% foliar spray of urea and NAA, applied at 35 DAS, resulted in the highest grain yield (9.66 q ha^{-1}).

Shrivastava and Shrivastava (1994) reported that chickpea was sprayed at 50% flowering with water, 2% urea, potassium sulphate and no spray. Foliar application of 2% urea gave the highest seed yield of 1.70 t/ha over control (0.66 t/ha). Ravi *et al*. (1998) reported that foliar application of 2% urea solution at flowering increased the grain yield by 22.9%over control.

Dudhade *et al*. (2003) compared the effect of foliar application of water, urea 2% and 3% and KCL 2% over no any spray in gram. They noted from the results that foliar spray of urea at 2% and 3% were equally effective and led to record grain yield of 1062 kg/ha, which were higher than other sprays, being significantly higher over untreated crop (698 kg/ha).

Mondal *et al.* (2012) studied the effect of foliar application of urea on physiological characters and yield of soybean and revealed that foliar application of urea at 1.5 % three times at reproductive stages may be used for getting increase seed yield in soybean (3.19 t ha^{-1}).

Bhowmick *et al.* (2013) observed that the foliar spray of 2% urea solution twice at flower initiation and 10 days thereafter also found superior to two rounds of either 3% KCl or simple water spray in influencing crop growth and yield in chickpea.

Thakur *et al.* (2017b) conducted an experiment to investigate the effect of foliar nutrition on growth and yield of rainfed blackgram. Due to increase in yield attributing characters by Pulse magic @ 10 g/l (10 percent nitrogen, 40 percent phosphorous, 3 percent micronutrient and 20 PPM plant growth regulator) , which finally increased the seed yield (1101 kg ha^{-1}) to the extent of 23 percent compared to control.

Reddy *et al.* (2018) investigated the response of finger millet to foliar nutrition on growth and yield on the entisols. Amongst the different foliar treatments urea spray @ 2% had recorded significantly highest values which was at par with 19:19:19 (N:P:K) but superior over DAP, $Ca(NO_3)_2$ and KNO_3 sprays applied @ 2%. The significantly highest grain (23.59 q ha^{-1}) and straw yield (31.96q ha^{-1}) were recorded by 2 % urea spray which was superior over foliar sprays of DAP, KNO3and $Ca(NO_3)_2$ @ 2 % each and at par with 2 % 19:19:19 (N:P:K) foliar spray (23.39 q ha^{-1}, 31.14 q ha^{-1} grain and straw yield, respectively).

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

Hafiz (2000) carried out two field experiments in Egypt to study the effects of late foliar spraying of aqueous solution of 1% urea (sprayed twice 80 and 90 days after sowing) and 3 nitrogen fertilizer rates (0, 20 and 40 kg N fed^{-1}) applied 21 days after sowing on the growth, yield and yield components of chickpea cultivars. Late supplementary foliar spraying with aqueous solution of 1% urea significantly increased stover yield compared to the unsprayed control.

Atram (2007) reported that foliar spray of nutrients, treatment of urea spray 2% at flower initiation stage and 10 days thereafter produced significantly higher straw yield of 2151.9 kg/ha as compared to water spray with yield of 1606.5 kg/ha.

Mahmud (2013) reported that recommended NPK and gypsum, B, S, Zn, and Mg in soil produced the highest (2.51 t ha^{-1}) stover yield which was statistically similar with recommended NPK and gypsum in soil and B, S, Zn and Mg as spray in chickpea. However, the lowest (1.57 t ha^{-1}) stover yield was observed from control which was statistically similar with F_3 (F_2 without B). Result showed that F_1 produced 60.38 % more stover yield than control.

Vadavia *et al.* (1991) found that application of 20 kg ha^{-1} N and 40 P ha^{-1} increased significant straw yield of chickpea.

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

Bisne (2015) stated that urea foliar spray @ 1% gave higher biological yield (5240.31 kg/ha) significantly dominated other treatment for biological yield in chickpea. The significantly lowest magnitude was noted in control (4722.05 kg/ha).

Bahr (2007) conducted a field experiment in private farm at Egypt to study the effect four urea foliar application treatments 1% urea sprayed at flowering, at pod set, pod filling and (control) unsprayed chickpea. Treatments of 1% urea foliar application at pod filling gave the highest biological yield (3.25) whereas lowest biological yield (1.56) in control.

Aggarwal *et al.* (2015) stated that biological yield in chickpea was significantly influenced by urea spray at different growth stages. The application of 2% urea spray at vegetative stage + flower initiation stage recorded maximum biological yield (5963kg/ha) which was statistically at par with all other treatments except unsprayed control.

Namvar *et al*. (2013) recorded that application of 100 kg urea/ha was increased the biological yield by 37. 79% as compared to control in chickpea.

Salvagiotti *et al.* (2008) reported that adding N increases the production of total dry matter in plants which can increase potential of plant to produce more plant height, branches, pods, seeds, which ultimately results in high grain and biological yield in soybean.

2.2.16 Harvest index (%)

Sritharan *et al.* (2015) reported that significant difference was also observed in HI due to treatments when compared to control. Foliar spray of 2% urea during 25 days after sowing and 15 days after first spray was found to be optimum for obtaining maximum HI (0.32) in blackgram which is higher than ther treatement, the lowest HI found in control (0.24).

Roy *et al.* (2016) reported the maximum harvest index (39.48%) was found from supplemental irrigation along with aqueous N before flowering, which was statistically similar with supplemental irrigation before flowering and PRH spray before flowering, whereas the minimum (35.35%) was found from control treatment which was statistically similar with kinetine spray before flowering in chickpea.

Atram (2007) reported that maximum harvest index (40%) in chickpea was observed with the treatment combination, urea spray 2% at flower initiation stage and 10 days thereafter followed by harvest index (39.6%) with urea spray 2% at vegetative and flower initiation stage. Lowest harvest index (38.4%) was recorded with water spray only.

Thakur *et al.* (2017b) conducted an experiment to investigate the effect of foliar nutrition on growth and yield of rainfed blackgram. Application of nutrients and growth regulator (10 percent nitrogen, 40 percent phosphorous, 3 percent micronutrient and 20 ppm plant growth regulator) increased the grain yield and thereby resulting increased HI values. The increased HI (38.91) might be due to the increased mobilization of metabolites to reproductive sinks.

Mukesh (2006) conducted a field experiment to study the impact of starter doses of nitrogen (0, 15 and 30 kg ha^{-1}) on nodulation and yield of different cultivars (Radhey, Avarodhi and K-850) of chickpea under irrigated condition and reported that harvest index were highest in the crop treated with 30 kg N ha^{-1}. Harvest index may be influenced by N fertilization.

Mondal *et al.* (2011) stated that foliar application of N and N plus micronutrients (0.1% w/v of B, Mo, Zn, Ca and Fe) at reproductive stage had no significant influence on harvest index of mungbean but had significant influence on yield attributes and yield. Foliar application of 1.5% N or N plus micronutrients resulted in harvest index (34.6 %).

2.3 Effect of supplementary foliar spray of boron on growth and yield of chickpea

2.3.1 Plant height (cm)

Uma and Karthik (2017) conducted an experiment to find out the influence of foliar nutrition on growth and seed yield of pulse crop viz., blackgram, greengram, cowpea and horse gram. The foliar application of 1% boron resulted in increased plant height 41.67cm, 46.77cm, 69.63cm and 63.97cm in blackgram, greengram, cowpea and horse gram respectively which is higher than the control (39.03cm, 48.33cm, 63.63 cm and 55.30 cm in blackgram, greengram, cowpea and horse gram respectively).2% DAP produced significantly increased all the growth parameters which was statistically on par with spray of 1% potassium chloride and 1% boron.

Ali and Mishra (2001) reported that foliar application of boron and molybdenum brought significant improvement in plant height in chickpea.

Rawashdeh and Sala (2015) reported that plant height increased significantly due to foliar application of micronutrient (Fe, B, Fe+B) at different stages of chickpea. At 90

DAS also the treatment potassium nitrate @ 2 percent + boric acid @ 50 ppm + zinc sulphate @ 1 percent at 30 DAS and 60 DAS recorded higher plant height (48.83 cm) which was 28.50 percent greater over the control (38.00 cm).

Dixit and Elamathi (2007) concluded that foliar application of B (0.5%) in green gram increased the plant height (32.26 cm) which higher than control.

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

Uma and Karthik (2017) reported that the foliar application of 1% boron resulted in increased Branches/plant (45.13, 50.98, 72.80 and 67.50 in blackgram, greengram, cowpea and horsegram) which was statistically on par with control (43.17, 52.54, 67.17 and 57.87 in blackgram, greengram, cowpea and horse gram respectfully).

Alam *et al.* (2017) stated that the highest number of primary branches plant^{-1} (4.93) and secondary branches plant^{-1} (23.13) was observed at 3 kg B ha^{-1} and the lowest one (4.24) was observed at control treatment (0 kg B ha^{-1}) in chickpea.

Moinuddin *et al*. (2017) affirmed that foliar application of micronutrients mixture i.e. mixture of Zn, B, Fe, Mn along with NPK (19-19-19) in potato produced the highest number of branches (13.65) over the control (10).

Gowthami and Rao (2014) carried out a field experiment at the Agricultural College Farm, Agricultural College, Bapatla to study the effect of foliar application of potassium, boron and zinc on growth and yield of soybean. At 90 DAS the treatment potassium nitrate @ 2 per cent + boric acid @ 50 ppm + zinc sulphate @ 1 per cent at recorded higher number of branches (9.63) which was 30.13% higher over control (7.40). Role of the nutrients in various physiological and biological processes contributing to the proper growth of plants to their maximum potential might be the reason for higher number of branches (Sawan *et al*., 2008).

2.3.3 Above ground dry matter plant^{-1} (g)

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

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 dry matter production by such in treatment.

Anwarullah and Shivashankar (1999) worked in two separate field experiments with different doses of foliar application of molybdenum and boron on green gram and black gram and found that application of boron increased leaf area index, total dry matter and yield.

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. 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.

Valenciano *et al.* (2010) studied the response of chickpea to the foliar applications of Zn, B and Mo was studied in pot experiments with natural conditions and acidic soils. There were low significant interactions between Zn and B for total DW, the highest total DW value was obtained with 4 mg Zn+ 2mg B per pot (6.85 g plant^{-1}) and the lowest was obtained with 0 mg Zn+ 2 mg B per pot (4.98 g plant^{-1}).

Hemantaranjan *et al.* (2000) reported that the reduction in height of shoot and length of roots and increased total drymatter production with foliar application of boric acid @ 50 and 100 ppm at 30 and 60 days after emergence (DAE) in soybean.

Significant increase in dry weight of plants were recorded in greengram with foliar application of boron @ 0.2 per cent along with DAP @ 2 per cent, NAA @ 40 ppm and Mo @ 0.05 per cent by Pradeep and Elamathi (2007).

2.3.4 Nodules plant^{-1} (no.) and nodules dry weight plant^{-1}(g)

Mahmood *et al.* (2011) investigated the effect of boron and stated that number of nodules, weight of nodules and size of nodules improved by treatment (2.86 mg B l^{-1}) while high concentration (4.86 mg B l^{-1}) showed adverse effect and significant reduction in nodule weight, size and numbers of nodule as compared to control in fababean. Low concentration of boron bounds the nitrogen fixation in legumes by restricting the nodule formation and nitrogen fixation increased with higher boron concentration (Yakubu *et al*, 2010).

Mahmud (2013) reported that It was observed that F_2 (Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray) produced the highest number of nodules plant^{-1} of chickpea at 60, 80 and 100 DAS. However, at 60, 80, 100 DAS and at harvest the lowest number of nodules plant^{-1} was observed from F_0 (control).

Alam *et al.* (2017) carried out an experiment to study the yield of chickpea as affected by boron application. Five varieties of chickpea namely BARI Chola-5, BARI Chola-6, BARI Chola-7, BARI Chola-8 and BARI Chola-9 and four levels of boron (0, 1, 2, 3 kg B ha^{-1}) were used in this experiment. The maximum number of nodules plant^{-1} (30.77) was obtained from BARI Chola-8 with 3 kg B ha^{-1} whereas the minimum one (16.30) was observed in BARI Chola-5 at 0 kg B ha^{-1}.

Shinde *et al.* (2017) conducted a field experiment at University of Agricultural Sciences, Raichur to study the influence of seed polymer coating with micronutrients and foliar spray on seed yield of chickpea. Among the different treatments imposed, seed polymer coating (@ 6 ml/kg) of chickpea seeds with the combination of $ZnSO_4$ + Boron + Ammonium molybdate + $FeSO_4$ (each @ 2 g/kg) of seed along with two foliar sprays (0.5 % + 0.2 % + 0.1 % + 0.5 %, respectively, $ZnSO_4$ and $FeSO_4$) at an interval of 10 days during flowering stage (50 and 60 DAS) recorded significantly higher effective root nodules plant^{-1} highly significant difference with respect to total number of nodules and effective root nodule/plant (55.0 and 25.5respectively) at 60 days after sowing compared to all other treatments and control (45.5 and 18.2, respectively).

2.3.5 Leaf area index (LAI)

LA and LAI are considered good surrogate measures of plant and crop photosynthesis which is an important factor of growth rate and eventual grain yield.

Singh *et al*. (1998) reported that the leaf area index at 45 DAS was significantly differed due to foliar spraying of micronutrients. Significantly higher LAI (3.60) was observed 0.1% boron spray recorded 2.67 lower LAI per plant was observed in Control (2.46) in mungbean.

Uma and Karthik (2017) conducted an experiment to find out the influence of foliar nutrition on growth and seed yield of pulse crops. The foliar application of 1% boron resulted in Leaf area index (LAI) 0.6 in blackgram & greengram, 0.9 in cowpea and 0.7 in horse gram which was statistically on par with control.

Kalyani *et al*. (1999) stated that leaf area index (LAI) of all the treatments gave good response to the foliar application of boron in pigeonpea (21.441, 25.719, 18.428 at 200, 300 and 400 ppm boric acid) than control (19.351) at 120 DAS.After an initial lag period, there was a rapid increase in LAI up to 120 days followed by a decrease in LAI which continued till the harvest both in control and boron treated plants.

Higher values of plant height, drymatter accumulation and leaf area per plant were recorded with N dose of 40 kg per feddan combined with 25 ppm boron in fababean (Mahmoud *et al*., 2011).

Gowthami and Rao (2014) reported that soybean plants sprayed with potassium nitrate @ 2 per cent + boric acid @ 50 ppm + zinc sulphate @ 1 % at 30 DAS and 60 DAS recorded higher leaf area index at 60 DAS (5.18) which was 37 percent higher over control (3.78).

Shinde *et al.* (2017) conducted an experiment at the Department of Seed Science and Technology, University of Agricultural Sciences, Raichur to study the influence of seed polymer coating with micronutrients and foliar spray on seed yield of chickpea. Seed polymer coating and foliar spray ($ZnSO_4$ 2 g/kg of seed+ Boron 2 g/kg of seed + Ammonium molybdate 2 g/kg of seed+ $FeSO_4$ 2 g/kg of seed) have shown highly significant difference with respect to LAI to control.

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

Kalyani *et al.* (1999) studied the response of pigeonpea with boron foliar spray at as boric acid at 200, 300 and 400 ppm. Increased leaf area in boron treated plants over the control might have contributed to greater crop growth rate (CGR) values in all the boron treated plants (72.48, 96.06 &68.28 at 200, 300 and 400 ppm boric acid) than control (41.96) at 120 DAS.

Wasaya *et al*. (2017) reported that maximum CGR was observed at 90 DAS, after which it started to decline in maize with higher value under soil applied B and Zn mixture. However, improvement in CGR was observed with application of B and Zn with higher value under soil application, which was at par with foliarly applied Zn and B mixture.

Gowthami and Rao (2014) reported that the treatment potassium nitrate @ 2 % + boric acid @ 50 ppm + zinc sulphate @ 1 % at 30 DAS and 60 DAS showed higher crop growth rate (36.44 g $m^{-2}d^{-1}$) at 45-60 DAS, followed by potassium nitrate @ 2% + boric acid @ 50 ppm (33.93 g $m^{-2}d^{-1}$) in soybean.

Rao (2015) conducted an experiment to find out effect of foliar spray of brassinosteroid+salicylic acid+borax on chickpea. The higher value of CGR was noticed during 55DAS-70DAS with brassinosteroid at 25 DAS+salicylic acid at 35 DAS+borax at 45 DAS and it was 39.65% higher than control.

According to Renukadevi *et al.* (2002) boron application maximize the light interception ratio, biomass production crop growth rate and seed yield in pulses.

2.3.7 Relative growth rate (g g^{-1} d^{-1})

Kalyani *et al.* (1999) conducted an experiment to determine the response of pigeonpea cv. LRG 30 with boron foliar spray at as boric acid at 200, 300 and 400 ppm. There was pronounced increase in the relative growth rate (RGR) of all the boron treated plants (310.72, 406.65 and 294.80 at 200, 300 and 400 ppm boric acid) over the control (204.90) at 120 DAS, though the RGR in general decreased with increasing age.

Gowthami and Rao (2014) reported that the treatments boric acid @ 50ppm at 30 and 60 DAS (0.0388 g g^{-1} d^{-1}), potassium nitrate @ 2 % (0.0379 g g^{-1} d^{-1}) and zinc sulphate @ 1 % (0.0373 g g^{-1} d^{-1}) were on par with the control which recorded low relative growth rate (0.0356 g g^{-1} d^{-1}) at 45-60 DAS in soybean.

2.3.8 Dry matter partitioning (%)

Rao (2015) conducted an experiment to find out effect of foliar spray of brassinosteroid + salicylic acid+borax on chickpea. The plant sprayed with brassinosteroid at 25DAS+salicylic acid at 35DAS + borax at 45 DAS increased 35, 46.5, 64.7% and 27.14% accumulation of dry matter in root, stem, leaves and pods compare to control.

Tekale *et al*. (2009) reported that productivity of pigeon pea was not only dependent on accumulation of total amount of dry matter but its effective partitioning into economic sink seems to be key to increase the yield. The leaf, stem, root and total dry matter plant^{-1} varied significantly at 125 and 180 DAS. Dry matter accumulation in leaf, stem, root and total dry matter was maximum in IAA + B + Zn at both FL and PI stages treatment. Dry matter accumulation in pods was the highest in IAA + B + Zn at both flowering and Pod initiation stages treatment (46%) as compared to control (34%).

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

Uma and Karthik (2017) stated that foliar spray of 2% DAP recorded the highest values for yield attributing characters but foliar spray of 1% boron produced 27 number pods/plant in cowpea which is higher than control.

Valenciano *et al.* (2011) studied the response of chickpea to the foliar applications of Zn, B and Mo was studied in pot experiments with acidic soil field condition. There were also low significant differences for the soil B application on the number of pods per plant. The fewest number of pods per plant (17.99 pods plant^{-1}) from the control treatment and the highest (19.02 pods plant^{-1}) were obtained in boron 1%.

Chatterjee and Bandyopadhyay (2015) reported that spraying of boron at 4 weeks of planting recorded increased the number of pods (24.89), that is 26% higher number of pods and 13% greater pod yield/plant over the control in cowpea. Foliar spray of boron at 4 weeks and 6 weeks and only 6 weeks also produced 24% and 18% greater number of pods and 11% and 7% higher pod yield/plant over the control respectively.

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}.

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 l^{-1} as boric acid, whereas Zn, Mn and Fe were applied at rates of 150, 300 & 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.

Shinde *et al.* (2017) reported that among the different treatments ZnSO4 2g/kg of seed+ Boron 2g/kg of seed+ ammonium molybdate 2 g/kg of seed+ FeSO4 2g/kg of seed recorded significantly higher number of pods (94.5) $plant^{-1}$ in chickpea compared to all other treatments and control (84.4).

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. After 32 days of sowing B deficient plants were sprayed with three concentrations of B (0.05%, 1% and 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 & number of seeds formed $plant^{-1}$. Foliar B application also improved the seed yield of blackgran.

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

Singh *et al*. (1998) reported that (8.5) seeds per pod were noticed in over rest of the treatments boron @ 0.1 % spraying in mungbean and lower number of seeds per pod was recorded in control (8.0).

Ali and Mishra (2001) conducted an experiment during the rabi seasons of 2003-04 and 2004-05 at Allahabad, Uttar Pradesh, to evaluate the effect of micronutrients on growth and yield of kabuli chickpea (*Cicer kabulium*) var. Pragati. 0.2 % borax at 50 and 60 days after sowing resulted in higher number of seeds per pod (1.3) than control (1.1)

Schon and Blevins (1990) conducted field experiments were completed with both soil and foliar applications of B in soybean. Six split foliar applications which totaled 1.12kg B/ha in 1987 increased the number of seeds/pod.

Gowthami and Rao (2014) reported that the foliar application of potassium, boron and zinc at 30 and 60 DAS does not significantly affect the number of seeds per pod as it is a genetically controlled parameter. Hence no significant differences were observed among treatments for the number of seeds per pod in soybean.

Shruthi (2013) stated that highest (2.51) seeds per pod in soybean were noticed in $ZnSO_4$ @ 0.3% + Boron @ 0.2%+ KNO_3 @ 0.5% over rest of the treatments. However, lower number of seeds per pod was recorded in control (2.14)

Alam *et al.* (2017) reported that the highest number of seeds pod^{-1} (1.90) was given by BARI Chola-8 with 3 kg B ha^{-1}. The lowest number of seeds pod^{-1} (1.56) was given by BARI Chola-5 at control treatment.

2.3.11 1000 seed weight (g)

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.).Yield contributing character like 100-seed weight showed no significant effect due to boron application. Average 100-seed weight, highest (5.79 g) was with boron 1% and lowest (5.57 g) with control.

Raza *et al.* (2014) reported that foliar application of B was significant affected on grain yield, number of grains per spike and 1000-grain weight.

Pradeep and Elamathi (2007) reported that significant increase in number of pods per plant, 1000 seed weight, seed and haulm yield was observed in greengram with foliar application of boron @ 2 per cent along with DAP @ 2 per cent, NAA @ 40 ppm and Mo @ 0.05 per cent at 30 days after sowing (DAS).

Shinde *et al.* (2017) reported that significantly higher hundred seed weight of chickpea was 25.9 g was recorded by $ZnSO_4$ 2g/kg of seed+ Boron 2 g/kg of seed+ Ammonium molybdate 2 g/kg of seed+ $FeSO_4$ 2g/kg of seed compared to all other treatments and control (23.6 g). This increase in hundred seed weight might be due to role of micronutrients (boron) in pollen germination, seed development, cell division, translocation of sugar and starch from source to sink (Valenciano *et al.,* 2010)

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}, 1000 seed weight and uptake of B in green gram over control irrespective of genotypes. The maximum increase in the parameter studied was found in the soil plus foliar application method.

Shruthi (2013) stated that hundred seed weight is also one of the yield contributing components however, which did not differ significantly due to higher number of seeds per plant iin soybean. Numerically higher 100 seed weight (14.93 g) was recorded in $ZnSO_4$ @ 0.3%+ Boron @ 0.2%+ KNO_3 @ 0.5% compared to control (10.77 g). Increased 100 seed weight may be due to the supplies of more nutrients in turn resulted in proper development of seed in the plant thereby increased the 100 seed weight in $ZnSO_4$ @ 0.3% + Boron @ 0.2% + KNO_3@ 0.5% compared to control.

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

Padbhushan and Kumar (2014) conducted a greenhouse experiment with green gram grown on boron (B) deficient calcareous soils was to study the influence of soil and foliar applied boron on green gram. It was found that soil applied boron has more influence on mean dry matter yield while foliar applied boron has on mean grain yield. Among all soil applied boron 0.5 mg kg^{-1} is best treatment while 0.1% is best foliar treatment. Soil applied boron was at the par with foliar applied boron.

Ali and Mishra (2001) conducted an experiment during the rabi seasons of 2003-04 and 2004-05 at Allahabad, Uttar Pradesh, to evaluate the effect of micronutrients on growth and yield of kabuli chickpea (*Cicer kabulium*) var. Pragati. 0.2 % borax at 50 and 60 days after sowing resulted in higher seed yield (17.96 kg ha^{-1}) than control.

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.

Tahlooth *et al.* (2006) stated that irrespective to water stress, foliar application of Zn, K, or B significantly increased all the yield contributing characters compared with control mungbean plants.

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.

Chatterjee and Bandyopadhyay (2015) reported that the treatment boron foliar spray with other combination produced 42% higher number of pods and 54% greater pod yield/plant in chickpea over the control. The treatment combination seed treatment with Mo and biofertilizers+ foliar spray of B at 4 weeks and 6 weeks of planting and Mo and biofertilizers+ foliar spray at 6 weeks of planting registered 41% and 36%

higher number of pods and 51% and 45% greater pod yield/plant over the control respectively.

Ali and Mahmoud (2013) reported that 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. This is to be logic since the highest values of yield components and consequently seed yield ha^{-1} gained with the same interaction.

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. 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 in pea.

Gowthami and Rao (2014) carried out an experiment at Agricultural College Farm, Bapatla 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 % at 30 and 60 DAS was found to be superior in increasing seed yield followed by potassium nitrate @ 2 % + boric acid @ 50 ppm at 30 and 60 DAS where as minimum results were found in control.

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

Mishpra *et al.* (2001) carried out an experiment to evaluate the effect of nutrient management and plant growth regulators on the yield of chickpea in Madhya Pradesh, India. Seeds and stover yields were higher in B and cephalexin treatments compared to the other growth regulator treatments.

Mahmoud *et al*. (2011) stated that straw and seed yield per feddan were significantly improved in fababean by applying nitrogen @ 40 kg nitrogen per faddan along with 50-100 ppm boron.

Alam *et al.* (2017) stated that highest stover yield (2.27 t ha^{-1}) of chickpea was noticed at the highest level of boron application (3 kg B ha^{-1}) and the lowest one (1.85

t ha^{-1}) was in control treatment. The effect between variety and boron level failed to produce significant variation on stover yield.

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

Tahir *et al.* (2013) conducted a field study at Agronomic Research Area, University of Agriculture, Faisalabad to evaluate the production potential of mungbean (*Vigna radiata* L.) in response to sulphur and boron. It appeared that sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1} significantly increased biological yield (7688 kg ha^{-1}).

El-Habbasha *et al.* (2012) reported that biological yield/ fed. of chickpea increased by 16.95% and 16.91% in the first and second season, respectively by increasing of compound foliar fertilizer to 200 g/fed. Compared to the control. The increase in yields and its components by foliar fertilizer with Fetrilon Combi-2 (Fe 4% - Zn 4% - Mn 3% - B 1.5% - Mg 2.2% - Cu 0.5 % - Mo 0.05% and S 2.5%) may be due to the easily absorbed forms of nutrients by leaves.

2.3.15 Harvest index (%)

Valenciano *et al.* (2010) studied the response of chickpea to the foliar applications of Zn, B and Mo was studied in pot experiments with natural conditions and acidic soils & the highest HI was obtained with the $Zn_4 \times B_2 \times Mo_2$ treatment (60.30%) while the smallest HI was obtained with the $Zn_0 \times B_0 \times Mo_0$ treatment (47.65%). HI was highly correlated with the number of pods per plant (0.531) and with seed yield (0.438). The number of pods per plant was closely correlated with seed yield (0.831).

Tekale *et al.* (2009) reported that maximum harvest index of pigeonpea was obtained with foliar spray of IAA + B + Zn at both flowering and pod initiation stages treatment (35.78) and the least effect was seen in B + Zn at flowering and pod initiation stages (29.18). These might be due to the fact that IAA promotes the prevention of pod abscission and cell elongation at suppression of abscission of pod was the major determining factor of the seed yield.

Valenciano *et al.* (2011) reported that 1% boron application recorded 45.62% HI and 45.37% HI found at no boron application in chickpea.

Johnson *et al.* (2005) carried out a field experiment over two seasons to compare soil fertilization and micronutrient seed priming as methods of improving Zn and B nutrition of each crop. Micronutrient treatments were evaluated for their effect on grain yield and grain micronutrient content. Soil B fertilization increased B content of the grain of lentil (*Lens culinaris*), chickpea (*Cicer arietinum*), increasing the yield of chickpea only.

So, this research review's purpose is to help the reader understand the effect of variety, urea and boron application on the growth and yield attributes of pulse crops specially chickpea. In Bangladesh, lack of proper variety selection and fertilizer management are major two points for reduced yield. So, it is important to conduct more studies to evaluate the contribution of variety, supplementary foliar spray of urea and boron in increasing chickpea production.

CHAPTER III

MATERIALS AND METHODS

The experiment was undertaken at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November, 2016 to April, 2017 to study the influence of supplementary foliar spray of urea and boron on the growth and yield of chickpea varieties. This chapter includes materials and methods that were used in conducting the experiment are presented below under the following headings:

3.1 Site Description

3.1.1 Geographical location

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated between 23°74′ N latitude and 90°33′E longitude and at an elevation of 8.4 m from sea level (Anon., 1989)

3.1.2 Agro-ecological region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Soil

The soil of the experimental site belongs to the general soil type, deep red brown terrace soils under Tejgaon series. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resources Development Institute (SRDI), Dhaka. The topography of land was medium high and soil texture was silty clay with pH 6.1 and Cation Exchange capacity 2.64 meq 100 g soil^{-1}, respectively. The morphological characteristics of the experimental field and physical and chemical properties of initial soil are given in Appendix II.

3.1.4 Climate

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

3.2 Planting material

The varieties BARI Chola-5 and BARI Chola-8 were used as test crops. The seeds were collected from the Agronomy Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. The seeds were healthy, pulpy, well matured and free from mixture of other seeds, weed seeds and extraneous materials. They grow both in *Kharif* and *Rabi* season. BARI Chola-5 bears good phenotypic characters; such as light green leaf, bushy type plant, 40-50 cm height, purple color flower, seed is smaller in size & deep brown in color. BARI Chola-8 bears green leaf, bushy type plant, 45-55 cm height, white color flower; seed is larger in size, round & whitish in color. Life cycle of this variety ranges from 125 to 130 days. Maximum seed yield is 1.5 to 2.0 t ha^{-1}.

3.3 Treatments of the experiment

The experiment consists of two factors:

<u>Factor A: Chickpea variety (2)</u>

i. V_1: BARI Chola-5
ii. V_2: BARI Chola-8

<u>Factor B: Supplementary foliar spray (5)</u>

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

There were in total 10 (2×5) treatment combinations such as V_1T_1, V_1T_2, V_1T_3, V_1T_4, V_1T_5, V_2T_1, V_2T_2, V_2T_3, V_2T_4 and V_2T_5.

3.4 Germination test

In germination test, BARI Chola-5 and BARI Chola-8 showed 100% and 85% germination in the petridish, respectively.

3.5 Land preparation

The land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 4 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The final land preparation were done on 28^{th} November, 2016. Experimental land was divided into unit plots following the design of experiment.

3.6 Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MoP), gypsum, zinc sulphate and boric acid were used as a source of nitrogen, phosphorous, potassium, sulphur and boron at the rate of 50, 90, 40, 110, 7 and 10 kg ha^{-1}, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation. All the fertilizers were collected from the farm of SAU.

Treatment Doses:

Treatments	**Doses/plot**
T_1 =Recommended Fertilizer(RF)	RF
T_2 =RF+ Foliar Spray (FS) of water at flower initiation(FI)	RF
T_3 =RF+ Urea (2%)FS at FI	RF+20g/L
T_4 =RF+ Boron (1%) FS at FI	RF+10g/L
T_5 =RF+ Urea (2%) + Boron (1%) FS at FI	RF+20g/L+10g/L

3.7 Experimental design and layout

The experiment was laid out in a Split-plot Design with three replications. An area of 24.9m × 14 m was divided into 3 blocks consisting 10 plots in each block. The two varieties and supplementary foliar sprays were assigned in the main plot and sub-plots, respectively. The size of the each unit plot was $8.4m^2$ (3.5 m × 2.4 m). The space between two blocks & two plots were 1.2 m & 0.5 m, respectively. Row to row and plant to plant distances were 40 and 10 cm respectively. The layout of the experiment is shown in Figure 1.

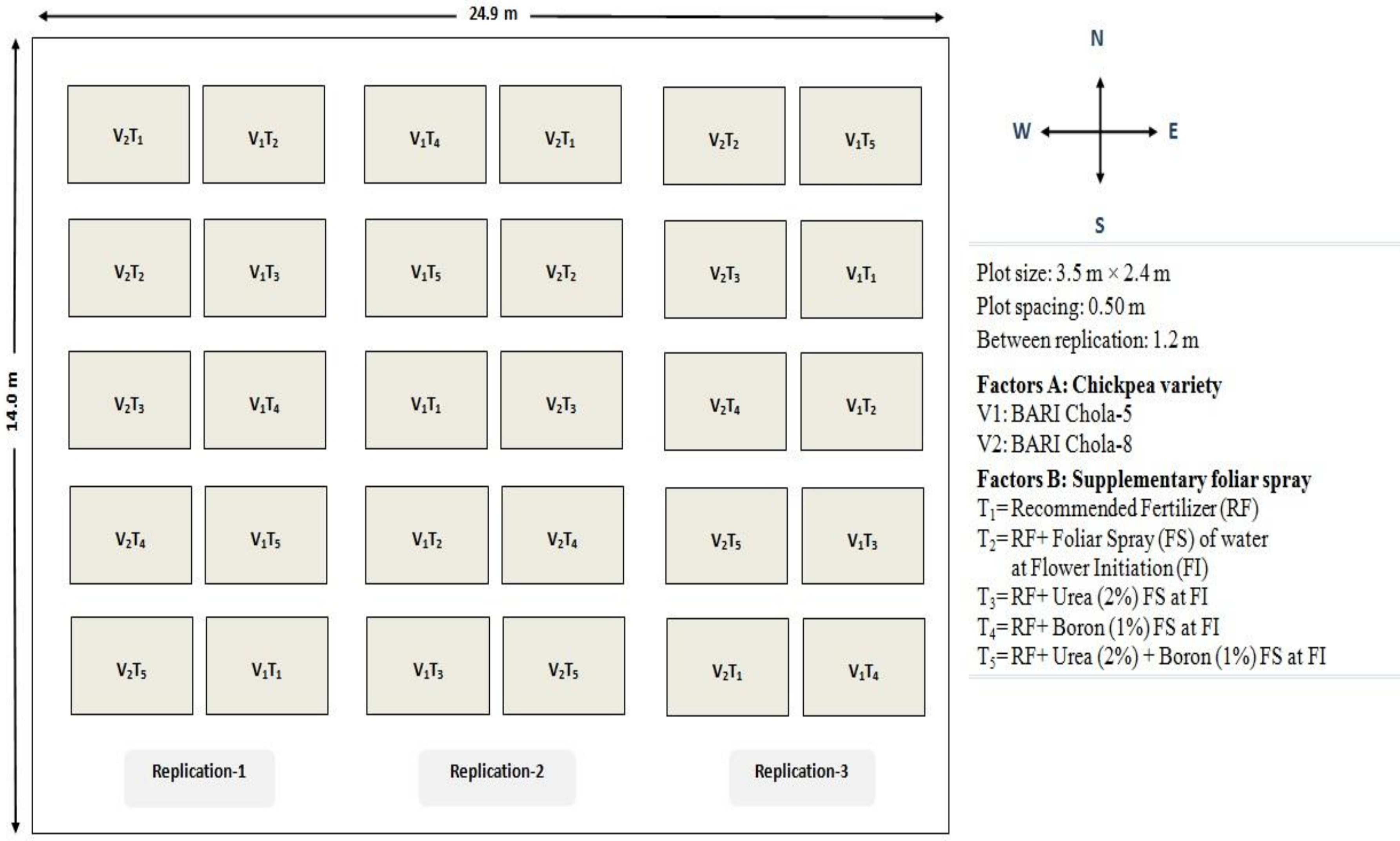


Figure 1. Field layout of the experiment

3.8 Seed sowing

Before sowing seeds were treated with Autostin to control the seed borne disease. The seeds of chickpea were sown on November 29, 2016 in solid rows in the furrows having a depth of 2-3 cm maintaining 40 cm row to row distance. Water was supplied every line before sowing of chickpea seeds. 90% of seeds were germinated on the 5th day after sowing.

3.9 Application of supplementary treatment

Foliar spray of water, 2% urea, 1% boron and 2% urea + 1% boron were applied in selected plots just after flowering (55 DAS).

3.10 Intercultural operations

3.10.1 Thinning and weeding

Seeds started germination of five days after sowing (DAS). Thinning was done two times; at 12 DAS and at 18 DAS to maintain optimum plant population in each plot. First weeding was done at 30 DAS (29 December, 2016) and then weeded as per necessary of the experimental plots.

3.10.2 Irrigation and mulching

The irrigation was done as per requirement. First irrigation was done at 12 DAS. Irrigation was continued till soil saturation. Mulching also done as par requirement few days after irrigation.

3.10.3 Protection against insect and pest

The experimental crop was infected with Sclerotium *rolfsi* at early stage of growth. So, Autostin @ 2% was applied 3 times at 5 days interval and infected plants were pulled out. At later stage of growth pod borer (*Maruca testulalis*) attacked the plant. Ripcord 10 EC was sprayed @ 1 mm per litre water for two times at 7 days interval to control the insects.

3.11 Harvesting and threshing

Harvesting of the crop was done after 128 DAS for data collection when about 80% of the pods attained maturity. A 2m^2 pre-marked area from middle portion of each plot was harvested at maturity. The harvested plants of each treatment were brought to the cleaned threshing floor and sun dried for three days and separated pods from plants by hand.

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 from 30 DAS and continued untilthe end of recording of yield contributing characters of the characters of the crop after harvest. Dry weights of plant were collected from the inner rows leaving border rows by destructive sampling of 5 plants at different dates. The following data were recorded during the experiment.

Crop growth characters

- Plant height (cm)
- Branches plant^{-1} (no.)
- Above ground dry matter plant^{-1} (g)
- Nodules plant^{-1} (no.)
- Nodules dry weight plant^{-1} (g)
- Leaf area index (LAI)
- Crop growth rate (CGR) plant^{-1}
- Relative growth rate (RGR) plant^{-1}
- Dry matter partitioning (%)

Yield contributing characters

- Pods plant^{-1} (no.)
- Seeds pod^{-1} (no.)
- 1000 seed weight (g)

Yield

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

Correlation-regression studies

- Above ground dry matter weight plant^{-1} (g) (90 DAS) and seed yield
- Pods plant^{-1} and seed yield

3.14 Detailed procedures of recording data

3.14.1 Crop growth characters

3.14.1.1 Plant height (cm)

Five plants were selected randomly from the inner row of each plot. The height of the plants were measured from the ground level to the tip of the plant at 30, 60, 90, 120 DAS and harvest (125 DAS). The mean value of plant height was recorded in cm.

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

The branches plant^{-1} was counted from five randomly sampled plants. It was done by counting total number of branches of all sampled plants at 30, 60, 90, 120 DAS and harvest (125 DAS) and then the average data were recorded.

3.14.1.3 Above ground dry matter plant^{-1} (g)

Five plants were collected randomly from each plot at 30, 60, 90, 120 DAS and harvest (125 DAS). Then the leaves were separated from each plant put into envelop and placed in oven maintaining 70^0C for 72 hours for oven dry until attained a constant weight and the mean of dry weight of leaves plant^{-1}, stem plant^{-1} and pods plant^{-1} was determined. The calculated value of leaf dry weight, stem dry weight and pods dry weight was added to determine the value of above ground dry matter weight and it was expressed in gram (g).

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

Five plants from each plot were uprooted carefully with soil at 60, 75 and 90 DAS then washed out with water. The number of nodules plant^{-1} was observed and counted from five plants and average number of nodules plant^{-1} was recorded as per treatment.

3.14.1.5 Nodule dry weight plant^{-1} (g)

Nodules of five sampled plants were collected at 60 DAS, 75 and 90 DAS, dried in oven and then averaged the dry weight and the value was recorded in gram (g).

3.14.1.6 Leaf area index (LAI)

Leaf area was measured by destructing method using CL-202 Leaf Area Meter (USA). All the leaves of the sampled plants were collected and measured the leaf area and expressed in cm^2. Then the mean was calculated. Leaf area index were estimated using the following formula (Hunt, 1981). It was done at 60, 90 and 120 DAS.

Leaf area index= $\frac{Leaf\ area\ per\ plant\ (cm^2)}{Ground\ coverage\ per\ plant\ (cm^2)}$

3.14.1.7 Crop growth rate (CGR)

The crop growth rate is the rate of dry matter production per unit area of land per unit of time. The crop growth rate values at different growth stages were calculated using the following formula (Brown, 1984).

CGR= $\frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1}$ g $m^{-2}d^{-1}$

Where,

W_1= Total dry matter production at previous sampling date

W_2= Total dry matter production at current sampling date

T_1= Date of previous sampling T_2= Date of current sampling

GA= Ground area (m^2)

3.14.1.8 Relative growth rate (RGR)

Relative growth rate is the increase in plant weight per unit plant weight per unit of time represents the efficiency of plant as a producer of a new material i.e. efficiency index of dry matter weight production (Hunt, 1978).

The relative growth rate (RGR) values at different growth stages were calculated using the following formula (Brown, 1984).

RGR= $\frac{\ln W_2 - \ln W_1}{T_2 - T_1}$ g g^{-1} d^{-1}

Where,

W_1= Total dry matter production at previous sampling date

W_2= Total dry matter production at current sampling date

T_1= Date of previous sampling

T_2= Date of current sampling

ln = Natural logarithm

3.14.1.9 Dry matter partitioning (%)

Stem dry weight, leaf dry weight and reproductive unit dry weight per plant at 30, 90 and 120 DAS were calculated as percentage compared to total dry matter weight per plant and partitioning of assimilates in different parts of plant calculated as percentage.

3.14.2 Yield contributing characters

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

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

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

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

3.14.2.3 Weight of 1000 seeds (g)

One thousand cleaned, dried seeds were counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

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

Seed yield was recorded from 2 m^2 area of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

3.14.2.5 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}.

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

Seed yield and Stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Seed yield + Stover yield.

3.14.2.7 Harvest index

Harvest index was calculated from the seed yield and Stover yield of chickpea for each plot and expressed in percentage.

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

3.15 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 chickpea cultivation. Data on different yield contributing characters and yield related traits were recorded to find out the response of two varieties of chickpea to supplementary foliar application of urea and boron**.** The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix III-XII. The results of the experiment have been presented, discussed and possible interpretations have been made under the following headings:

4.1 Crop growth characters

4.1.1 Plant height (cm)

4.1.1.1 Effect of variety

Plant height is one of the most important morphological characters that act as a potent indicator of availability of growth resources in its vicinity. Figure 2 showed that statistically significant variation was recorded in terms of plant height of BARI Chola-5 and BARI Chola-8 at 30, 60, 90, 120 DAS and harvest (125 DAS).

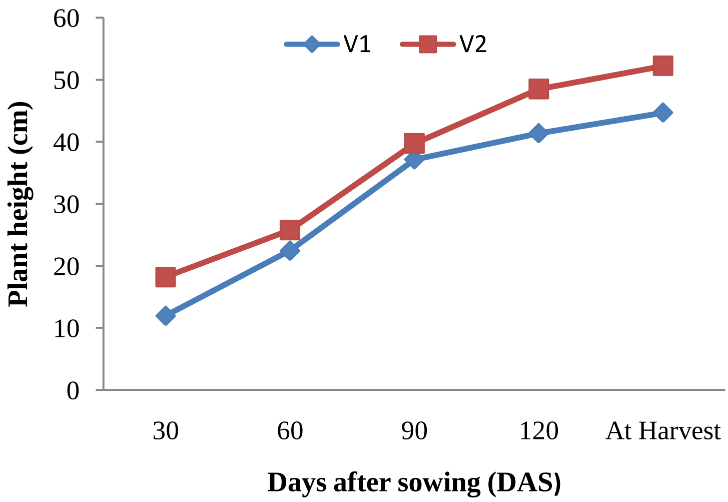


Figure 2. Effect of variety on plant height of chickpea at different days after sowing

(LSD $_{(0.05)}$ =1.92, 2.59, 1.81, NS and NS at 30, 60, 90,120 and harvest, respectively**)**

V_1= BARI Chola-5, V_2=BARI Chola-8

At 30, 60, 90, 120 and 125 DAS the tallest plants (18.197, 25.752, 39.713, 48.480 and 52.21cm, respectively) were recorded from V_2 (BARI Chola-8), whereas the shortest plants (11.943, 22.431, 37.132, 41.34 and 44.67cm, respectively) were found from V_1 (BARI Chola-5). Different varieties produced different plant height on the basis of their genetic characters of chickpea and improved varieties is the first and vital requirement for initiation and accelerated production program. Golldani and Moghaddam (2006) reported various plant heights for different chickpea varieties.

4.1.1.2 Effect of supplementary foliar spray

Significant variation was observed on the plant height of chickpea when added foliar spray was applied. Statistically significant variation was observed in terms of plant height of chickpea at 30, 90, 120 and harvest treatment management under the present trial (Fig. 3). At 30 DAS, the longest plant height (16.19 cm) was observed in T_5 which is statistically similar with all other treatment except T_2 and the shortest plant height (13.89cm) was observed in T_2 which is statistically similar with T_1 and T_3.

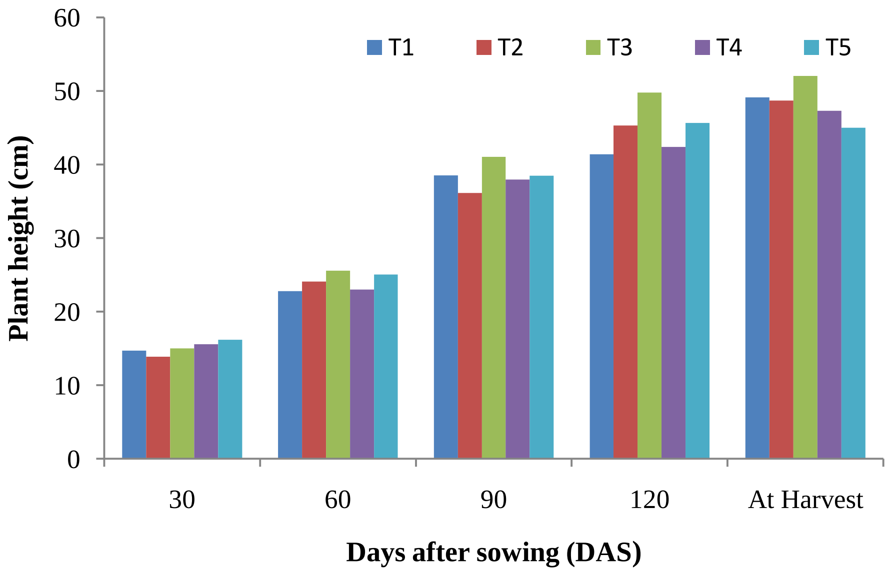


Figure 3. Effect of supplementary foliar spray on plant height of chickpea at different days after sowing (LSD $_{(0.05)}$ =1.54, NS, 3.70, 5.61 and 4.49 at 30, 60, 90, 120 and harvest, respectively)

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.

At 60 DAS, the longest plant height (25.55 cm) was observed in T_3 and the shortest plant height (22.79 cm) was observed in T_1. At 90 DAS, the longest plant height (41.05cm) was observed in T_3 which is statistically similar with all other treatment except T_2 and the shortest plant height (36.12cm) was observed in T_2 which is statistically similar with T_1, T_4 and $T_{5.}$ At 120 DAS the longest plant height (49.79 cm) was observed in T_3 which is statistically similar with T_2 and T_5 and the shortest plant height (41.39cm) was observed in T_1 which is statistically similar with $T_{2,}$ T_4 and T_5. The highest plant height (52.06 cm) was at T_3 which is statistically similar with T_1 and T_2 and the shortest plant height (45.02 cm) was at T_5 which is statistically similar with T_1, T_2 and T_4 at harvest (125 DAS) was found. In the present study, the increase in plant height by urea spray may be attributed to the increase in N status in plant system. Thus nitrogen containing source (urea) has increased the height substantially compared to the rest of the nutrients (Dudhade *et al*., 2003). Supplementary spraying ensured favorable condition for chickpea plant with longest plant. Sritharan *et al.* (2015) also reported higher plant height due to the foliar spray of 2% urea in chickpea.

4.1.1.3 Combined effect of variety and supplementary foliar spray

Combined effect of variety and supplementary foliar spray viewed significant variation in terms of plant height of chickpea at 30, 60, 90, 120 DAS and at the harvest period (Table 1). The highest plant height (19.91cm) at 30 DAS was observed at V_2T_5 which was statistically similar with V_2T_4 (18.94 cm) and V_2T_3 (18.09 cm), where as the lowest plant height (11.14 cm) was in V_1T_2 which was statistically similar (11.95, 11.99, 12.17 and 12.47 cm respectively) with $V_1T_{3,}$ $V_1T_{1,}$ V_1T_4 and V_1T_5 respectively. At 60 DAS the highest plant height was observed at V_2T_3 (27.07 cm) which was statistically similar with V_1T_3 (24.02 cm), V_1T_5 (23.37 cm), V_2T_1 (24.13 cm), V_2T_2 (26.18 cm), V_2T_4 (26.62 cm) and V_2T_5 (26.75 cm) whereas the lowest plant height (21.33 cm) was in V_1T_4 which was statistically similar with $V_1T_{1,}$ $V_1T_{2,}$ V_1T_3, V_1T_5, V_2T_1 and $V_2T_{4.}$ Combined of V_2T_3 scored the highest plant height (41.98 cm) at 90 DAS which was statistically similar with V_1T_1 (37.26), V_1T_3 (40.13), V_1T_5 (38.12), V_2T_1 (39.79), V_2T_2 (36.90), V_2T_4 (41.07) and V_2T_5 (38.82). On the other hand, the lowest plant height (34.81 cm) was obtained from the combination of V_1T_4which was statistically similar with $V_1T_{1,}$ V_1T_2, V_1T_5, $V_2T_{1,}$ V_2T_2 and $V_2T_{5.}$ At 120 DAS, highest plant height (52.15 cm) was recorded from the combination V_2T_3 which was statistically similar with V_1T_3 (47.43 cm), V_2T_2 (49.59 cm), V_2T_4 (48.40 cm) and V_2T_5 (50.20 cm). The shortest plant height (36.43 cm) was recorded from the combination V_1T_4 which was statistically similar with V_1T_1, V_1T_2, V_1T_5 and V_2T_1. At harvest, treatment combination V_2T_3 scored the highest plant height (54.14 cm) which was statistically similar with all other combination except V_1T_1 (45.53 cm), V_1T_2 (44.38 cm), V_1T_4 (41.82 cm) and V_1T_5 (41.64 cm). On the other hand, combination V_1T_5 gave the lowest plant height (41.64 cm) which was statistically similar with V_1T_1, V_1T_2 and V_1T_4 treatment combinations at harvest.

Table 1. Combined effect of variety and supplementary foliar spray on plant height of chickpea at different days after sowing

Treatment combinations	Plant height (cm) at different days after sowing (DAS)				
	30	60	90	120	At harvest
V_1T_1	11.99 d	21.45 b	37.26 a-c	40.71cd	45.53 bc
V_1T_2	11.14 d	21.99 b	35.34 bc	41.01cd	44.38 bc
V_1T_3	11.95 d	24.02 ab	40.13 ab	47.43 a-c	49.96 ab
V_1T_4	12.17 d	21.33 b	34.81 c	36.43 d	41.82 c
V_1T_5	12.47 d	23.37 ab	38.12 a-c	41.13 cd	41.64 c
V_2T_1	17.40 bc	24.13 ab	39.79 a-c	42.07 b-d	52.70 a
V_2T_2	16.65 c	26.18 a	36.90 a-c	49.59 ab	53.01 a
V_2T_3	18.09 a-c	27.07 a	41.98 a	52.15 a	54.17 a
V_2T_4	18.94 ab	24.62 ab	41.07 a	48.40 abc	52.76 a
V_2T_5	19.91 a	26.75 a	38.82 abc	50.20 a	48.41 ab
LSD $_{(0.05)}$	2.17	4.11	5.23	7.93	6.35
CV (%)	8.33	9.85	7.86	10.20	7.58

V_1= BARI Chola-5, V_2= BARI Chola-8

T_1= Recommended Fertilizer (RF), T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI),

T3= RF+ Urea (2%) FS at FI, T_4= RF+ Boron (1%) FS at FI,

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

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

4.1.2.1 Effect of variety

Number of total branches (primary and secondary) plant^{-1} of BARI Chola-5 and BARI Chola-8 showed significant variation at 60, 90, 120 DAS and harvest (125 DAS) showed in Figure 4. At 30, 60, 90,120 DAS and harvest the maximum number of branches plant^{-1} (2.83, 10.871, 13.317, 19.973 and 24.811, respectively) was observed from V_2 (BARI Chola-8) and the minimum number (2.51, 7.147, 10.871, 15.8 and

21.187, respectively) from V_1 (BARI Chola-5). Although management practices influence the number of branches plant^{-1}, varieties itself also manipulated it. Roy (2013) also reported varietal difference in number of branches plant^{-1} in BARI Chola-8 and BARI Chola-9.

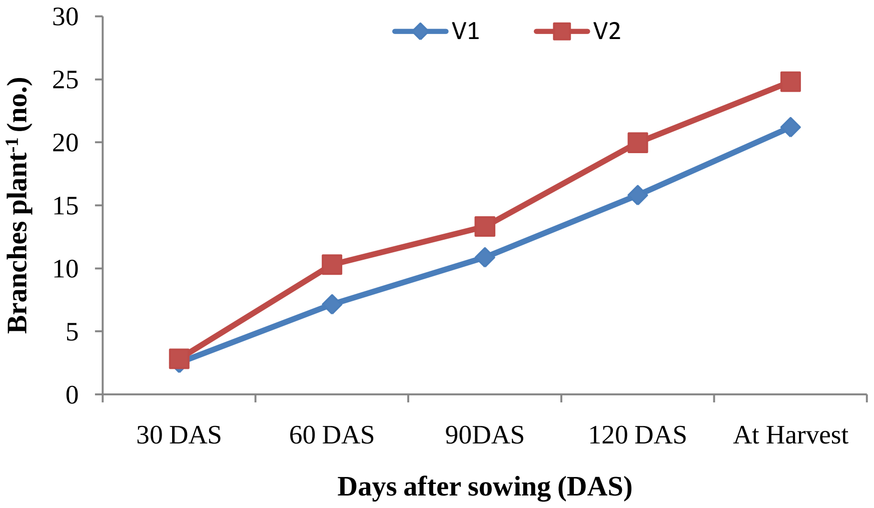


Figure 4. Effect of variety on branches plant^{-1} of chickpea at different days after sowing (LSD $_{(0.05)}$ =NS, 0.44, 0.07, 2.90 and 1.52 at 30, 60, 90,120 and harvest, respectively)

V_1= BARI Chola-5, V_2=BARI Chola-8

4.1.2.2 Effect of supplementary foliar spray

Number of branches (primary and secondary) plant^{-1} of chickpea was observed significant variation in case of different treatments. At 30 DAS highest branches plant^{-1} (2.87) was observed in T_5 which was statistically similar with all the treatment except T_2 (2.43). After treatment spray, T_3 treatment showed highest branches plant^{-1} (10.70, 19.63, 22.40 and 25.83 at 60, 90, 120 DAS and at harvest, respectively). The lowest branches plant^{-1} in T_4 (7.850), T_5 (5.77), T_1 (16.70) and T $_5$ (21.07) was recorded at 60, 90, 120 DAS and at harvest, respectively illustrated in Figure 5. Supplementary spraying ensured favorable condition for the growth of chickpea plant with maximum branches plant^{-1}. Increase in number of branches may be due to more nutrient uptake during vegetative growth. While at later stage nutrients were diverted towards reproductive parts of plants. Hafiz (2000) reported that late supplementary foliar spraying with aqueous solution of 1% urea significantly increased all the studied growth characters. Bahr (2007) and Caliskan *et al.* (2008) reported similar results in chickpea and soybean, respectively.

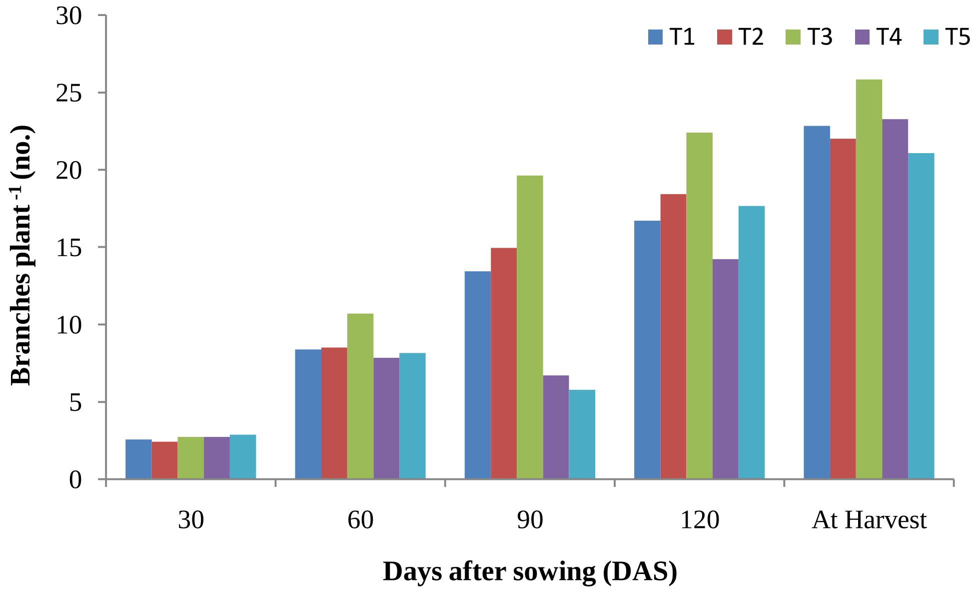


Figure 5. Effect of supplementary foliar spray on branches plant^{-1} of chickpea at different days after sowing (LSD $_{(0.05)}$ =0.31, 0.90, 1.81, 1.63 and 2.46 at 30, 60, 90, 120 and harvest, respectively)

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.

4.1.2.3 Combined effect of variety and supplementary foliar spray

Combined effect of variety and supplementary foliar spray through foliar application showed significant differences on total branches plant^{-1} at 30, 60, 90, 120 DAS and at harvest (Table 2). The result revealed that, the highest branches plant^{-1} (3.13) was observed from combination V_2T_5 was statistically similar with V_1T_1, V_2T_2, V_2T_3 and V_2T_4. At 60, 90, 120 DAS and at harvest the highest branches/plant (13.40, 21.00, 26.40 and 27.45) was recorded in V_2T_3 at 60 DAS, 90 DAS, 120 DAS, respectively. At harvest the highest value found at V_2T_3 which was statistically simillar with V_1T_3, V_2T_1, and V_2T_4. The lowest branches plant^{-1} (2.13) was observed in V_1T_2 that is statistically similar with $V_1T_{3,}$ V_1T_4 and V_2T_1 at 30 DAS. At 60 DAS the lowest branches plant^{-1} (6.53) was recorded in V_1T_1 that is statistically similar with $V_1T_{2,}$ V_1T_4 and V_1T_5 not any other treatment. The minimum branches plant^{-1} (5.43) was observed in V_1T_5 that is statistically similar with V_1T_4, V_2T_4 and V_2T_5 at 90 DAS. At 120 DAS lowest branches plant^{-1} (12.47) was recorded in V_2T_4 that is statistically similar with V_1T_1.

Table 2. Combined effect of variety and supplementary foliar spray on branches plant^{-1} of chickpea at different days after sowing

Treatment combinations	Branches plant^{-1} (no.) at different days after sowing (DAS)				
	30	60	90	120	At harvest
V_1T_1	2.80 a-d	6.53 f	11.80 d	13.33 ef	19.00 d
V_1T_2	2.13 f	7.07 ef	12.33 d	15.60 de	20.20 d
V_1T_3	2.53 c-f	8.00 de	18.25 b	18.40 c	24.20 a-c
V_1T_4	2.47 d-f	7.27 d-f	6.53 e	16.00 d	22.47 cd
V_1T_5	2.60 b-e	6.87 ef	5.43 e	15.67 d	20.07 d
V_2T_1	2.33 ef	10.22 b	15.07 c	20.07 bc	26.67 ab
V_2T_2	2.73 a-e	9.95 b	17.55 bc	21.27 b	23.80 bc
V_2T_3	2.93 a-c	13.40 a	21.00 a	26.40 a	27.45 a
V_2T_4	3.00 ab	8.43 cd	6.87 e	12.47 f	24.07 a-c
V_2T_5	3.13 a	9.47 bc	6.10 e	19.67 bc	22.07 cd
LSD $_{(0.05)}$	0.44	1.28	2.56	2.31	3.47
CV (%)	9.56	8.47	12.22	7.45	8.72

V_1= BARI Chola-5, V_2=BARI Chola-8

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.

Finally, at harvest the lowest branches plant^{-1} (19) was recorded in V_1T_1 that is statistically similar with V_1T_2, V_1T_4, V_1T_5 and V_2T_5 (Table 2).

4.1.3 Above ground dry matter plant^{-1} (g)

Irrespective of variety and different levels of treatment differences the accumulation of above ground dry matter (AGDM) was slow during lag phase (30-60 DAS) of chickpea. Thereafter it increased rapidly up to 120 DAS and had slow increase up to harvest (125 DAS) with little fall in BARI Chola-5. This increase may be due to gradual accumulation of food material in different vegetative and reproductive phase of the plant.

4.1.3.1 Effect of variety

Dry matter is the material which was dried to a constant weight. Above ground dry matter (AGDM) production indicates the production potential of a crop. A high dry matter production is the first perquisite for high yield.

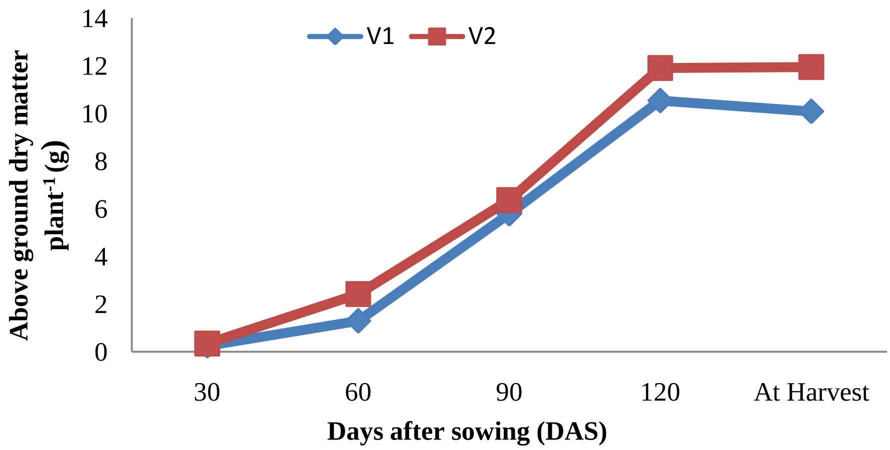


Figure 6. Effect of variety on above ground dry matter plant^{-1} of chickpea at different days after sowing (LSD $_{(0.05)}$ =0.05, 0.14, 0.24, NS and 1.14 at 30, 60, 90,120 and harvest, respectively)

V_1= BARI Chola-5, V_2=BARI Chola-8

AGDM of two varieties were measured at 30, 30, 60, 90, 120 and harvest. It was evident from Figure 6. that AGDM significantly varied at all sampling dates except 120 DAS, V_2 showed the highest above ground dry weight plant^{-1} (15.66) which is non- significant with V_1 at 120 DAS. Figure shows that V_2 (BARI Chola-8) achieved the highest dry matter throughout the growing period (0.34, 2.42, 6.37, 11.91 and 11.95 g plant^{-1} at 30, 60, 90, 120 and harvest, respectively), while the minimum dry matter content plant^{-1} (0.25, 1.30, 5.79, 10.54 and 10.09g plant^{-1} at 30, 60, 90, 120 and harvest, respectively) in V_1 (BARI Chola-5).

Genetic variation of chickpea might be due to this result. V_2 (BARI Chola-8) recorded 36%, 86.15%, 10.17%, 13% and 18.43% higher yield than V_1 (BARI Chola-5) at 30, 30, 60, 90, 120 and harvest. Quader (2013) also found BARI Chola-6 gaining higher dry matter weight than BARI Chola-5. But Das (2006) opined the pattern of dry matter production in the varieties BU Chola-1, BARI Chola-6 and BARI Chola-7 is almost similar.

4.1.3.2 Effect of supplementary foliar spray

Statistically significant variation was recorded for above ground dry matter plant^{-1} at 30, 60, 90, 120 DAS & harvest due to different foliar spray treatments (Fig. 7).

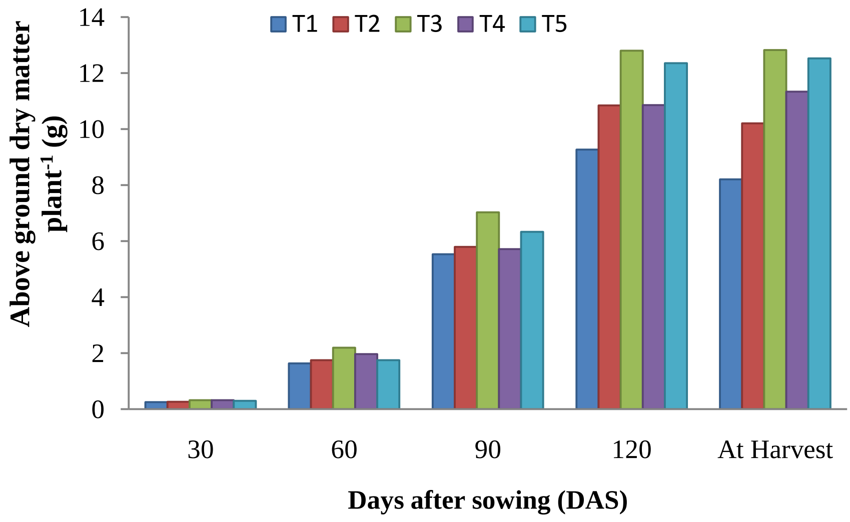


Figure 7. Effect of supplementary foliar spray on above ground dry matter plant^{-1} of chickpea at different days after sowing (LSD $_{(0.05)}$ =0.039, 0.268, 0.723, 0.788 and 1.039 at 30, 60, 90, 120 and harvest, respectively)

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.

Result showed that the the highest above ground dry weight plant^{-1} (0.310, 2.190, 7.032, 12.80 and 12.82) was recorded at 30, 60, 90, 120 and at harvest, respectively at $T_{5.}$ At 30 and 60 DAS T_3 was statistically similar with $T_{4.}$ At 90,120 and at harvest T_3 was statistically similar with $T_{5.}$ The lowest above ground dry weight plant^{-1} (0.252, 1.633, 5.333, 9.273 and 8.210 g plant^{-1}) was obtained at 30, 60, 90, 120 and harvest, respectively at T_1 followed by T_2. T_3 gave 28.45%, 34.11%, 27.09%, 38.04% and 56.15% higher yield than control. The results indicated that AGDM increased slowly at the early stages of growth and then increased rapidly with the advancement of plant age and the rapid increase in AGDM at the later stages of growth (up to 120 DAS) was due to the development of a considerable amount of leaf area compared to early stages (Yasari and Patwardhan, 2006).

Nitrogen foliar spraying ensured favorable condition for higher leaf area index as it facilitates higher light interception for the growth of chickpea plant with optimum vegetative growth and the ultimate results was the highest dry matter content plant^{-1}. This was corroborated with the findings of Kannan (1986) stated that application of urea increased the TDMP by reducing the leaf senescence. Increase in branching and total dry weight of chickpea due to foliar spray of urea was also reported by Bahr (2007).

4.1.3.3 Combined effect of variety and supplementary foliar spray

Combined effect of variety and supplementary foliar spray showed significant variation on above ground dry weight plant^{-1} at all growth stages (Table 3). At 60, 75, 90 and 105 DAS the maximum dry matter content plant^{-1} (5.23 g, 6.25 g, 6.57 g ad 7.02 g, respectively) was attained from V_2T_3 (BARI Chola-8 and RF+ Urea (2%) FS at FI). At 30 DAS V_2T_3 statistically similar with V_2T_4 but V_2T_3 statistically similar with V_2T_5 in other growth stages. Lowest above ground dry weight plant^{-1} (0.22, 1.053 g plant^{-1} at 30 and 60 DAS, respectively) was observed at V_1T_1 (BARI Chola-5 and control i.e., no spray at flowering and afterwards) which was statistically similar with $V_1T_{2,}$ $V_1T_{3,}$ V_1T_4 at 60 DAS and $V_1T_{2,}$ V_1T_5 at 75 DAS, respectively.

Table 3. Combined effect of variety and supplementary foliar spray on above ground dry matter plant^{-1} of chickpea at different days after sowing

Treatment combinations	Above ground dry matter plant^{-1}(g) at different days after sowing (DAS)				
	30	60	90	120	At harvest
V_1T_1	0.22 e	1.053 d	5.097 c	8.670 d	7.833 c
V_1T_2	0.24 cde	1.233 cd	5.500 c	9.903 c	8.750 c
V_1T_3	0.2300 de	1.600 c	6.763 ab	11.73 b	11.61 b
V_1T_4	0.267 cde	1.543 c	5.577 c	10.84 bc	10.99 b
V_1T_5	0.2800 bcd	1.057 d	6.030 bc	11.57 b	11.27 b
V_2T_1	0.2800 bcd	2.213 b	5.970 bc	9.877 c	8.587 c
V_2T_2	0.2933 bc	2.273 b	6.093 bc	11.81 b	11.67 b
V_2T_3	0.4000 a	2.780 a	7.300 a	13.86 a	14.03 a
V_2T_4	0.3800 a	2.393 b	5.847 bc	10.89 bc	11.69 b
V_2T_5	0.3233 b	2.450 ab	6.637 ab	13.13 a	13.79 a
LSD $_{(0.05)}$	0.06	0.38	1.02	1.11	1.47
CV (%)	7.75	11.75	9.71	5.73	7.70

V_1= BARI Chola-5, V_2=BARI Chola-8

T_1= Recommended Fertilizer (RF), T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI),

T_3= RF+ Urea (2%) FS at FI, T_4= RF+ Boron (1%) FS at FI,

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

4.1.4 Dry matter partitioning (%)

Accumulation of dry matter and its distribution into different plant components is an important consideration in achieving desirable economic yield from crop plants (Rawsthorne *et al.*, 1985).

4.1.4.1 Effect of variety

Dry matter accumulation and partitioning into different parts at vegetative, development and maturity stage varied due to variety. V_2 produced 71.42% leaf at vegetative state (30 DAS) which was greater than V_1 and in the grain developing stage (90 DAS) V_2 translocated 10.78% assimilates to flower and pod which was higher than V_1 (7.63%). V_2 acquired 40.57% leaf at development stage which was lower than V_1 but translocated higher amount of assimilates (39.95%) in pod at maturity stage (120 DAS) which was greater than V_1 (37.82%) showed in Figure 8. V_2 acquired higher leaf and dry matter partitioning was also higher in V_2 than V_1. It may be due to genetically or environmental factors.

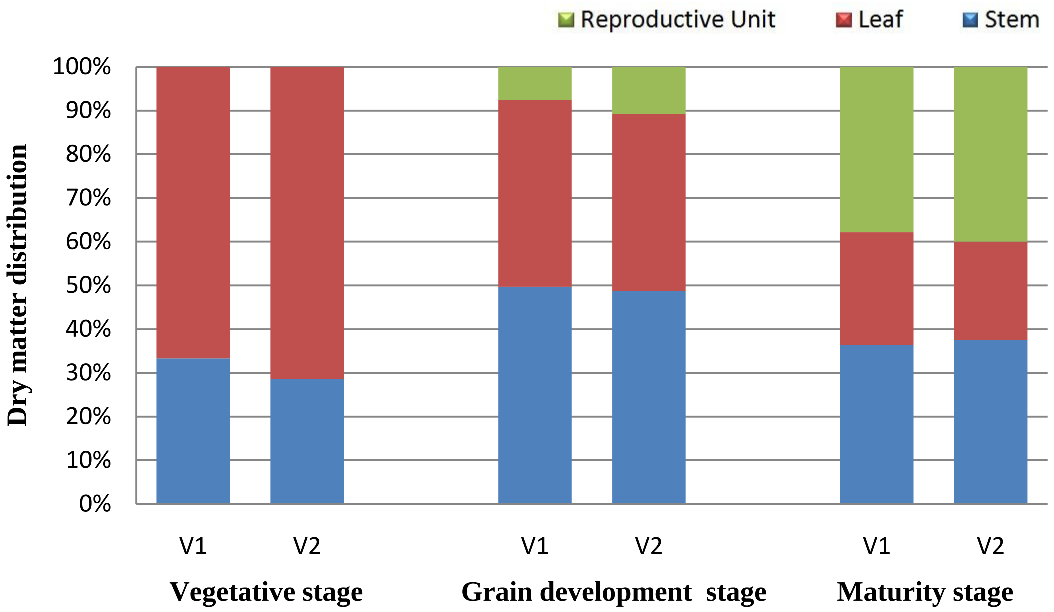


Figure 8. Effect of variety on dry matter partitioning (%) of chickpea

V_1= BARI Chola-5, V_2=BARI Chola-8

Decreasing leaf and stem dry weight may be due to remobilization of assimilates towards grain. Similar trend was observed in blackgram (Kulsum *et al.*, 2007). It could be concluded that varietal differences between chickpea varieties may be due to genetical differences between varieties and growth habit as well as the differences between genotypes concerning partition of dry matter. These results of varietal differences in growth parameters are in agreement with those obtained by (Hafiz, 2000, Dordas, 2009 and Akay, 2011).

4.1.4.2 Effect of supplementary foliar spray

At development stage T_3 treatment gave maximum dry matter accumulation (40.03%) in leaf and 10.78% assimilates to reproductive unit (flower and pod) which were greater than other treatments and at the maturity stage it translocated 42.97% assimilates in pod whereas T_1 recorded 7.62% and 34.02% assimilates partitioned in reproductive unit in grain development (90 DAS) and maturity stage (120 DAS), respectively (Fig. 9). T_3 influenced to translocate 26.31% higher assimilates to pod than control at maturity. In dry matter partitioning, most of the treatments transferred more than 30% assimilates to the seed at maturity. Due to foliar spray of urea, leaf area and assimilation of photosynthate in leaf increased and ultimately higher assimilate partitioned to pod than other treatment. The foliar added nitrogen is stored temporarily in the pod and later incorporated into the seed (Farrington *et al.*, 1977).

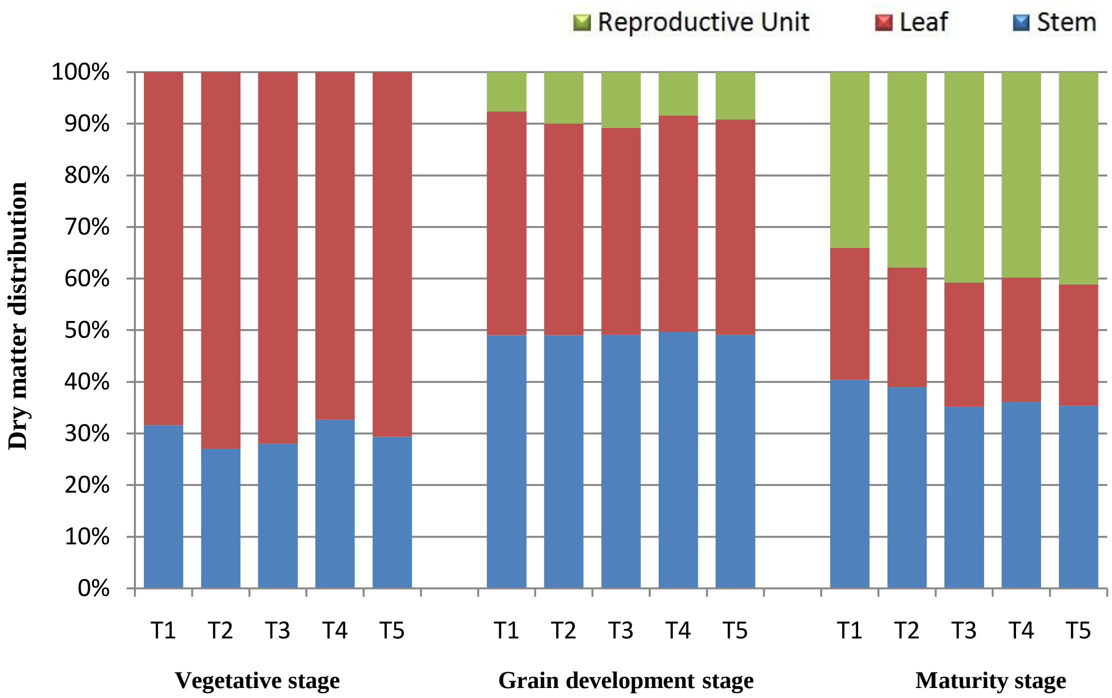


Figure 9. Effect of supplementary foliar spray on dry matter partitioning (%) of chickpea

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.

Similar trend of dry matter partition was noticed by Karim and Fattah (2003) in chickpea and by Islam *et al.* (2006) in lentil.

4.1.4.3 Combined effect of variety and supplementary foliar spray

In case of combined effect of variety and supplementary foliar spray, variation was observed in dry matter partitioning. At vegetative state (30 DAS), V_2T_2 obtained the highest leaf dry matter accumulation (70.70%) than other combinations showed in Figure 10. At the grain development stage (90 DAS), all the combinations showed more than 35% assimilates transfer to leaf and the highest dry matter assimilates in reproductive unit (flower and pod) found in V_2T_3 (12.28%) and lowest in V_1T_1

(6.12%). At maturity the highest dry matter partitioning to pod was found in V_2T_3 (43.11%) and the lowest dry matter partitioning to pod was found in V_2T_1 (33.55%) and followed by V_1T_1 (34.55%). V_2T_3 (BARI Chola-8 and RF+ Urea (2%) FS at FI) recorded highest leaf area index, dry matter accumulation finally highest dry matter partitioning to pod. Higher amount of leaf in the vegetative stage, higher photosynthesis, dry matter production and dry matter partitioning capability results in the ultimate higher reproductive units in crop.

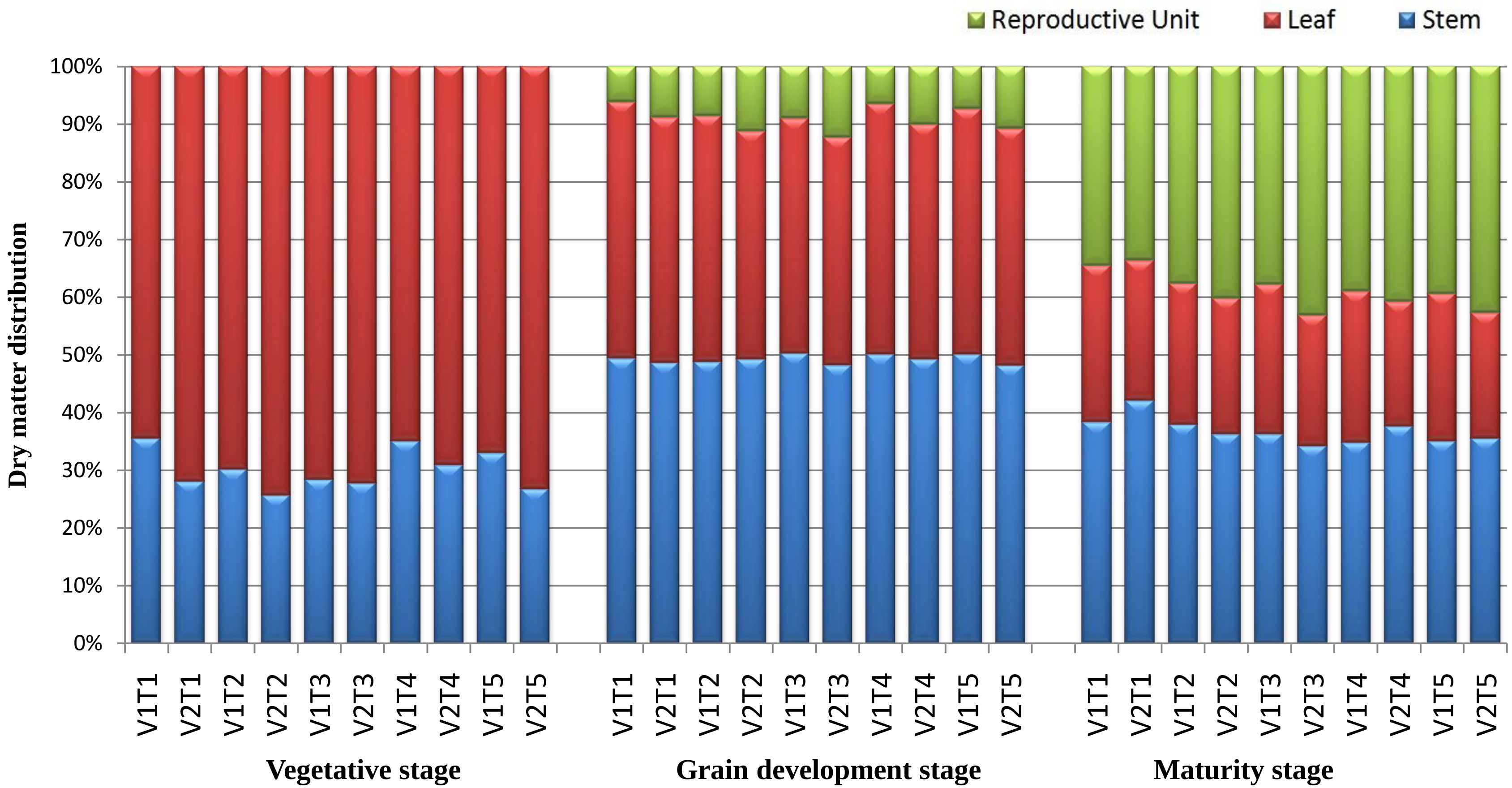


Figure 10. Combined effect of variety and supplementary foliar spray on dry matter partitioning (%) of chickpea

V_1= BARI Chola-5, V_2=BARI Chola-8

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

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

4.1.5.1 Effect of variety

Number of nodules plant^{-1} of chickpea varied significantly due to variety treatments were showed in Figure 11. The maximum numbers of root nodules per plant were observed at 75 days after sowing in both treatments and thereafter showed declining trend in later observations. It might be due to the fact that nodules begin to degenerate soon after flowering. It was observed that BARI Chola-5 (V_1) produced the highest number of nodules plant^{1} (17.77, 20.58 at 60 and 75 DAS respectively). However, BARI Chola-8 (V_2) produced the lowest number of nodules plant^{-1} at 60 and 75 DAS. The number of nodule plant^{1} at 90 DAS was recorded (12.73) and (13.48) from V_1 and V_2 and there was no significant variation**.** V_1 produced 8.55% and 14.84% higher nodules plant $^{-1}$ than V_2 at 60 and 75 DAS respectively; V_2 produced 5.89% higher nodules plant^{-1} than V_1 at 90 DAS. Bhuiyan *et al.* (2009) reported BARI Chola-3 as higher producer of nodules (42.6). Eusuf Zai *et al.* (1999) counted significantly more nodules in variety BARI Chola-6.

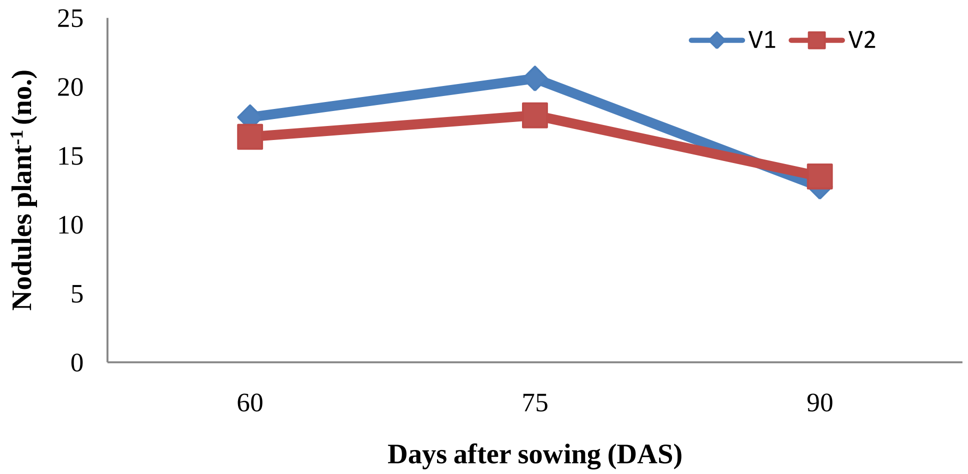


Figure 11. Effect of variety on nodules plant^{-1} of chickpea at different days after sowing

(LSD $_{(0.05)}$ = 1.31, 1.34 and NS at 60, 75 and 90 DAS, respectively).

V_1= BARI Chola-5, V_2=BARI Chola-8

4.1.5.2 Effect of supplementary foliar spray

Number of nodules plant^{-1} of chickpea varied significantly due to various spray treatments showed in Figure 12. It was observed that T_3 produced the highest number of nodules plant^{-1} (21.28, 25.41 and 16.91) at 60, 75 and 90 DAS. However, at 60, 75 and 90 DAS the lowest number of nodules plant^{-1} was observed from T_1 (10.95, 12.56 and 6.63, respectively). Nitrogen requirement in legumes during reproductive stage is far higher which was met from foliar application of urea in our study resulting in higher nodule number and nodule dry weight. However, in control treatment, this N requirement might have been met at the expense of nodule growth. T_3 (RF+ Urea (2%) FS at FI) recorded 94.33%, 94.34% and 155.13% higher nodules plant^{-1} than T_1 (control). Aggarwal *et al.* (2015) found significant improvement in nodule number and nodule dry weight with 2% urea spray at different growth stages over no urea spray whereas Kumar (2018) found similar findings in black gram by 2% urea spray at flowering.

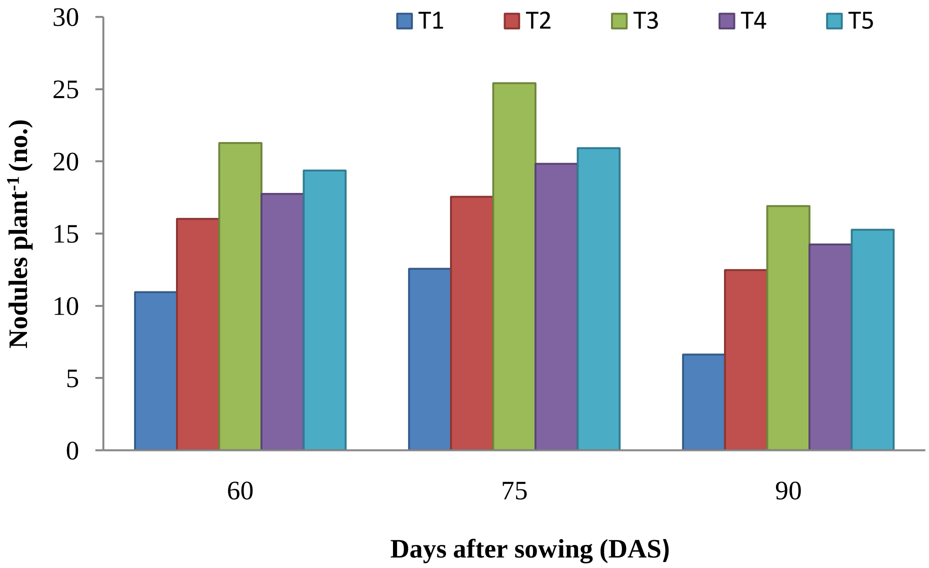


Figure 12. Effect of supplementary foliar spray on nodules plant^{-1} of chickpea at different days after sowing (LSD $_{(0.05)}$ = 1.08, 1.14 and 1.11 at 60, 75 and 90 DAS, respectively)

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.

4.1.5.3 Combined effect of variety and supplementary foliar spray

The chickpea varieties responded differently to foliar spraying in terms of nodule number plant^{-1} (Table 4). At 60 DAS, the combined effect V_1T_5 was achieved the highest number of nodule plant^{-1} (20.95) which was statistically similar with V_1T_3 (21.62) and V_2T_3 (20.94) combinations when the lowest (10.85) was obtained from the V_2T_1 which was statistically similar with V_1T_1 combination. At 75 DAS, the highest number of nodule plant^{-1} (27.13) was recorded from V_1T_3 combination, followed by V_2T_3 (23.69) and the lowest number of nodule (12.02) plant^{-1} was recorded from V_2T_1 combination which was statistically similar with V_1T_1 combination. The highest number of nodule plant^{-1} (17.76) was recorded from V_2T_3 combination, secondly from V_1T_3 combination (16.07) and the lowest number of nodule (6.06) plant^{-1} was recorded from V_1T_1 combination which was statistically similar with V_2T_1 combination at 90 DAS.

Table 4. Combined effect of variety and supplementary foliar spray on nodules plant^{-1} of chickpea at different days after sowing

Treatment combinations	Nodules plant^{-1} (no.) at different days after sowing (DAS)		
	60	75	90
V_1T_1	11.06 d	13.10 f	6.060 f
V_1T_2	15.99 c	18.16 de	10.28 e
V_1T_3	21.62 a	27.13 a	16.07 b
V_1T_4	19.24 b	21.64 c	15.13 bc
V_1T_5	20.95 a	22.88 bc	16.11 b
V_2T_1	10.85 d	12.02 f	7.197 f
V_2T_2	16.03 c	16.92 e	14.66 bcd
V_2T_3	20.94 a	23.69 b	17.76 a
V_2T_4	16.24 c	17.99 de	13.34 d
V_2T_5	17.78 b	18.97 d	14.43 cd
LSD $_{(0.05)}$	1.53	1.61	1.56
CV (%)	5.17	4.82	6.89

V_1= BARI Chola-5, V_2=BARI Chola-8

T_1= Recommended Fertilizer (RF), T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI),

T_3= RF+ Urea (2%) FS at FI, T_4= RF+ Boron (1%) FS at FI,

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

4.1.6 Nodules dry weight plant^{-1} (g)

4.1.6.1 Effect of variety

Nodule dry weights showed significant variation at 60, 75 and 90 DAS for the varieties illustrated in Figure 13. At 60 and 75 DAS, BARI Chola-5 (V_1) showed significantly highest nodule dry weight plant^{-1} (0.53 and 0.67 g) whereas, V_2 produced mimimum nodules dry weight of 0.42 and 0.51g at 60 and 75 DAS, respectively. At 90 DAS V_2 (BARI Chola-8) showed significantly highest (0.35g) nodule dry weight followed by V_1 (BARI Chola-5) (0.26 g). Similar results were observed by many other scientists while experimenting with various legumes. Das *et al.* (2009) showed variation in nodule dry weight plant^{-1} with different varieties (8.49 mg and 4.17 mg in BARI Chola-7 and the BU Chola-1 respectively). Solaiman *et al.* (2007) opinioned that BARI Chola-5 performed best in recording number and dry weight of nodules.

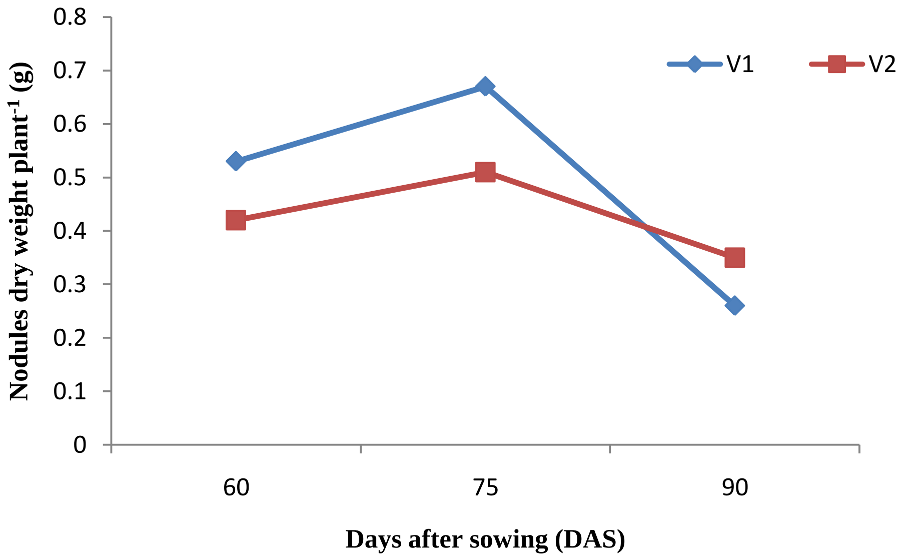


Figure 13. Effect of variety on nodules dry weight plant^{-1} of chickpea at different days after sowing (LSD $_{(0.05)}$ = 0.07, 0.09 and 0.02 at 60, 75 and 90 DAS, respectively)

V_1= BARI Chola-5, V_2=BARI Chola-8

4.1.6.2 Effect of supplementary foliar spray

Nodule dry weight showed significant variation for different supplementary foliar spray (Fig. 14). Maximum nodule dry weight (0.62, 0.70 and 0.44g) was recorded from T_3 (RF + Urea (2%) FS at FI) treatment at 60, 75 and 90 DAS respectively. On the contrary, the lowest nodule dry weight recorded from T_1 (control) (0.30, 0.38 and 0.18g) at 60, 75 and 90 DAS respectively. Kumar (2018) observed that root nodule weight per plant was highest with application of urea 2% spray at flowering in blackgram.

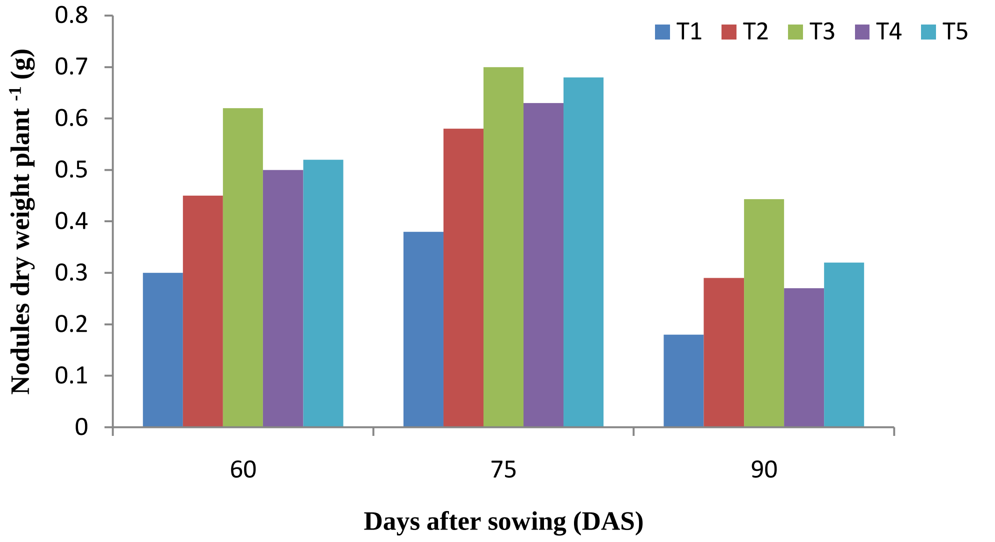


Figure 14. Effect of supplementary foliar spray on nodules dry weight plant^{-1} of chickpea at different days after sowing (LSD $_{(0.05)}$ = 0.04, 0.05 and 0.01 at 60, 75 and 90 DAS, respectively)

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.

4.1.6.3 Combined effect of variety and supplementary foliar spray

Combined effect on nodule dry weights at 60, 75 and 90 DAS was found significant difference (Table 5). At 60 DAS, the highest nodule dry weight (0.62 g) was noted from V_2T_3 combination which was statistically similar with V_1T_3, V_1T_4 and V_1T_5. At 75 DAS, the highest nodule dry weight (0.78 g) was noted from V_1T_5 and it was statistically similar with V_1T_3 and V_1T_4 recorded 0.74 and 0.75 g nodule dry weight plant^{-1} respectively. The lowest nodule dry weight observed from V_2T_1 (0.22 and 0.34g) at 60 and 75 DAS whereas, V_1T_1 produced lowest nodule dry weight plant^{-1} (0.17g) and V_2T_3 produced highest nodule dry weight plant^{-1} (0.537g) at 90 DAS.

Table 5. Combined effect of variety and supplementary foliar spray on the nodules dry weight plant^{-1} (g) of chickpea at different days after sowing

Treatment combinations	Nodules dry weight plant^{-1} (g) at different days after sowing (DAS)		
	60	75	90
V_1T_1	0.37 d	0.42 f	0.17 f
V_1T_2	0.48 b	0.68 bc	0.257 d
V_1T_3	0.61 a	0.74 ab	0.35 c
V_1T_4	0.57 a	0.75 ab	0.233 e
V_1T_5	0.61 a	0.78 a	0.267 d
V_2T_1	0.22 e	0.34 g	0.190 g
V_2T_2	0.42 cd	0.48 ef	0.323 d
V_2T_3	0.62 a	0.65 c	0.537 a
V_2T_4	0.42 cd	0.51 de	0.307 d
V_2T_5	0.44 bc	0.57 d	0.37 b
LSD $_{(0.05)}$	0.05	0.07	0.01731
CV (%)	6.55	6.40	6.03

V_1= BARI Chola-5, V_2=BARI Chola-8

T_1= Recommended Fertilizer (RF), T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI),

T_3= RF+ Urea (2%) FS at FI, T_4= RF+ Boron (1%) FS at FI,

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

4.1.7 Leaf area index

Leaf area index is one of the principle factors influencing canopy net photosynthesis of the crop plants and it is the ratio of leaf area to its ground area and it is the functional size of the standing crop on unit land area (Hunt, 1978). LAI increased with the growth of N fertilizer rate. Increasing of LAI was attributed to the rise in leaf number and total leaf area / plant, population density and leaf senescence (Alam and Haider, 2006; Yasari and Patwardhan, 2006). The higher productivity of a crop depends on the persistence of high LAI over a greater part of its vegetative phase. Crop production practically means the efficient interception of photosynthetically active radiation (PAR) and its conversion into food and other useable materials. Efficient interaction of PAR by a crop canopy requires adequate leaf area expansion.

4.1.7.1 Effect of variety

Leaf Area Index (LAI) showed significant variation among the different varieties showed in Figure 15. LAI starts from low values, reaches a certain peak and then declines with plant aging. LAI of chickpea also showed the same trend as dry matter weight. V_2 (BARI Chola-8) obtained highest LAI (0.88, 1.93 and 1.27 at 60, 90 DAS and 120 DAS respectively) as par V_1 (BARI Chola-5) obtaining 0.67, 1.64 and 0.85 at 60, 90 DAS and 120 DAS respectively. V_2 (BARI Chola-8) showed 31.34%, 17.68% and 49.41% higher LAI than V_1 (BARI Chola-5) at 60, 90 DAS and 120 DAS respectively. Difference due to variety in LAI also reported by Hoque (2005).

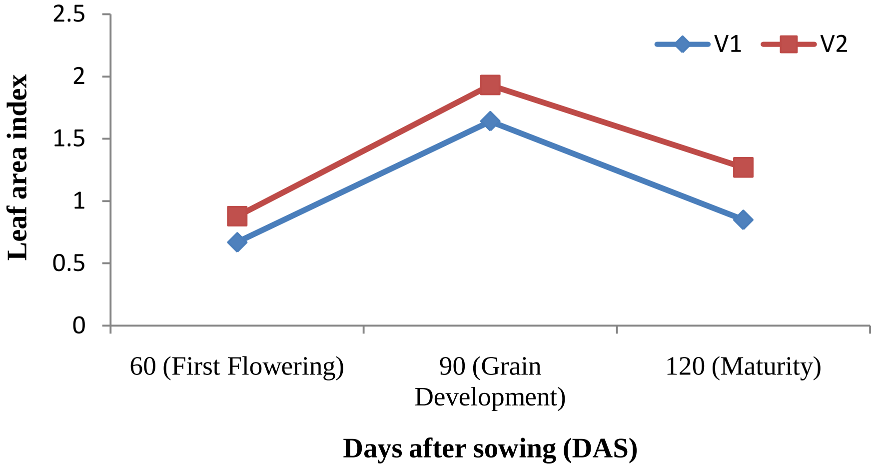


Figure 15. Effect of variety on leaf area index of chickpea at different days after sowing (LSD $_{(0.05)}$ = 0.02, 0.02 and 0.02 at 60, 90 and 120 DAS, respectively)

V_1= BARI Chola-5, V_2=BARI Chola-8

4.1.7.2 Effect of supplementary foliar spray

The chickpea varieties responded differently to foliar spraying in terms of leaf area index showed in Figure 16. T_3 (RF + Urea (2%) FS at FI) recorded highest LAI (0.90, 2.01, and 1.12 at 60, 90 and 120 DAS respectively). The lowest LAI 0.67 at 60 DAS was recorded from T_1; 1.65 from T_1 at 90 DAS and 1.00 is recorded in T_1 at maturity (120 DAS). The maximum LA at peak flowering contributes to better yielding ability in grain legumes (Thandapani, 1985) which is a pre-requisite to maximize the photosynthetic activity. In contrast in control plants the total LAI declined at later period due to the onset of senescence phenomenon (Kalarani, 1991). The urea sprayed plant maintained comparatively more LAI at different stages, thus aiding in the supply of photosynthesis for the development of pods and grains and also intensification of metabolic activity and efficient utilization of N (Beninger, 1978).

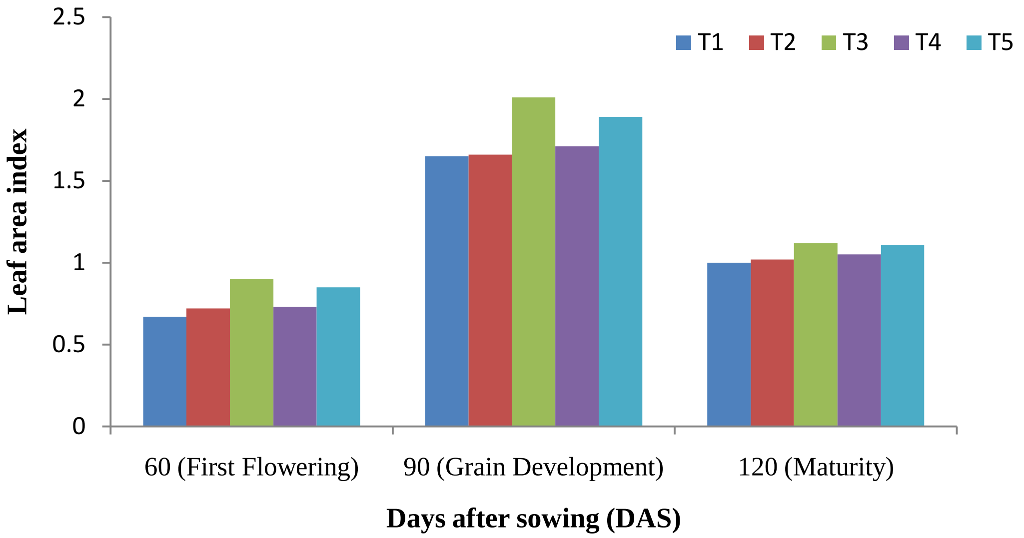


Figure 16. Effect of supplementary foliar spray on leaf area index of chickpea at different days after sowing (LSD $_{(0.05)}$ = 0.04, 0.01 and 0.01 at 60, 90 and 120 DAS, respectively)

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.

Highest LAI was attributed to delay in leaf senescence of abscission, initiated by Urea (2%) FS at FI along with recommended fertilizer. High LAI at the time of pod formation stage was associated with high rate of current photosynthesis with better translocation efficiency of the crop, which intimately reflected on pod yield.

The findings were in conformity with the results of black gram which showed a higher leaf area index due to foliar spray of Brassinosteriod 0.1 ppm and urea 2% (Surendar *et al.*, 2013).

4.1.7.3 Combined effect of variety and supplementary foliar spray

The chickpea varieties responded differently to foliar spraying in respect of LAI shown in Table 6. The highest LAI (1.03, 2.23 and 1.29) at 60, 90, 120 DAS, respectively were found from the interaction effect of V_2T_3 (RF + Urea (2%) FS at FI, V_2T_3 at 60 and 120 DAS was statistically similar with V_2T_5 at 60 DAS and V_2T_4, V_2T_5 at 120 DAS respectively. Lowest LAI (0.56 and 0.73) at 60, and 120 DAS, respectively was found from the combined effect of V_1T_1. At 90 DAS the lowest LAI (1.50) was found from the combined effect of V_1T_2 was statistically similar with V_1T_1.

Table 6. Combined effect of variety and supplementary foliar spray on leaf area index of chickpea at different days after sowing

Treatment combinations	Leaf area index at different days after sowing (DAS)		
	60 (First Flowering)	90 (Grain Development)	120 (Maturity)
V_1T_1	0.56 e	1.53 g	0.73 g
V_1T_2	0.64 d	1.50 g	0.78 f
V_1T_3	0.77 b	1.78 cd	0.96 d
V_1T_4	0.67 cd	1.63 f	0.83 e
V_1T_5	0.70 c	1.71 e	0.94 d
V_2T_1	0.78 b	1.77 d	1.26 bc
V_2T_2	0.79 b	1.79 c	1.25 c
V_2T_3	1.03 a	2.23 a	1.29 a
V_2T_4	0.79 b	1.79 c	1.27 ab
V_2T_5	1.00 a	2.07 b	1.28 ab
LSD $_{(0.05)}$	0.05	0.02	0.02
CV (%)	3.48	0.33	0.91

V_1= BARI Chola-5, V_2=BARI Chola-8

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

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

Crop growth rate (CGR) is regarded as the most meaningful growth function since it represents the net results of photosynthesis, respiration and canopy area interaction (Alam and Haider, 2006). Crop production is determined by CGR as a function of light interception by the leaf area of a crop. CGR is also a representative of the most common agronomic measurements such as yield of dry matter per unit land area. In general, CGR depends mainly on the amount and intensity of intercepted energy and photosynthetic efficiency of the canopy. The average daily increment in crop growth rate (CGR) is an important useful tool for estimating production efficiency, enabling comparison between the treatments.

4.1.8.1 Effect of variety

Crop growth rate is a measure of the increase in size, mass or crops over a period of time. Varietal effect had significant influence on crop growth rate (Fig. 17). Starting from lower value, it rapidly increased up to 90-120 DAS in a certain peak and then declined at the later stages of growth.

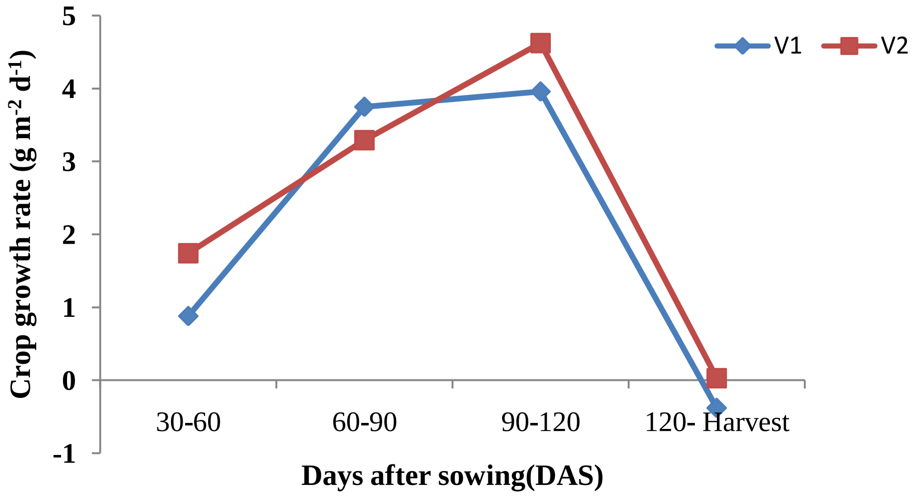


Figure 17. Effect of variety of chickpea on crop growth rate at different days after sowing (LSD $_{(0.05)}$ =0.11, 0.02, NS and 0.13 at 30-60, 60-90, 90-120 DAS and 120 DAS- harvest, respectively)

V_1= BARI Chola-5, V_2=BARI Chola-8

The highest CGR (1.74, 4.62 and 0.03 g m^{-2} d^{-1}) recorded from V_2 (BARI Chola-8) at 30-60 DAS, 90-120 DAS and 120 DAS-harvest. The lowest CGR (0.88, 3.96 and -0.38 g m^{-2} d^{-1}) recorded from V_1 (BARI Chola-5) at same growth stages. At 60-90 DAS highest CGR (3.75 g m^{-2} d^{-1}) obtained at V_1 which is significantly higher than V_2 (3.29 g m^{-2} d^{-1}). Hoque (2005) also reported higher CGR in BINA Chola-3 than BINA Chola-2.

4.1.8.2 Effect of supplementary foliar spray

Crop growth rate (CGR) showed significant variation among the different foliar spray at 30-60, 60-90, 90-120 and 120 DAS-at harvest explained in Figure 18. CGR increased with increasing growth stage and reached pick at pod development and filling stage 90-120 DAS and slowly declined for most of the treatments, even negative score was recorded on some treatments up to harvest (125 DAS).

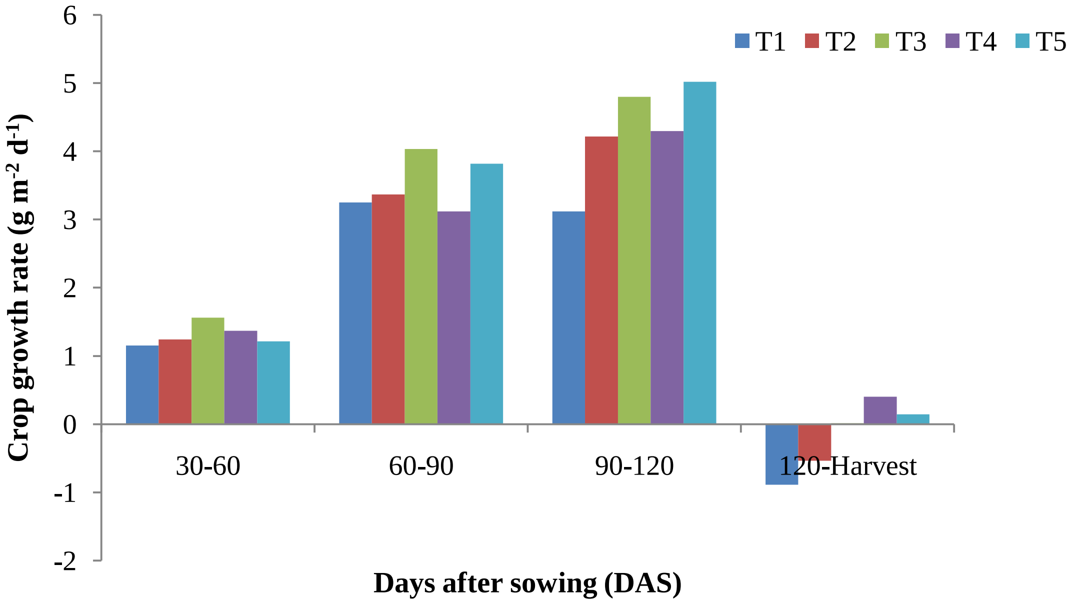


Figure 18. Effect of supplementary foliar spray on crop growth rate of chickpea at different days after sowing (LSD $_{(0.05)}$ = 0.22, 0.38, 0.46 and 0.04 at 30-60, 60-90, 90-120 DAS and 120 DAS- harvest, respectively)

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_3 (RF+ Urea (2%) FS at FI) gave maximum values of CGR at 30-60 DAS (1.560g m^{-2} d^{-1}) and 60-90 DAS (4.035 g m^{-2} d^{-1}) which were statistically similar to those of T_4 at 30-60 DAS (1.370 g m^{-2} d^{-1}) and T_5 at 60-90 DAS (3.817 g m^{-2} d^{-1}) whereas the minimum CGR (1.155 and 3.120 g m^{-2} d^{-1}) were recorded from treatment T_1 and T_4 at 30-60 and 60-90 DAS, respectively. At 90-120 DAS, highest CGR found at T_5 (5.018 g m^{-2} d^{-1}) which was statistically similar with T_3 (4.800 g m^{-2} d^{-1}) and lowest value found from T_1 (3.117 g m^{-2} d^{-1}). At 120 DAS-harvest, the lowest CGR (-0.8900 g m^{-2} d^{-1}) was received from treatments T_1 and maximum values of CGR (0.400 g m^{-2} d^{-1}) at T_4 was observed.

Higher CGR may be due to higher production of dry matter owing to greater LAI and higher light interception caused by nitrogen efficiency (Yasari and Patwardhan, 2006). The decline in crop growth rate after 60 DAS might be due to loss in dry matter on account of senescence and decrease of leaf area index (Kalyani *et al.*, 1999). Similar results were also reported by Sritharan *et al.* (2015) in blackgram and Atram (2007) in chickpea.

4.1.8.3 Combined effect of variety and supplementary foliar spray

CGR Showed significant difference among different variety and treatment combinations (Table 7). The highest CGR (1.980, 4.303 and 5.460 g m^{-2} d^{-1} at 30-60, 60-90 and 90-120 DAS, respectively) were observed from the combined effect of V_2T_3, V_1T_3 and V_2T_3, respectively which were statistically identical with V_2T_4 and V_2T_5 at 30-60 DAS; V_1T_5 and V_2T_3 at 60-90 DAS; V_2T_5 at 90-120 DAS. At 120-harvest, the highest CGR recorded in V_2T_4 (0.670 g m^{-2} d^{-1}). The lowest CGR value found at V_1T_5, V_2T_4, V_1T_1 and V_2T_1 at 30-60, 60-90, 90-120 DAS and 120-harvest, respectively.

Table 7. Combined effect of variety and supplementary foliar spray on crop growth rate of chickpea at different days after sowing

Treatment combination	Crop growth rate (g m^{-2} d^{-1}) at different days after sowing (DAS)			
	30-60	**60-90**	**90-120**	**120-harvest**
V_1T_1	0.6967 d	3.370 bcd	2.977 f	-0.700 f
V_1T_2	0.8300 cd	3.557 bc	3.670 de	-0.960 g
V_1T_3	1.140 c	4.303 a	4.140 cd	-0.110 d
V_1T_4	1.063 c	3.363 bcd	4.390 c	0.130 c
V_1T_5	0.6500 d	4.143 a	4.623 c	-0.260 e
V_2T_1	1.613 b	3.130 cd	3.257 ef	-1.080 h
V_2T_2	1.653 b	3.183 cd	4.760 bc	-0.110 d
V_2T_3	1.980 a	3.767 ab	5.460 a	0.140 c
V_2T_4	1.677 ab	2.877 d	4.200 cd	0.670 a
V_2T_5	1.773 ab	3.490 bc	5.413 ab	0.550 b
LSD $_{(0.05)}$	0.31	0.54	0.65	0.05
CV (%)	13.79	8.86	8.82	-19.64

V_1= BARI Chola-5, V_2=BARI Chola-8

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

4.1.9 Relative growth rate (g g^{-1} d^{-1})

Relative growth rate (RGR) is the increase of materials per unit of plant materials per unit of time.

4.1.9.1 Effect of variety

Irrespective of N fertilizer treatments, RGR was high in the early growth period and showed a decreasing trend as the crop advanced in age represented in Figure 19. RGR of chickpea plant was not varied significantly at 30-60 DAS and 90-120 DAS due to variety, whereas 60-90 DAS and 120 DAS- harvest data varied significantly. It was revealed that the highest RGR (0.066, 0.05, 0.021 and 0.01g $g^{-1}d^{-1}$ at 30-60, 60-90, 90-120 and 120 DAS- harvest, respectively) was observed from variety V_2, V_1, V_2 and V_1, respectively. Whereas the lowest RGR (0.055, 0.032, 0.02 and 0.001g $g^{-1}d^{-1}$ at 30-60, 60-90, 90-120 and 120 DAS- harvest, respectively) were measured from variety V_1, V_2, V_1 & V_2 respectively. This may be due to the fact that in the initial stages of the plant growth the ratio between alive and dead tissues is high and almost entire cells of productive organs are activity engaged in vegetative matter production and, consequently, the RGR of plants is high, while with plant aging, leaf senescence, the metabolic activity of tissues decreases and hence the tissues cannot contribute to the growth that results in RGR decreasing (Zajac *et al.*, 2005; Alam and Haider, 2006; Palta *et al.*, 2005). Hoque (2005) also reported higher RGR in BINA Chola-3 than BINA Chola-2 at 70-80 DAS.

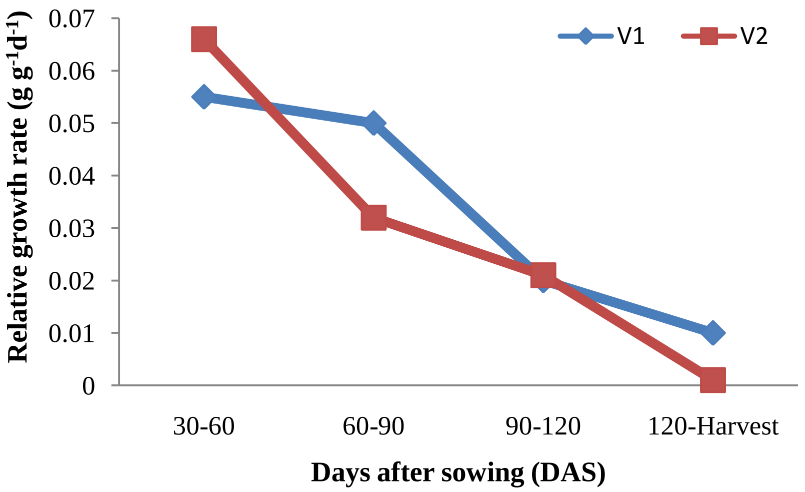


Figure 19. Effect of variety of chickpea on relative growth rate at different days after sowing (LSD $_{(0.05)}$ = NS, 0.016, NS and 0.016 at 30-60, 60-90, 90-120 DAS and 120 DAS-harvest, respectively)

V_1= BARI Chola-5, V_2=BARI Chola-8

4.1.9.2 Effect of supplementary foliar spray

Relative growth rate was also not significantly affected by supplementary foliar spray from beginning to 90-120 DAS (Fig. 20). Result showed that the highest RGR (0.065, 0.046, 0.022 and 0.008 g g^{-1} d^{-1} at 30-60, 60-90, 90-120 and 120 DAS-harvest, respectively) were gained from treatments T_3, T_5, T_5 and T_4 respectively. Whereas the lowest RGR (0.056, 0.036, 0.0175 and -0.024 g g^{-1} d^{-1} at 30-60, 60-90, 90-120 and 120 DAS-harvest, respectively) were attained from T_5, T_4, T_1 and T_1, respectively. These results concur with the observations made by Zajac *et al*. (2005) and Alam and Haider (2006).

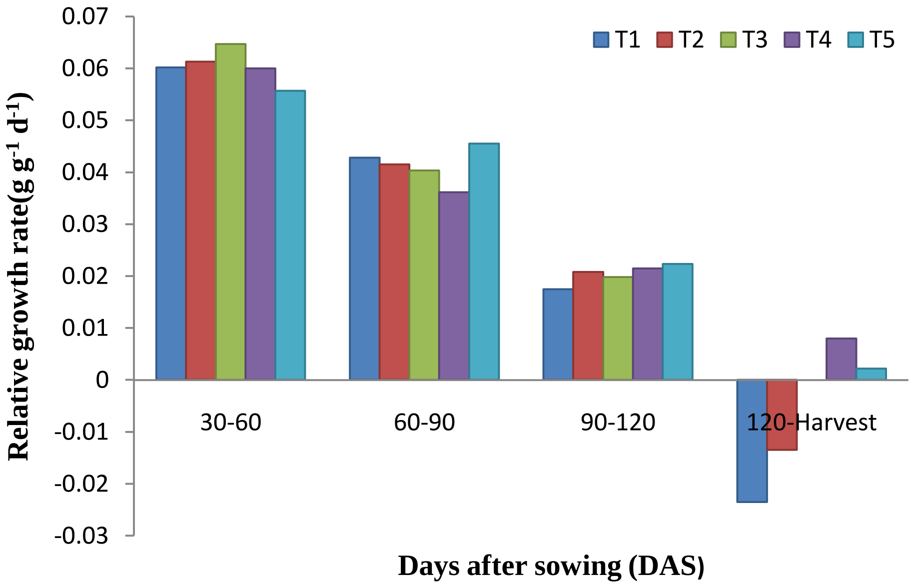


Figure 20. Effect of supplementary foliar spray on relative growth rate of chickpea at different days after sowing (LSD $_{(0.05)}$ = NS, NS, NS and 0.01224 at 30-60, 60-90, 90-120 and 120 DAS-harvest, respectively)

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.

4.1.9.3 Combined effect of variety and supplementary foliar spray

The chickpea varieties did not response unequally to different foliar spray in terms of relative growth rate represented in Table 8. The highest RGR (0.06867, 0.05800, 0.02267 and 0.01400 g g^{-1} d^{-1} at 30-60, 60-90, 90-120 DAS and 120 DAS-harvest, respectively) were gained from the combined effect of V_2T_1, V1T_5, V_2T_5, and V_2T_4 respectively. Whereas the lowest RGR (0.044, 0.02967, 0.01667, -0.0270 at 30-60, 60-90, 90-120 DAS and 120 DAS-harvest, respectively) were attained from the combinations of V_1T_5, V_2T_4, V_2T_1, and V_2T_1, respectively.

Table 8. Combined effect of variety and supplementary foliar spray on relative growth rate of chickpea at different days after sowing

Treatment combinations	Relative growth rate (g g^{-1} d^{-1}) at different days after sowing (DAS)			
	30-60	**60-90**	**90-120**	**120-harvest**
V_1T_1	0.05167 ab	0.05267 a	0.01833	-0.02000 cd
V_1T_2	0.05433 ab	0.05000 ab	0.01967	-0.02500 d
V_1T_3	0.06500 a	0.04833 abc	0.01833	-0.002000 ab
V_1T_4	0.05867 ab	0.04267 abcd	0.022	0.002000 ab
V_1T_5	0.04400 b	0.05800 a	0.022	-0.005667 bc
V_2T_1	0.06867 a	0.03300 bcd	0.01667	-0.02700 d
V_2T_2	0.06833 a	0.03300 bcd	0.022	-0.002000 ab
V_2T_3	0.06433 a	0.03233 cd	0.02133	0.002000 ab
V_2T_4	0.06133 a	0.02967 d	0.021	0.01400 a
V_2T_5	0.06733 a	0.03300 bcd	0.02267	0.01000 ab
LSD (0.05)	0.01731	0.01731	NS	0.01731
CV (%)	6.42	7.68	7.95	-19.39

V_1= BARI Chola-5, V_2=BARI Chola-8

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

4.2 Yield contributing character

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

Pod number is a major yield determining factor in pulses and it was greatly influenced by the nutrients.

4.2.1.1 Effect of variety

No significant variation was recorded for pods plant^{-1} of BARI Chola-5 and BARI Chola-8 due to varietal variation represented in Figure 21. V_2 (BARI Chola-8) produced 6.44% higher pod plant^{-1} while V_1 (BARI Chola-5). Pods plant^{-1} varied for different varieties might be due to genetical and environmental influences as well as management practice nutrient availability. Mirzakhani *et al*. (2013) reported that the number of pods in the plant there were no significant differences between the different cultivars. Bhuiyan *et al.* (2009) also found significant variation in number of pod plant^{-1} using various chickpea varieties however, Khatun *et al.* (2010) found contrasting results.

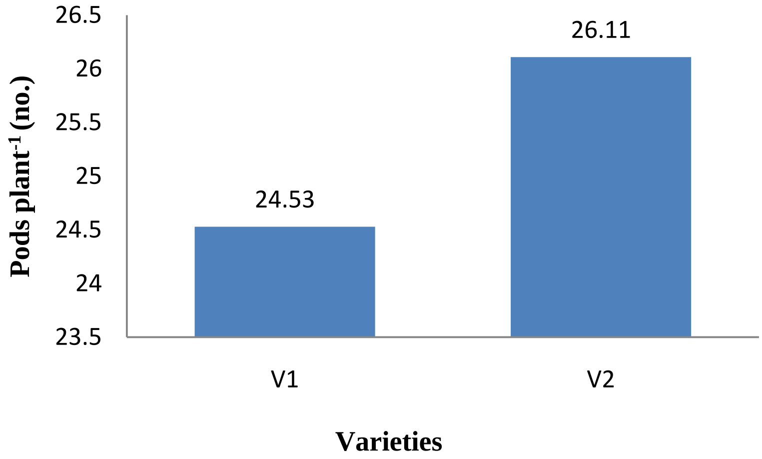


Figure 21. Effect of variety on pods plant^{-1} of chickpea (LSD $_{(0.05)}$ = NS)

V_1= BARI Chola-5, V_2=BARI Chola-8

4.2.1.2 Effect of supplementary foliar spray

Different foliar spraying showed significant variation in terms of pods plant^{-1} of chickpea (Fig. 22). The highest pods (28.27) was found from T_3 (RF + Urea (2%) FS at FI), while the lowest pods plant^{-1} (23.53) was observed from T_1 (control i.e., no spray at FI) which was statistically similar with T_2 (24.35) and T_4 (24.34). T_3 produced 20.14%, 8.23% and 16.0% higher pods plant^{-1} than $T_{1,}$ T_5 and T_2 treatment. The highest pod in T_3 may be produced because of maximum dry matter content plant^{-1} pods plant^{-1} than T_1. These results were also in close consonance with the findings of Venkatesh and Basu (2012) and Aggarwal *et al.* (2015) who reported that the highest pods per plant were recorded in 2% urea spray at 75 DAS which was higher than control and water spray in chickpea.

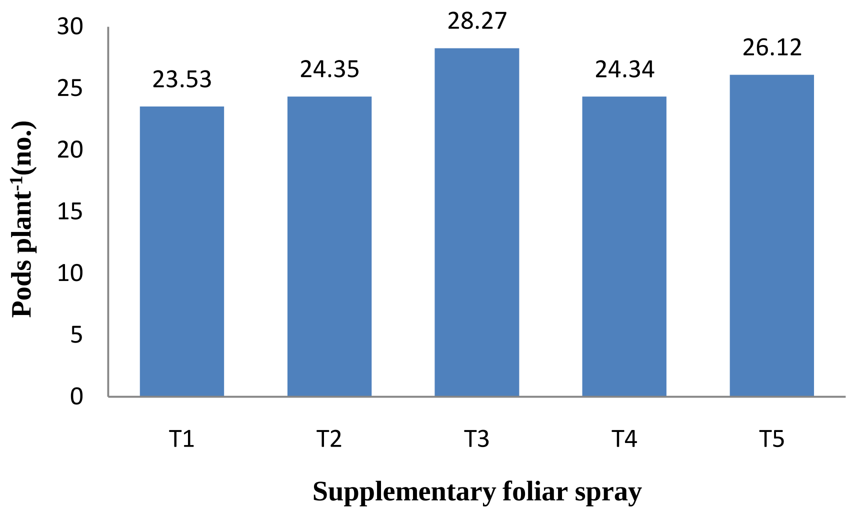


Figure 22. Effect of supplementary foliar spray on pods plant^{-1} of chickpea (LSD $_{(0.05)}$ = 1.612)

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

4.2.1.3 Combined effect of variety and supplementary foliar spray

Significant variation was observed due to the interaction effect of chickpea varieties and different supplementary foliar spray on pods plant^{-1} (Table 9). The maximum pods plant^{-1} (29.17) was found from V_2T_3 (BARI Chola-8 and RF+ Urea 2% FS at FI) which was statistically identical with V_1T_3 (27.37) and the minimum pods plant^{-1} (22.47) from V_1T_1 (BARI Chola-5 and control i.e., no spray at flowering) which statistically identical with V_1T_2 (23.69) V_1T_4 (23.37) and V_2T_1 (24.60).

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

The number of seeds per pod is one of the most important yield attributing characters. More number of seeds per pod ultimately leads to the higher grain yield.

4.2.2.1. Effect of variety

Number of seeds pod^{-1} of chickpea varied significantly due to variety showed in Figure 23. It was observed that BARI Chola-5 (V_1) produced the highest (2.00) number of seed pod^{-1} and BARI Chola-8 (V_2) produced the lowest (1.52) number of seed pod $^{-1}$. Therefore less number of grains per plant was compensated by more photosynthate mobilization to individual grains; leading to the production of larger grain by BARI Chola-8 and genotypes with more pod development period having higher seed growth would be desirable character for maintaining higher yield. V_1 recorded 31.58% higher seeds pod^{-1} than V_2. Different varieties responded differently for number of seeds pods^{-1} to input supply, cultivation method and the prevailing environment during the growing season. Similar results were reported by Ghassemi-Golezani *et al.* (2012) and Khatun *et al.* (2010) in chickpea.

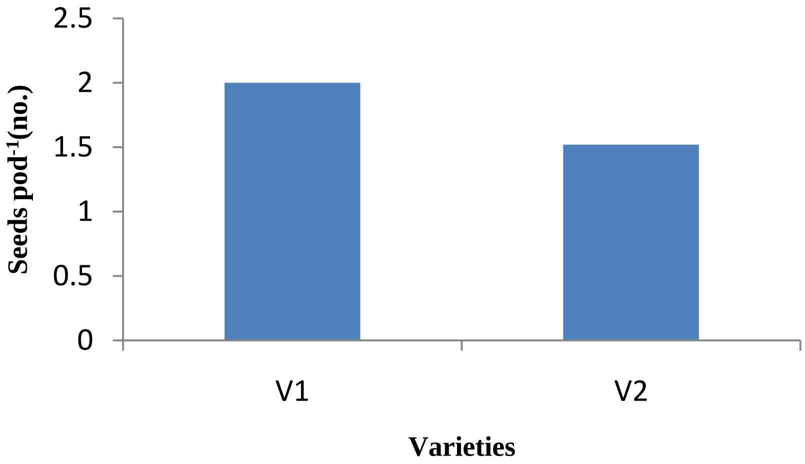


Figure 23. Effect of variety on seeds pod^{-1} of chickpea (LSD $_{(0.05)}$ = 0.09)

V_1= BARI Chola-5, V_2=BARI Chola-8

4.2.2.2 Effect of supplementary foliar spray

Different foliar spray treatments that applied on chickpea showed statistically significant variation in terms of seeds pod^{-1} of chickpea showed in Figure 24. The maximum seeds pod^{-1} (1.92) was found from T_3 (RF+ Urea 2% FS at FI), which was closely followed (1.80, 1.79 and 1.76) by T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) and T_2 (RF+ Foliar Spray (FS) of water at flower initiation (FI) and T_4 (RF+ Boron (1%) FS at FI), again the minimum seeds pod^{-1} (1.51) was observed from T_1 (control).These results are supported by Atram (2007).

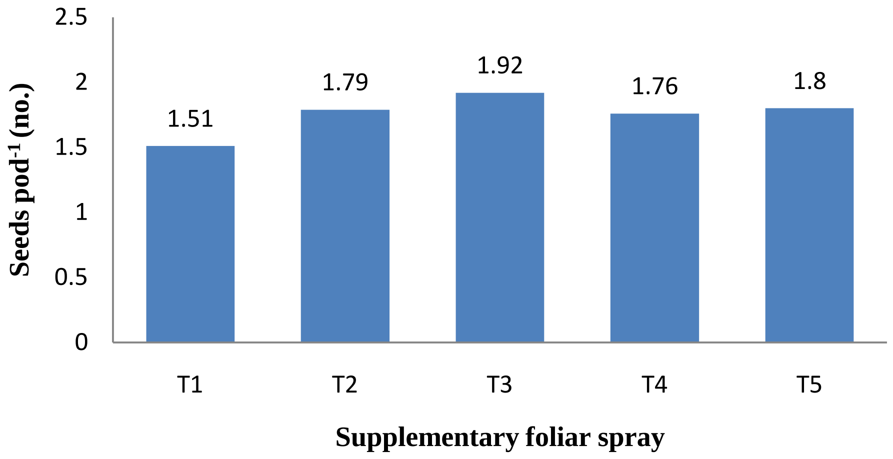


Figure 24. Effect of supplementary foliar spray on seeds pod^{-1} of chickpea (LSD $_{(0.05)}$ = 0.08)

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

4.2.2.3 Combined effect of variety and supplementary foliar spray

Seeds pod^{-1} of chickpea showed significant differences due to the interaction effect of chickpea varieties and different supplementary treatments (Table 9). The treatment combination V_1T_3 (BARI Chola-5 and RF + Urea 2% FS at FI) recorded the maximum pods plant^{-1} (27.37) and the minimum pods plant^{-1} (1.52) from V_2T_5 (BARI Chola-8 and Urea (2%) + Boron (1%) FS at FI) which statistically identical with V_2T_4 (1.55) and V_2T_2 (1.54).

4.2.3 1000 seed weight (g)

Singh and Sekhon (2006) stated that seed weight has a significant contribution to the final yield of the crops.

4.2.3.1 Effect of variety

Statistically significant variation was recorded in terms of weight of 1000-seeds of BARI Chola-5 and BARI Chola-8 was represented in Figure 25. The maximum weight of 1000-seed (276.87g) was found from V_2 (BARI Chola-8), while the minimum weight of 1000-seed (123.38g) was attained from V_1 (BARI Chola-5). Mirzakhani *et al*. (2013) reported that weight of 100 seeds in the plant there were no significant differences between the different chickpea cultivars. Thousand seed weight ranged from 110-120g in BARI Chola-5, 140-150 g in BARI Chola-6, and 250-260 g in BARI Chola-8 was observed by Bakr *et al.* (2002). Khatun *et al.* (2010) and Bhuiyan *et al.* (2009) reported the same.

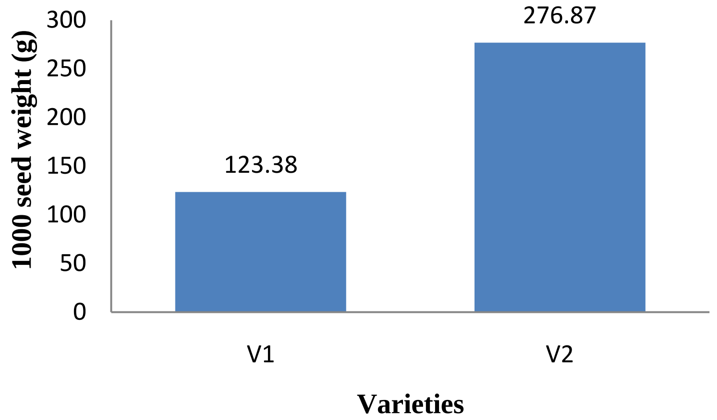


Figure 25. Effect of variety on 1000 seed weight of chickpea (LSD $_{(0.05)}$ = 26.92)

V_1= BARI Chola-5, V_2=BARI Chola-8

4.2.3.2 Effect of supplementary foliar spray

1000-seed weight showed significant variation for different foliar spray treatment showed in Figure 26. It was observed that T_3 (RF+ Urea (2%) FS at FI) produced the highest (220.9g) 1000-seed weight of chickpea and T_1 (control) produced the lowest (185.6g) 1000-seed weight. Results showed that 19.02% more 1000 seed weight found in T_3 treatment compared to control. T_3 gave statistically similar result with T_2 and T_5. Tanwar *et al.* (2014) and Bahr (2007) recorded similar improvement in seed weight in chickpea.

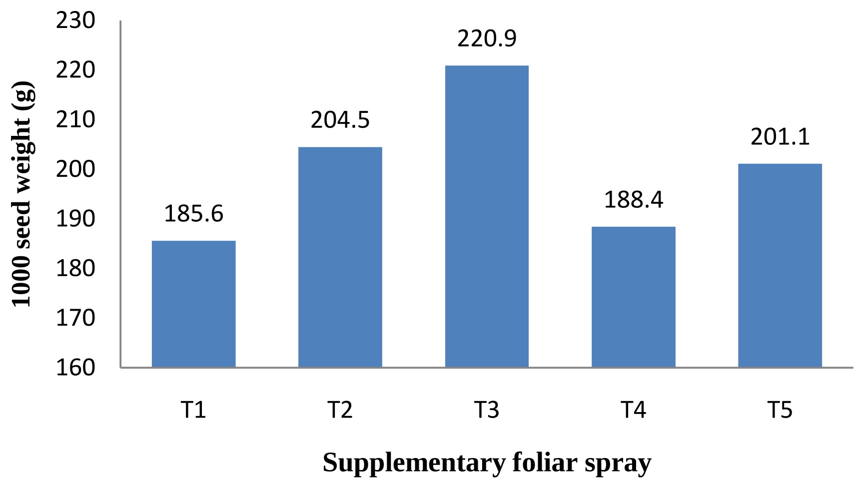


Figure 26. Effect of supplementary foliar spray on 1000 seed weight of chickpea (LSD $_{(0.05)}$ = 26.82)

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

4.2.3.3 Combined effect of variety and supplementary foliar spray

Chickpea varieties and different supplementary treatments showed significant differences on weight of 1000-seed due to interaction effect (Table 9). The maximum weight of 1000-seed (298.0 g) was observed from V_2T_3 (BARI Chola-8 and RF + Urea (2%) FS at FI) which was statistically similar with the treatment combinations of V_2T_2 (281.2 g), V_2T_5 (272 g), V_2T_4 (270.4 g) and V_2T_1 (262.7 g) accordingly and the minimum weight of 1000-seed (108.5 g) from V_1T_1 (BARI Chola-5 and control) which was statistically similar with V_1T_2 V_1T_4 and V_1T_5.

Table 9. Combined effect of variety and supplementary foliar spray on pods plant^{-1}, seeds pod^{-1} and 1000 seed weight of chickpea

Treatment combinations	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000 seed weight (g)
V_1T_1	22.47 f	1.68 d	108.5 b
V_1T_2	23.69def	2.03 bc	127.9 b
V_1T_3	27.37 ab	2.20 a	143.7 b
V_1T_4	23.37 ef	1.98 c	106.4 b
V_1T_5	25.75 bcd	2.09 b	130.3 b
V_2T_1	24.60 cdef	1.33 g	262.7 a
V_2T_2	25.01 cde	1.54 ef	281.2 a
V_2T_3	29.17 a	1.64 de	298.0 a
V_2T_4	25.30 bcde	1.55 ef	270.4 a
V_2T_5	26.49 bc	1.52 f	272.0 a
LSD $_{(0.05)}$	2.28	0.11	37.93
CV (%)	5.20	3.38	10.95

V_1= BARI Chola-5, V_2=BARI Chola-8

T_1= Recommended Fertilizer (RF), T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI),

T_3= RF+ Urea (2%) FS at FI, T_4= RF+ Boron (1%) FS at FI,

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

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

Increased crop growth rate and net assimilation rate indicate the optimum physiological growth of a crop that produces maximum seed yield. The grain yield per hectare is the final expression of physiological and metabolic activities of the plant. Grain yield is the product of a cumulative effect of all the factors contributing to better growth and thereby effectively increasing the yield per plant and ultimately the yield per hectare.

4.2.4.1 Effect of variety

No significant variation was recorded in terms of seed yield of BARI Chola -5 and BARI Chola-8 showed in Figure 27. Numerically the higher seed yield (1.47 t ha^{-1}) was observed from V_2 (BARI Chola-8), whereas the lower seed yield (1.32 t ha^{-1}) was found from V_1 (BARI Chola-5). Varieties plays an important role in producing high yield of chickpea and yield also varied for different varieties might be due to genetical and environmental influences as well as management practices. Hasanuzzaman *et al.* (2007) and Atram (2007) reported that chickpea genotypes differed significantly with respect to grain yield.

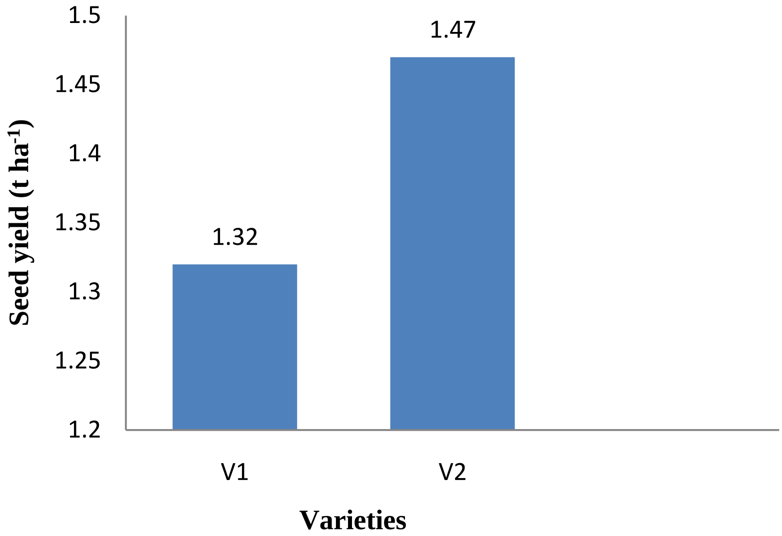


Figure 27. Effect of variety on seed yield of chickpea (LSD $_{(0.05)}$ = NS)

V_1= BARI Chola-5, V_2=BARI Chola-8

4.2.4.2 Effect of supplementary foliar spray

Different supplementary foliar spray treatment showed significant variation for seed yield of chickpea representned in Figure 28. The highest seed yield (1.69 t ha^{-1}) was recorded from T_3 (RF+ Urea (2%) FS at FI) and closely followed (1.40 t ha^{-1} and 1.38 t $ha^{-1}$and 1.38 t ha^{-1} respectively) by T_5 (RF+ Urea (2%) + Boron (1%) and T_2 (RF+ FI of water at flower initiation) and T_4 (RF+ Boron (1%) FS at FI) while the lowest seed yield (1.14 t ha^{-1}) was attained from T_1 (control). T_3 produced 48.25% higher seed yield control. Foliar spray of urea showed a distinct effect in retarding the leaf senescence and in turn produced higher dry matter and grain yield. Higher number of branches per plant, more number of pods plant and higher grain yield per plants were in favor of the treatment which might have resulted in increased grain yield (kg/ha). The higher yield noticed in urea spray might also be due to longer retention of the effective photo assimilatory surface (Prabakaran, 2002). Palta *et al*. (2005) reported that the potential to increase yields of chickpea by application of foliar nitrogen near flowering in environments in which terminal droughts reduce yield. Hafiz (2000) reported similar observations in their study of foliar spraying with aqueous solution of 1% urea compared to the unsprayed control. Similar results of increase in seed yield due to foliar spray of urea under normal irrigated condition was reported by Das and Jana (2015) in greengram, blackgram, lathyrus, lentil and chickpea.

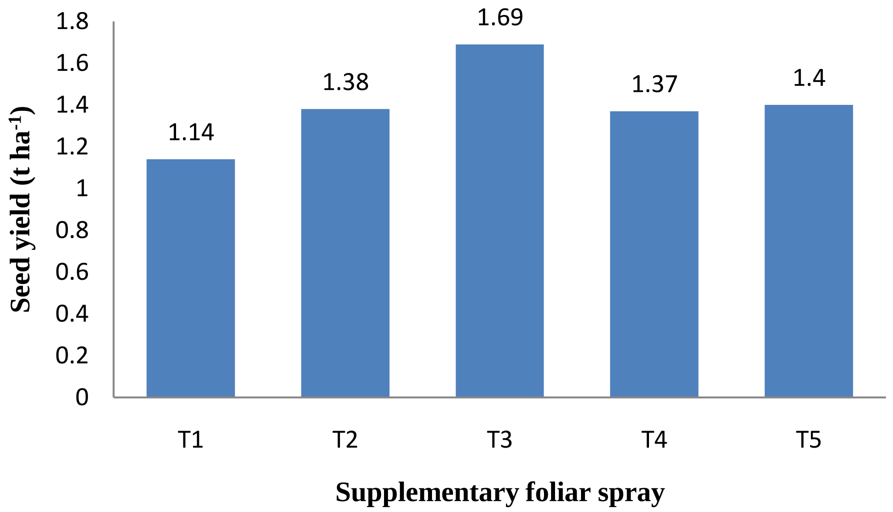


Figure 28. Effect of supplementary foliar spray on seed yield of chickpea (LSD $_{(0.05)}$ = 0.14)

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

4.2.4.3 Combined effect of variety and supplementary foliar spray

Different foliar spray treatments that applied on chickpea showed statistically significant variation in terms of seed yield of chickpea (Table 10). The maximum seed yield (1.75) was found from V_2T_3 (BARI Chola-8 and RF + Urea 2% FS at FI), which was statistically significant with the yield (1.62 t ha^{-1}) of V_1T_3 (RF + Urea (2%) FS at FI) again the minimum seed yield (1.05 t ha^{-1}) was observed from V_1T_1 (BARI Chola-5 + RF) and it was statistically similar with V_2T_1.

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

The increase in straw yield is directly related to increase in vegetative growth and to some extent in the reproduction portion of the plants.

4.2.5.1 Effect of variety

Stover yield also differs significantly due to variety treatments showed in Figure 29. It was observed that the BARI Chola-8 (V_2) produced the highest (2.54 t ha^{-1}) stover yield and BARI Chola-5 (V_1) produced the lowest (1.90 t ha^{-1}) stover yield. Result showed that BARI Chola-8 (V_1) produced 33.68% more stover yield than BARI Chola-5 (V_2). Khatun *et al.* (2010) and Bhuiyan *et al.* (2009) also found significant variation of stover yield due to various chickpea varieties. Ali *et al.* (2010) showed in their study chickpea genotype 97086 produced higher biological (7658 kg/ha).

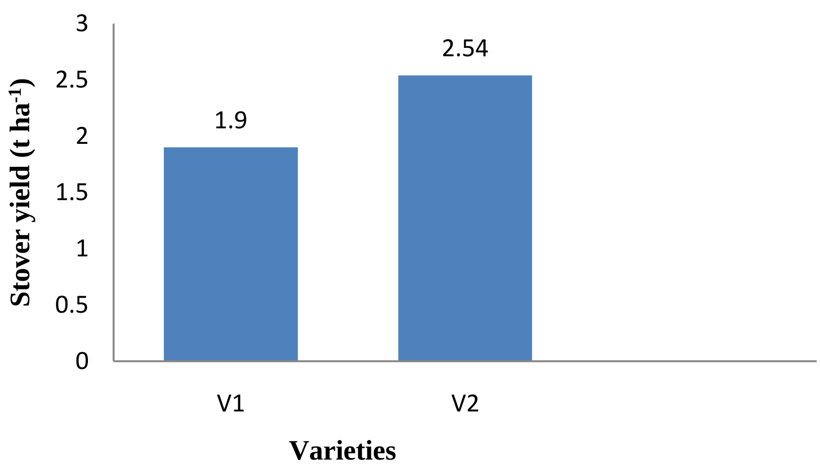


Figure 29. Effect of variety on stover yield of chickpea (LSD $_{(0.05)}$ = 0.25)

V_1= BARI Chola-5, V_2=BARI Chola-8

4.2.5.2 Effect of supplementary foliar spray

Different supplementary foliar spray treatment showed significant variation for seed yield of chickpea demonstrated in Figure 30**.** It was observed that T_3 produced the highest (2.56 t ha^{-1}) Stover yield. However, the lowest (2.05 t ha^{-1}) stover yield was observed from T_4 which was statistically similar with T_1 and T_2. Result showed that T_3 produced 24.27% more stover yield than control. The higher straw yield per hectare may be due to the beneficial effect of nitrogen on physiological characters, which influenced growth attributes such as plant height and number of branches per plant. Roy *et al.* (2016) and Bhowmick *et al.* (2013) have reported similar findings in chickpea.

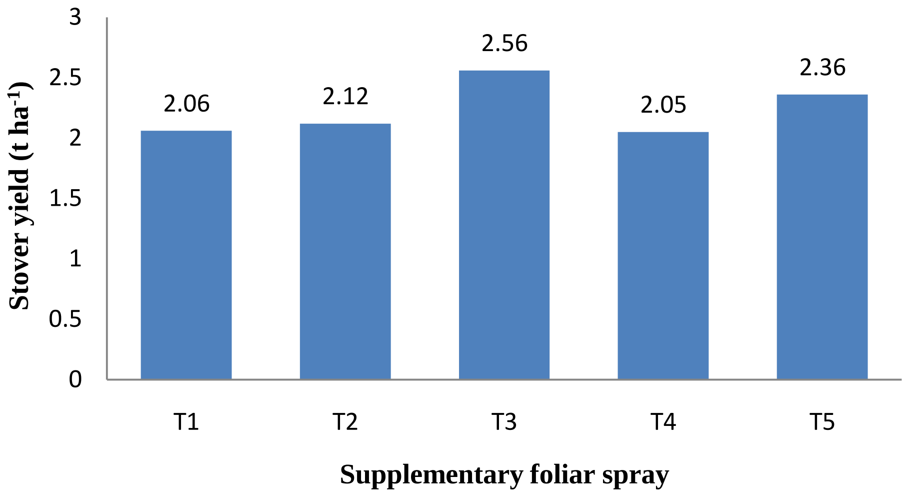


Figure 30. Effect of supplementary foliar spray on stover yield of chickpea (LSD $_{(0.05)}$ = 0.22)

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

4.2.5.3 Combined effect of variety and supplementary foliar spray

Stover yield varied significantly due to various treatment combinations of variety and supplementary foliar spray (Table 10). It was observed that the treatment combination of V_2T_3 produced the highest (2.87 t ha^{-1}) stover yield which was statistically similar with V_2T_5 and V_2T_4 acquiring 2.82 and 2.73 t ha^{-1}. However, the lowest (1.37 t ha^{-1}) stover yield was observed from V_1T_4 combination.

4. 2. 6 Biological yield (t ha^{-1})

4.2.6.1 Effect of variety

There was significant variation on the biological yield of chickpea due to varietal difference (Fig. 31). It was found that the highest biological yield of chickpea (4.01 t ha^{-1}) was reported in V_2 (BARI Chola-8). On the contrary, the lowest biological yield (3.22 t ha^{-1}) was observed in the V_1 **(**BARI Chola-5). Highest biological yield recorded (4.41 t ha^{-1}) from BARI Chola 9 than BARI Chola 5 in the findings of Roy (2013).

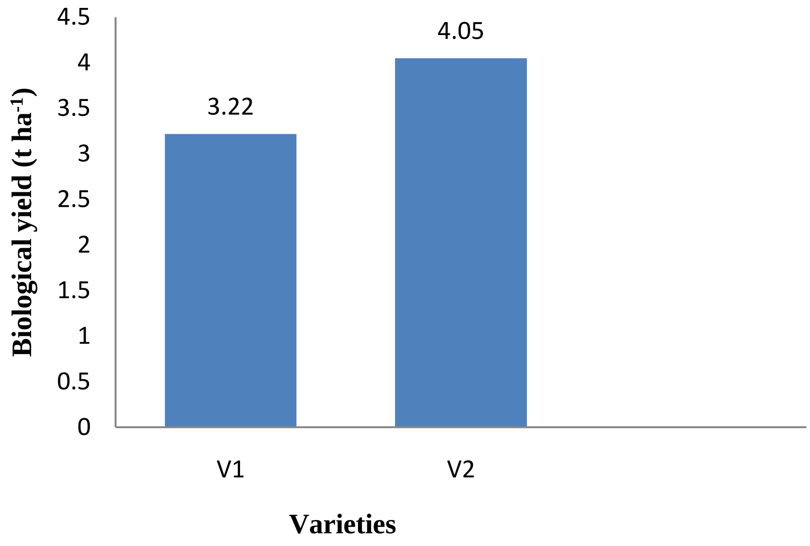


Figure 31. Effect of variety on biological yield of chickpea (LSD $_{(0.05)}$ = 0.43)

V_1= BARI Chola-5, V_2=BARI Chola-8

4.2.6.2 Effect of supplementary foliar spray

There laid significant variations in respect of biological yield of chickpea due to supplementary foliar applications.

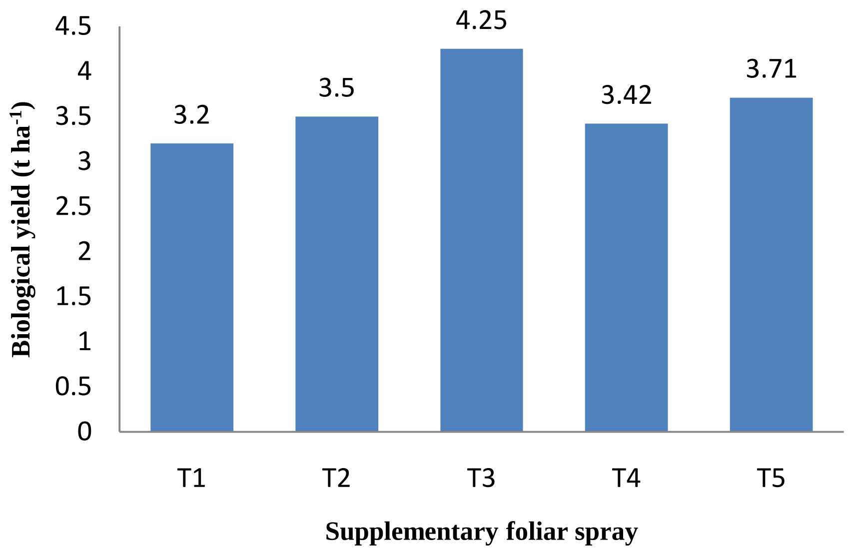


Figure 32. Effect of supplementary foliar spray on biological yield of chickpea (LSD $_{(0.05)}$ = 0.27)

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_3 (RF+ Urea (2%) FS at FI) gave the highest biological yield (4.25 t ha^{-1}) among the different treatments, followed by 3.71 and 3.50 t ha^{-1} at T_5 (RF + Urea (2%) + Boron (1%) FS at FI) and T_2 (RF+ FI of water at flower initiation) and the lowest biological yield (3.20 t ha^{-1}) was observed with T_1 (control) treatment represented in Figure 32. Increasing seed and biological yield as a result of urea foliar application was also reported by Zeidan (2003).

4.2.6.3 Combined effect of variety and supplementary foliar spray

The combined effect of different variety and foliar application on the biological yield of chickpea showed was significant variation (Table 10). The maximum biological yield (4.62 t ha^{-1}) was observed with the interaction of V_2T_3 (RF + Urea (2%) FS at FI) which were statistically similar with V_2T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) recorded 4.29 t ha^{-1}. On the other hand, the minimum biological yield (2.70 t ha^{-1}) was recorded in V_1T_4 treatment combination which was statistically similar with V_1T_1 (control that is RF without spray) treatment combination.

4.2.7 Harvest index (%)

The harvest index is the ratio of grain yield and straw yield.

4.2.7.1 Effect of variety

Harvest index of BARI Chola-5 and BARI Chola-8 showed statistically significant variation under the present trial which showed in Figure 33.

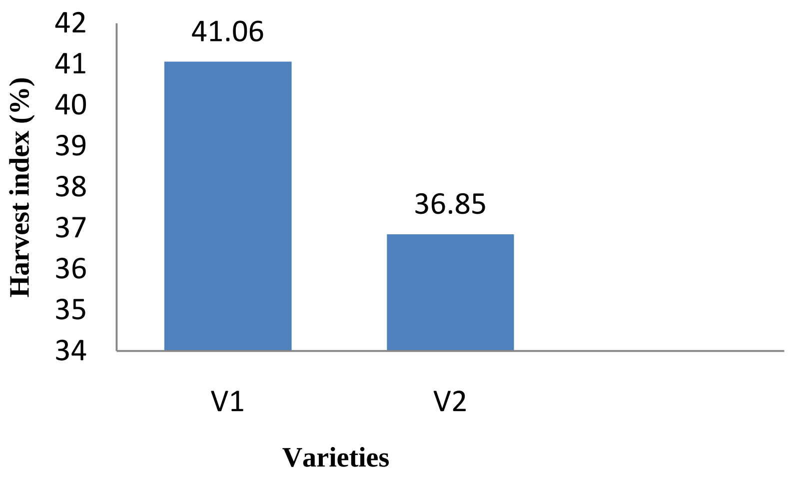


Figure 33. Effect of variety on harvest index (%) of chickpea (LSD $_{(0.05)}$ = 2.30)

V_1= BARI Chola-5, V_2=BARI Chola-8

The maximum harvest index (41.06%) was found from V_1 (BARI Chola-5), while the minimum (36.85%) was recorded from V_2 (BARI Chola-8). BARI Chola-5 recorded 10.25% higher HI than BARI Chola-8. Roy (2013) found maximum harvest index BARI Chola-9 and minimum from BARI Chola-8.The highest harvest index was found in the variety BARI Chola-7 in the findings of Das *et al.* (2009).

4.2.7.2 Effect of supplementary foliar spray

Statistically significant variation was recorded for harvest index due to the supplementary foliar application of urea and boron. Figure 34 revealed that the highest harvest index was recorded from T_4 (41.65 %) which was statistically significant with T_3 (39.90 %) and T_2 (39.26 %) while the lowest harvest index was attained from T_1 (35.51%).

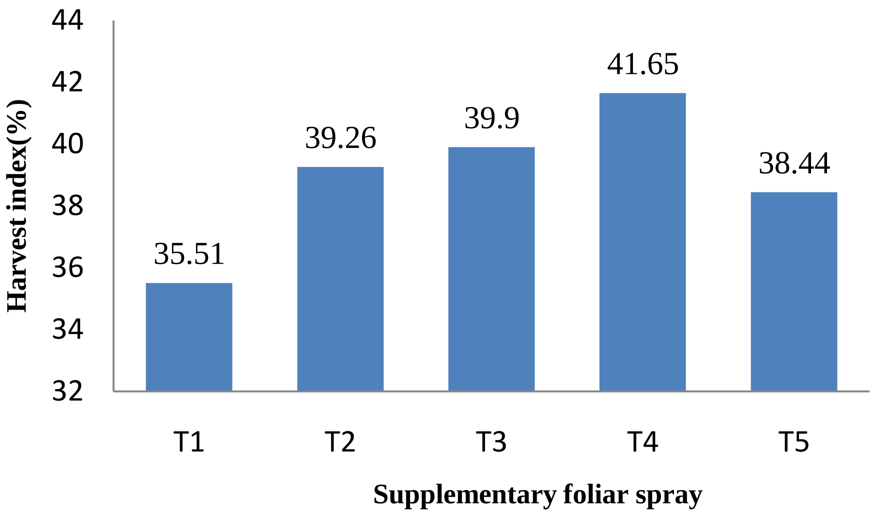


Figure 34. Effect of supplementary foliar spray on harvest index (%) of chickpea (LSD $_{(0.05)}$ = 3.08)

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

The best harvest index recorded by 1% urea foliar application at pod filling stage reported by Bahr (2007). Atram (2007) observed about 40% HI with spraying of 2% urea at flower initiation stage and 10 days thereafter in chickpea wheareas highest harvest index was reported by Thakur *et al.* (2017b) by (10 percent nitrogen, 40 percent phosphorous, 3 percent micronutrient and 20 ppm plant growth regulator) in blackgram.

4.2.7.3 Combined effect of variety and supplementary foliar spray

Interaction effect of chickpea varieties and different foliar spray treatments showed statistically significant variation in terms of harvest index (Table 10).

Table 10. Combined effect of variety and supplementary foliar spray on the seed yield, stover yield, biological yield and harvest index of chickpea

Treatment combinations	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
V_1T_1	1.05 e	1.95 cd	3.00 gh	35.00 d
V_1T_2	1.25 d	2.15 bc	3.40 ef	36.82 d
V_1T_3	1.62 ab	2.25 b	3.87 cd	41.86 bc
V_1T_4	1.32 cd	1.37 e	2.70 h	49.04 a
V_1T_5	1.33 cd	1.79 d	3.12 fg	42.55 b
V_2T_1	1.23 de	2.18 bc	3.41 ef	36.01 d
V_2T_2	1.50 bc	2.10 bcd	3.60 de	41.70 bc
V_2T_3	1.75 a	2.87 a	4.62 a	37.93 cd
V_2T_4	1.42 cd	2.73 a	4.15 bc	34.26 d
V_2T_5	1.47 bc	2.82 a	4.29 ab	34.34 d
$LSD_{(0.05)}$	0.20	0.30	0.38	4.35
CV (%)	8.32	7.98	6.15	6.46

V_1= BARI Chola-5, V_2=BARI Chola-8

T_1= Recommended Fertilizer (RF), T_2= RF+ Foliar Spray (FS) of water at flower initiation (FI),

T_3= RF+ Urea (2%) FS at FI, T_4= RF+ Boron (1%) FS at FI,

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

The maximum harvest index (49.04%) was recorded from V_1T_4 (BARI Chola-5 and RF+ Boron (1%) FS at FI), whereas the minimum (34.24%) was observed from V_2T_4 (BARI Chola-8 and RF+ Boron (1%) FS at FI) which was statistically similar with V_2T_5, V_2T_1, V_1T_2, V_1T_1 and V_2T_1 reported 34.34%, 36.01%, 36.82%, 35.00% and 36.01%, respectively.

4.3 Correlation-regression studies

The final yield of crop is the cumulative effects of growth attributes and such of those treatments which manipulate the favorable parameters could result in the positive relationship with higher productivity. The relationships of total dry matter production & pods were correlated with the final yield presented in the Figure 35 and Figure 36. Based on the results arrived from the correlation revealed that the correlation between above ground dry matter (90 DAS) and pods plant^{-1} were showed significant positive correlation with yield.

4.3.1 Above ground dry matter (AGDM) plant^{-1} vs. seed yield

The increase in total dry weight in plants could be attributed to maximum accumulation of assimilates in different parts of plants during growth and development of chickpea crop with greater LAI and dry matter partitioning.

Dry matter weight plant^{-1} at 90 DAS has significant and linear relationship with seed yield of chickpea plants (R^2 = 0.848**) showed in Figure 35. Thakur *et al.* (2017b) and Surendar *et al.* (2013) also observed the same trend in chickpea.

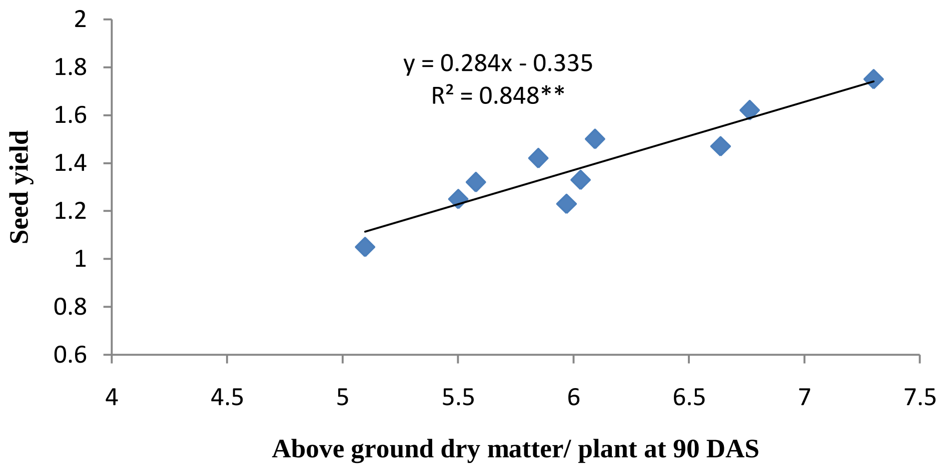


Figure 35. Relationship between above ground dry matter (90 DAS) and seed yield of chickpea

4.3.2 Pods plant^{-1} vs. seed yield

In case of correlation regression analysis, pods/plant has significant and linear relationship with seed yield of chickpea plants (R^2 = 0.840**) showed in Figure 36.

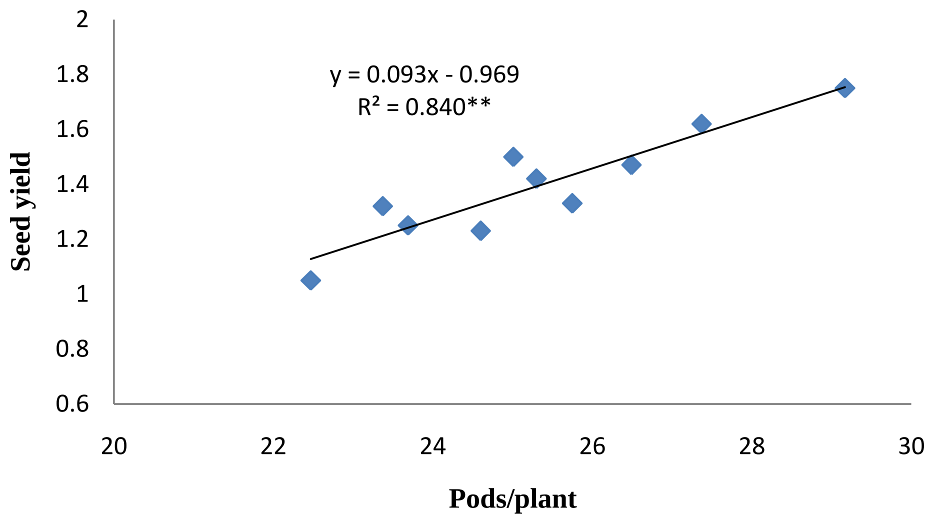


Figure 36. Relationship between pods plant $^{-1}$ and seed yield of chickpea plants.

The increasing pods/plant due to high dry matter accumulation and partitioning to pod resulted in higher seed yield in chickpea. Karim and Fattah (2007) also found the similar trend in chickpea.

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 November, 2016 to April, 2017 to observe the influence of supplementary foliar spray of urea and boron in chickpea cultivation in rabi season under the Modhupur Tract (AEZ-28). The experiment consists of two factors: Factor A: Chickpea variety (2) as V_1: BARI Chola-5 and V_2: BARI Chola-8, Factor B: Supplementary foliar spray (5 levels) as T_1= Recommended Fertilizer (RF), T_2= RF + Foliar Spray (FS) with 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. 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 on different growth parameters, yield attributes and yield were recorded and statistically significant variation was recorded for different parameters.

Data were recorded on crop growth parameters like plant height, branches plant^{-1}, nodules plant^{-1}, nodule dry weight plant^{-1}, above ground dry matter plant^{-1}, leaf area index, crop growth rate, relative growth rate and dry matter partitioning at different growth stages. Other yield and yield contributing character like pods plant^{-1}, seeds pod^{-1}, 1000-seeds weight, seed yield, 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 the results it was observed that two varieties of chickpea had significant difference. At harvest the tallest plant (52.21cm), maximum number of branches plant^{-1} (24.811) and maximum above ground dry matter weight plant^{-1} (11.95g) was recorded from V_2 (BARI Chola-8), whereas the shorter plant (44.67cm), minimum number of branches plant^{-1} (21.187) and minimum dry matter weight plant^{-1} (10.09g) was recorded from V_1(BARI Chola-5). In case of dry matter partitioning, highest assimilate translocated to leaf (42.63%) at 90 DAS found in V_1 (BARI Chola-5) and lowest (40.57%) in V_2 (BARI Chola-8) but V_2 translocated 10.78% assimilates to flower and pod which was higher than V_1 (7.63%). But highest dry matter translocation (39.95%) to pod recorded in V_2 (BARI Chola-8) and lowest dry matter translocation (37.82%) recorded in V_1 (BARI Chola-5) at 120 DAS (maturity). The highest nodules plant^{-1} (20.58) and nodule dry weight plant^{-1} (0.67g) was observed from V_1 (BARI Chola-5) and the lowest nodules plant^{-1} (17.92) and nodule dry weight plant^{-1} (0.51g) was observed from V_2 (BARI Chola-8) at 75 DAS. At 60, 90 and 120 DAS, highest leaf area index (0.88, 1.93 and 1.27 respectively) recorded in V_2 (BARI Chola-8), whereas the lowest leaf area index (0.67, 1.64 and 0.85) found from V_1 (BARI Chola-5) at same DAS. Crop growth rate (CGR) was highest (4.62 g m^{-2} d^{-1}) in V_2 and lowest (3.96 g m^{-2} d^{-1}) in V_1 at 90-120 DAS. The maximum relative growth rate (RGR) (0.066 g g^{-1} d^{-1}) was obtained from V_2 (BARI Chola-8) at 30-60 DAS and the minimum RGR (0.055 g g^{-1} d^{-1}) was recorded from V_1 (BARI Chola-5). Highest number of pods plant^{-1} (26.11), 1000 seed weight (276.87g), seed yield (1.47 t ha^{-1}), stover yield (2.54 t ha^{-1}) and biological yield (4.01 t ha^{-1}) recorded in V_2 (BARI Chola-8) whereas lowest number of pods plant^{-1} (24.53), 1000 seed weight (123.38g), seed yield (1.32 t ha^{-1}), stover yield (1.90 t ha^{-1}) and biological yield (3.22 t ha^{-1}) recorded in V_1 (BARI Chola-5). Maximum seeds pod^{-1} (2.00) and harvest index (41.06%) recorded from V_1 and minimum seeds pod^{-1} and harvest index (1.52 and 36.85%, respectively) found in V_2 (BARI Chola-8).

Supplementary foliar spray also significantly influenced all growth and yield attributes. At harvest, the tallest plant (52.06 cm), highest branches plant^{-1} (25.83) and highest above ground dry matter weight plant^{-1} (12.82g) was recorded from T_3 (RF+ Urea (2%) FS at FI) whereas, the shortest plant (45.02 cm), minimum number of branches plant^{-1} (21.07) recorded at T_5 (RF+ Urea (2%) + Boron (1%) FS at FI) and minimum above ground dry matter plant^{-1} (8.210g) was recorded from T_1 (Recommended Fertilizer) at same DAS. In case of dry matter partitioning, highest assimilate translocated to reproductive unit (10.78% and 40.70%) at 90 DAS and 120 DAS, respectively were found from T_3 (RF+ Urea (2%) FS at FI) whereas lowest assimilate translocated to pod 7.62% and 34.023% were found from T_1 (Recommended Fertilizer) at 90 and 120 DAS. The highest nodules plant^{-1} (25.41) and nodules dry weight plant $^{-1}$ (0.70g) were observed from T_3 (RF+ Urea (2%) FS at FI) whereas, and the lowest nodules plant^{-1} (12.56) and nodule dry weight plant $^{-1}$ (0.38g) found in T_1 (Recommended Fertilizer) treatment at 75 DAS. Highest leaf area index (2.01) recorded at T_3 and lowest leaf area index (1.65) from T_1 at 90 DAS. Highest crop growth rate (5.018 g m^{-2} d^{-1}) recorded at T_5 (RF + Urea (2%) + Boron (1%) FS at FI) which was statistically similar with T_3 (4.80 g m^{-2} d^{-1}) and highest relative growth rate (0.0647 g g^{-1} d^{-1}) at T_3 (RF + Urea (2%) FS at FI) at 90-120 DAS and 30-60 DAS, respectively whereas lowest crop growth rate (3.117 g m^{-2} d^{-1}) recorded at T_1 (Recommended Fertilizer) and relative growth rate (0.056 g g^{-1} d^{-1}) reported from T_5 (RF + Urea (2%) + Boron (1%) FS at FI) at same DAS, respectively. Highest number of pods $plant^{-1}$ (28.27), seeds pod^{-1} (1.92), 1000 seed weight (220.90 g), seed yield (1.69 t ha^{-1}), stover yield (2.56 t ha^{-1}) and biological yield (4.25 t ha^{-1}) from T_3 (RF+ Urea (2%) FS at FI) and highest harvest index (41.65%) from T_4 (RF+ Boron (1%) FS at FI) were recorded. Lowest number of pods $plant^{-1}$ (23.53), seeds pod^{-1} (1.51), 1000 seed weight (185.6 g), seed yield (1.14 t ha^{-1}), stover yield (2.05 t ha^{-1}), biological yield (3.20 t ha^{-1}) and harvest index (35.51%) recorded from T_1 (Recommended Fertilizer).

Combined effect of varieties and different supplementary foliar spray also significantly affected growth as well as yield and yield contributing characters of chickpea. At harvest, the tallest plant (54.17 cm), highest branches $plant^{-1}$ (27.45) and highest above ground dry matter weight $plant^{-1}$ (14.03g) was recorded from V_2T_3 (BARI Chola-8 and RF+ Urea (2%) FS at FI) whereas, the shortest plant (41.64 cm) at V_1T_5, lowest number of branches $plant^{-1}$ (19.00) and above ground dry matter weight $plant^{-1}$ (7.833g) was recorded from V_1T_1 (BARI Chola-5+Recommended Fertilizer) at same DAS. The highest nodules $plant^{-1}$ (27.13) observed from V_1T_3 and lowest data (12.02) from V_2T_1 at 75 DAS. Highest nodule dry weight (0.78g) found at V_1T_5 combination and lowest nodule dry weight (0.34g) found at V_2T_1 at 75 DAS. Highest leaf area index (2.23) at 90 DAS and highest crop growth rate (5.460 g m^{-2} d^{-1}) at 90-120 DAS recorded from V_2T_3 (BARI Chola-8 and RF+ Urea (2%) FS at FI) whereas lowest leaf area index (1.50) at V_1T_2 and crop growth rate (2.977 g m^{-2} d^{-1}) at V_1T_1 recorded at same 90 DAS and 90-120 DAS, respectively. Again, highest relative growth rate (0.06867 g g^{-1} d^{-1}) recorded from V_2T_1 (BARI Chola-8 and RF) and lowest relative growth rate (0.044 g g^{-1} d^{-1}) recorded from V_1T_5. In case of dry matter partitioning, highest assimilate translocated to reproductive unit (12.28 %) observed from V_2T_3 and lowest (6.12%) from V_1T_1 at 90 DAS and highest dry matter partitioned to pod (43.11%) found from V_2T_3 and lowest dry matter partitioned to pod

(33.55%) from V_2T_1 at 120 DAS. Highest number of pods plant^{-1} (29.17), 1000-seed weight (298.0g), seed yield (1.75 t ha^{-1}), stover yield (2.87 t ha^{-1}) and biological yield (4.62 t ha^{-1}) recorded from V_2T_3 (BARI Chola-8 and RF+ Urea (2%) FS at FI) whereas highest seeds pod^{-1} (2.20) was found from V_1T_3 (BARI Chola-5 and RF+ Urea (2%) FS at FI) and highest harvest index (49.04%) found at V_1T_4 (BARI Chola-5 and Boron (1%) FS at FI) combinations. On the contrary, lowest pods plant^{-1} (22.47), seeds pod^{-1}(1.33), 1000-seed weight (106.4 g), seed yield (1.05 t ha^{-1}), stover yield(1.37 t ha^{-1}), biological yield (2.70 t ha^{-1}) and harvest index (34.27%) recorded from V_1T_1, V_2T_1, V_1T_4, V_1T_1, V_1T_4, V_1T_4 and V_2T_4, respectively.

Considering the findings of the present experiment, following conclusions may be drawn:

Irrespective of variety, supplementary nitrogen application perhaps contributes to the demand of nitrogen during reproductive stage of plant and gave better result in all the parameters.

BARI Chola-8 or BARI Chola-5 cultivation with recommended fertilizer along with foliar spray of urea (2%) at flower initiation showed maximum yield contributing characters and yield.

RECOMMENDATION

As the results of study indicated that supplementary foliar application of 2% urea along with recommended fertilizer was found influencing to chickpea production so further such study is needed in different agro-ecological zones of Bangladesh for regional validity of the foliar spray management.

REFERENCES

Abbasi, A., Jafari, D. and Sharifi, R. S. (2013). Nitrogen rates effects and seed inoculation with *Rhizobium legominosarum* and plant growth promoting rhizobacteria (PGPR) on yield and total dry matter of chickpea (*Cicer arietinum* L.). *Tec. J. Eng. Appl. Sci*. **3**(23): 3275-3280.

Aggarwal, N., Singh, G., Ram, H., Sharma, P. and Kaur, J. (2015). Irrigated chickpea's symbiotic efficiency, growth and productivity as affected by foliar application of urea. *Intl. J. Agri. Sci.* **7** (5): 516-519.

Ahlawat, I.P.S., Gangaiah, B. and Ashraf, Z. M. (2007). Nutrient management in chickpea. In: Chickpea breeding and management (Yadav S.S., Redden R., Chen W., Sharma B., eds). CAB International, Wallingford, Oxon, United Kingdom. pp. 213-232.

Akay, A. (2011). Effect of zinc fertilizer applications on yield and element contents of some registered chickpeas varieties. *African J. Biotechnol*. **10**(60): 12890-12896.

Aktar, R. (2013). Performance of prilled urea and urea super granules in chickpea cultivation. M.S Thesis. Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207.

Alam, M. Z., Haider S. A. (2006). Growth attributes of barley (*Hordeum Vulgare* L.) cultivars in relation to different doses of nitrogen fertilizer. *J. Life Earth Sci.* **1**(2): 77-82.

Alam, M. S., Aliand, K. J. and Hoque, A. (2017). Yield and yield component of chickpea as affected by boron application. *J. Exp. Agric. Int.* **15**(2): 1-9.

Ali M. and Mishra J. P. (2001). Effect of foliar nutrition of boron and molybdenum on chickpea. *Indian J. Pulses Res*. **14**: 41-43.

Ali, Abbas., Ali, Z., Iqbal, J., Nadeem, M.A., Akhtar, N., Akram, H.M. and Sattar, A. (2010). Impact of nitrogen and phosphorus on seed yield of chickpea. *J. Agric. Res.* **48**(3): 335-343.

Ali, E. A. and Mahmoud, A. M. (2013). Effect of foliar spray by different boron and zinc concentrations on seed yield and yield components of mungbean in sandy soil. *Asian J. Crop Sci.* **5**: 33–40.

Ali, M. Z. and Ahmed, F. (2016). Screening of lentil genotypes against drought stress. **In**: Unfavorable ecosystem: Crop production under high temperature and drought stress (Aziz, M. A. and Mondol, M. R.I., eds.) BARI, Joydebpur, Gazipur. pp. 161-172.

Ali, S., Schwanke, G. D., People, M. B., Scott, J. F. and Herridge, D. F. (2014). Nitrogen, yield and economic benefits of winter legumes for wheat production in rainfed Northern Pakistan. *Pakistan J. Agron.* **1**(1): 15–19.

Aliloo, A. A., Khorsandy, H. and Mustafavi, S. H. (2012). Response of chickpea (*Cicer arietinum* L.) cultivars to nitrogen application at vegetative and reproductive stages. *Cercetari Agron. In Moldova.* 4: 152.

Anadhakrishnaveni, S., Palchamy, A. and Mahendran, S. (2004). Effect of foliar spray of nutrients on growth and yield of greengram (*Phaseolus radiatus). Legume Res.* **27**(2): 149-150.

Anonymous (1988a). The Year Book of Production. FAO, Rome, Italy.

Anonymous (1988b). Land Resources Appraisal of Bangladesh for Agricultural Development. Report No. 2. Agroecological Regions of Bangladesh, UNDP and FAO. pp. 472-496.

Anonymous. (1989). Annual Report 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

Anwarullah, M. S. and Shivashankar, K. (1999). Influence of seed treatment and foliar nutrition of Mo and B on green gram and black gram. *J. Agric. Sci.* **118**: 1-3.

Atram, S. S. (2007). Effect of seed priming and foliar spray of urea on productivity of chickpea (*Cicer arietinum* l.) under rainfed condition. M.S. Theis. Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur,India. pp. 81-86.

Bahr A. A. (2007). Effect of plant density and urea foliar application on yield and yield components of chickpea (*Cicer arietinum*). *Res. J. Agri. Biol. Sci.* **3**(4): 220-223.

Bakr, M. A., Siddique, K. H. M. and Johansen, C. (2002). Integrated management of botrytis grey mould of chickpea in Bangladesh and Australia. Summary Proceedings of a Project Inception Workshop. 1-2, June 2002, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh. pp. 22-23.

BARC (Bangladesh Agricultural Research Council). (2012). Fertilizer Recommendation Guide. Bangladesh Agriculture Research Council, Farmgate, Dhaka. p. 41.

BARI (Bangladesh Agricultural Research Institute). (2014). Krishi Projukti Haat Boi (In bangali). Joydebpur, Gazipur. p. 140.

BBS (Bangladesh Bureau of Statistics). (2010). Stistical Year Book of Bangladesh. Statistics Division, Ministry of Planning, Government of the People Republic of Bangladesh, p. 34.

Bcek, D. P., Wery, J., Saxena, M. C. and Ayadi, A. (1991). Di-nitrogen fixation and nitrogen balance in cool-season food legumes. *Agron. J.* **83**: 334-341.

Beninger, H. (1978). The role of potassium in yield formation. Potash Review Subject 16, Suite 78, *Int. Potash Inst. Berne* (Switzerland), p.3

Bhattacharya, S. S., Mandal, D., Chattopadhyay, G. N. and Majumdar, K. (2004). Effect of Balanced Fertilization on Pulse Crop Production in Red and Lateritic Soils. *Better Crops.* **88**(4): 25-27.

Bhowmick, M. K., Duary, B., Biswas, P. K., Rakshit, A. and Adhikari, B. (2013). Seed priming, row spacing and foliar nutrition in relation to growth and yield of chickpea under rainfed condition. *J. Crop Weed*. **10**(2): 277-280.

Bhuiyan, M. A. H., Khanam, D., Ullah, M. H. and Alam, M. M. (2009). Effect of inoculation and varietal interactions of chickpea at southern region of Bangladesh. Bulle. the Institute Tropical Agriculture, Kyushu University. **32**: 17-23.

BINA (Bangladesh Institute of Nuclear Agriculture). (2012). Annual Report 2010-2011. BAU Campus, Mymensingh, Bangladesh., p.190.

Bisne, P. S. (2015). Mitigation of drought for improving productivity by foliar application of urea and salicylic acid in chickpea (*Cicer arietinum* L.) genotypes. M.S. thesis.

Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh.

Brijnandan, A., Jamwal, B. S., Sharma, B. C., Kumar, A. and Gupta, V. (2014). Seed priming and foliar nutrition studies on growth, yield and quality of chickpea under subtropical kandi areas of hills of shivalik foothills of Jammu region. *Intl. J. Basic. Appl.Agric. Res*. **12**: 184-187.

Brown, R. H. (1984) Physiological basis of crop growth and development. **In**: growth of the green plant. Teasar, M. B. (Ed.). Madison, Wisconsin. pp. 153-173.

Buneo, J. X. U. (1997). Foliar fertilization in soybean. *Agric. Tech. Mexico*. **21**: 3-17.

Caliskan S., Ozkaya I., Caliskan M. E., Arslan M. (2008). The eff ect of nitrogen and iron fertilization on growth, yield and fertilizer use efficiency of soybean in Mediterranean type soil. *Field Crops Res*. **108**: 126-132.

Chatterjee, R., Bandyopadhyay, S. (2015).Effect of boron, molybdenum and biofertilizers on growth and yield of cowpea (*Vigna unguiculata* L. Walp.) in acid soil of eastern Himalayan region. *J. Saudi Soc. Agric. Sci.* **5**: 55-90.

Chaudhari, R. K., Patel, T. D., Patel, J. B. and Patel R. H. (1998). Response of chickpea cultivars to irrigation, nitrogen and phosphorus on sandy loam soil. *Intl. Chickpea Newsl*. **5**: 24-26.

Das, A. K., Haque, Q. A., Moynul, M. and Islam, M. S. (2009). Effect of phosphorus fertilizer on the drymatter accumulation nodulation and yield in chickpea. *Bangladesh Res. Pub. J.* **1**(1):47-60.

Das, R. C. and Sahoo K. C. (1975). Foliar treatments of nutrition on potato (*Solanum tuberosum* L.) variety Kufri Sindhuri. *Res. J. Orissa Univ. Agri. Tech.* **5** (1-2): 96-103.

Das, S. K. and Jana, K. (2015). Effect of foliar spray of water soluble fertilizer at pre flowering stage on yield of pulses. *Agric. Sci. Digest.* **35**(4): 275-279.

Deolankar, K. P. (2005). Effect of fertigation on growth and yield of chickpea. *J. Maharashtra Agril. Uni*. **30**(2): 170-172.

Dixit, P. M. and Elamathi, S. (2007). Effect of foliar application of DAP, micronutrients and NAA on growth and yield of green gram (*Vigna radiata* L.). *Legume Res*. **30**: 305-307.

Dordas, C. (2009). Dry matter, nitrogen and phosphorus accumulation, partitioning and remobilization as affected by N and P fertilization and source–sink relations. *Eur J. Agron.* **30**: 129-139.

Duan, W., Yu, Z., Zhang, Y., Wang, D. and Xu, Z. (2014). Effects of nitrogen application on biomass accumulation, remobilization, and soil water contents in a rainfed wheat field. *Turk. J. Field Crop.* **19**(1): 25-34.

Dudhade, D. O., Jamadagni, B. M., Dhonde, S. R. and Kanwade, D. G. (2003). Effect of foliar fertilizer application on yield of rain fed gram. *J. Maharashtra Agri.Univ.* **28**(1): 108-109.

Edris, K. M., Islam, A. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh, Dept. Soil Survey, BAU and Govt. Peoples Republic of Bangladesh. p. 118.

El-Habbasha, S. F., Amal,G. A. and Magda, H. M.(2012). Response of some chickpea cultivars to compound foliar fertilizer under sandy soil conditions. *J. Appl. Sci. Res.* **8**(10): 5177-5183.

Eusuf Zai, A. K., Solaiman, A. R. M. and Ahmed, J. U. (1999). Response of some chickpea varieties to *Rhizobium* inoculation in respect to nodulation, biological nitrogen fixation and dry matter yield. *Bangladesh J. Microbiol.* **16**(2):135-144.

Fallah, S., Ehsanzadeh, P. and Daneshvar, M. (2005). Grain yield and yield components in three chickpea genotypes under dryland conditions with and without supplementary irrigation at different plant densities in Khorram-Abad, Lorestan. *Iranian J. Agril. Sci*. **36**(3): 719-731.

FAO (Food and Agricultural Organization). (2013). Yearly yield of chickpea 2013. FAO Stat. Citation, 2013.

Farrington, P., Greenwood, E. A. N., Titmanis, Z. V., Trinik, M. J. and Smith, D.W. (1977). Fixation, accumulation and distribution of nitrogen in a crop of *Lupinus angustifolius* cv. Unicrop. *Australian J. Agric. Res.* **28**: 237-24.

Gabal, M. R., Abdellah, I. M., Abed, I. A. and Elassiouty, F. M. (1995). Effect of Cu, Mn, B and Zn foliar application on common bean growth, flowering and seed yield. *Acta Hort.* **168**: 307-319.

Gagandeep, K., Navita, G., Jagmeet, K. and Sarvjeet, S. (2015). Growth efficiency and yield of pigeonpea (*Cajanus cajan* L.) as affected by foliar application of mineral nutrients. *J. Pl. Sci. Res*. **2**(2): 1-9.

Gangwar, K. S. and Singh, N. P. (2002). Growth and development behaviour of lentil in relation to zinc application. *Indian J. Agric. Res.* **35**: 38-42.

Ghassemi-Golezani, K., Mustafavi, S.H., Shafagh, K. J. (2012). Field performance of chickpea cultivars in response to irrigation disruption at reproductive stages. *Res. on Crops.* **13** (1): 107-112 .

Golldani, A. and Moghaddam, P. R. (2006). Effect of different irrigation levels on phenology, physiology characteristics, and yield components of three chickpea (*Cicer arietinum* L.) cultivars in Mashhad. *Agril. Sci. Tech*. **20**(3): 21-32.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research (2nd edn.) Int. Rice Res. Inst., A Willey. *Intl. Sci.*, Pub. pp. 28-192.

Gowthami, P. and Rao, R. G. (2014). Influence of foliar application potassium, boron and zinc on growth and yield of soybean. *Intl. J. Food, Agric. Vet. Sci.* **4**(3): 81-86.

Gupta, U. C. and Cutcliffe, J. A. (1978). Effects of methods of boron application on leaf tissue concentration of boron and control of brown-heart in rutabaga. *Can. J. Plant Sci.* **58**: 63-68.

Gurha, S. N., Ghosh, A. and Singh, R. A. (2001). Effect of stunt disease on yield parameters in chickpea. *Indian J. Pulses Res*. **14**(1): 74-75.

Hafiz, S. I. (2000). Response of three chickpea cultivars to late foliar spraying with urea as a supplement for early soil applied nitrogen in sandy soils. *Annals of Agril. Sci*. **38**(1): 31-46.

Haque, M. R., Khan, M. M., Ahmed, F. and Rahman, M. T. (2016). Screening of wheat genotypes against drought stress (field). **In:** Unfavourable ecosystem: Crop production under high temperature and drought stress (Aziz, M. A. and Mondol, M. R.I., eds.) BARI. Joydebpur, Gajipur. pp. 95-110.

Hasanuzzaman, M., Karim, M. F., Fattah, Q. A. and Nahar, K. (2007). Yield performance of chickpea varieties following application of growth regulator. *Am-Euras. J. Sci. Res.*, **2**(2): 117-120.

Hemantaranjan, A., Trivedi, A. K and Maniram, G. (2000). Effect of foliar applied boron and soil applied iron and sulphur on growth and yield of soybean (*Glycine max* L. Merr). *Indian J. Plant Physiol*. **5** (2): 142-144.

Hoque, M. M. (2005). Effect of GABA on morpho-physiological and yield contributing characters of chickpea. M.S. thesis. Department of Crop Botany, Bangladesh Agriculture University, Mymensingh.

Hunt, R. (1978). Plant growth analysis. The institute of Biology's studies in Biology No. 96. Edward Arnold (Publishers) Limited, London, UK.

Hunt, R. (1981). Plant growth analysis. The Camalot press Ltd. Southampton, UK.

Islam, M. S., M. F. Karim, M. J. Ullah, Q. A. Fattah and M. I. Hossain. (2006). Effect of Knap and NAA on shoot dry matter, yield attributes and yield of lentil (*Lens culinaries*). *J. Agric. Educ. Technol.* **9**(1&2): 55-58.

Jayabal, A., Revathy, M. and Saxena, M. G. (1999). Effect of foliar nutrition on nutrient uptake pattern in soybean. *Andhra Agric. J*. **46**: 243-244.

Johnson, S. E., Lauren, J.G., Welch, R. M. and Duxbury, J. M. (2005). A comparison of the effects of micronutrient seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicer arietinum*), Lentil (*Lens culinaris*), Rice (*Oryza sativa*) and Wheat (*Triticum aestivum*) in Nepal. *Expl. Agric.* **4**: 427-448.

Kalarani, M. K. (1991). Senescence regulation in soybean (*Glycine max* (L.). M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Kalyani, R. R., Sree, D. V., Satyanarayana, N. R. and Rao, M. (1999). Effect of foliar application of boron on crop growth and yield of pigonpea (*Cajanus Cajan* L.) (Mill sp). *Indian J. Plant Physiol.* **2** (4): 223 -226.

Kannan, S. (1986). Foliar absorption and transport inorganic nutrients CRC Crit. Rev. *Plant Sci. J.* **1:** 341-375.

Karasu, A., Oz, M. and Dogan, R. (2009). The effect of bacterial inoculation and different nitrogen doses on yield and yield components of some chickpea genotypes (*Cicer arietinum* L.). *African J. Biotechnol.* **8**(1): 59-64.

Karim, M. D. and Fattah, Q. A. (2007). Growth analysis of chickpea cv. BARI chhola-6 as affected by foliar spray of growth regulators. *Bangladesh J. Bot*. **36**(2): 105-110.

Karim, M. F. and Fattah, Q. A. (2003). Dry matter accumulation and partitioning in chickpea (*Cicer arietinum* L.) as affected by nitrogen levels and KNap concentrations. *Dhaka Univ. J. Biol. Sci.* **12**(2): 115-121.

Katare, R. A., Bhale, V. M. and Mulgir, K. S. (1984). Effect of irrigation on chickpea grain yield. *J. Maharstra Agric Univ.* **9**(2): 217-219.

Kay, D. E. (1979). Food Legumes. Crop and Product Digest, No. 3. Tropical Products Institute, London. pp. 26-37.

Khanna-Chopra, R., Sinha, S. K. (1987). Chickpea: physiological aspect of growth and yield. **In:** The chickpea. Saxena MC, Singh KB(eds). Wallingford, Oxon, UK, CAB International. pp. 163-189.

Khatun, A., Bhuiyan, M. A. H., Nessa, A., & Hossain, S. B. (2010). Effect of harvesting time on yield and yield attributes of chickpea (*Cicer arietinum* L.). *Bangladesh J. Agril. Res.* 35(1): 143-148.

Kulsum, M. U., Baque, M. A., Akter, A. and Karim, M. A. (2007). Effect of different nitrogen levels on dry matter production, canopy structure and light transmission of blackgram. *Asian J.Plant Sci.* **6**: 1044-1050.

Kumar, D., Singh, R. P., Somasundaram, J. and Jamra, S. (2018). Effect of foliar application of nutrients on growth and development of blackgram (*Vigna mungo* (L.) Hepper) under rainfed vertisols of central India. *Int. J. Chem. Stud*. **6**(1): 609-613.

Latha, M.R. and Nadanassababady, T. (2003). Foliar nutrition in crops. *Agric. Rev.* **24**(3): 229-234.

Mahmoud, S. M., Abdalla., Fouad E., Abou, E. and Abdel, K. M. (2011). Boron/Nitrogen interaction effect on growth and yield of fababean plants grown under sandy soil conditions. *Int. J. Agric. Res*.**1** (4): 322-330.

Mahmud, M. S. (2013). Growth and yield of chickpea as influenced by different micronutrients. M.S thesis. Department of agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207.

Manonmani, V. and Srimathi, P. (2009). Influence of mother crop nutrition on seed and quality of balckgram. *Madras Agric. J.* **96**(16): 125-128.

Mansur, C. P., Palled, Y. B., Salimath, P. M. and Halikatti, S. I. (2006). Pattern of leaf area, canopy width and dry matter production in chickpea genotypes as influenced by plant densities and phosphorus levels. *Karnataka J. Agric. Sci.* **19**(3): 493-497.

Martens, D. C. and Westermann, D. T. (1991) *Fertilizer application for correcting micronutrient deficiencies.* **In**: Micronutrients in Agriculture (2nd Edition). SSSA Book Series, No. 4. pp. 549-592. SSSA, 677 S. Segoe Rd., Madison, WI 53711.

Maurya, B. R., Sanoria, C. I. and Ram, P. C. (1987). Combined culture treatment enhances nodulation, yield and quality of chickpea. *Seeds and Farms.* **13**(8): 25-27.

Mirzakhani, S., Yarnia, M. and Khoei, F. R. (2013). Effects of water deficit stress on grain related traits in cultivars of chickpea (*Cicer arietinum* L.). *Res. Crops*. **14**(3): 769-776.

Mishpra, S. K., Shrivastava, G. K., Pandey, D. and Tripathi, R. S. (2001). Optimization of chickpea production through nutrient management and growth regulators under rice based cropping system in vertisols. *Ann. Agric. Res.* **22**(2): 299-301.

Mitra, R., Panwar, S. E. and Bhatia, C. G. (1988). Nitrogen the major limiting factor for mungbean yield, Proceedings of the second International Mungbean Symposium. Tainan, Taiwan: Asian Vegetable Research and Development Center (AVRDC). pp. 244-251.

Moghazy, A. M., Saed, S. M. El. and Awad, S. M. El. (2014). The influence of boron foliar spraying with compost and mineral fertilizers on growth, green pods and seed yield of pea. *Nat. Sci.* **12**(7): 221-229.

Moinuddin, G., Jash, S., Sarkar, A. and Dasgupta, J. (2017). Response of potato (*solanum tuberosum* l.) to foliar application of macro and micronutrients in the red and lateritic zone of west bengal. *J. Crop Weed*. **13**(1): 185-188.

Mondal, M. M. A., Puteh, A., Malek, M. A. and Roy, S. (2012). Effect of foliar application of urea on physiological characters and yield of soybean. *Legume Res.* **35**(3): 202-206 .

Mondal, M. M. A., Rahman, M. A., Akter, M. B. and Fakir, M. S. A. (2011). Effect of foliar application of nitrogen and micronutrients on growth and yield in mungbean. *Legume. Res*. **34** (3): 166-171.

Mukesh, K. (2006). Impact of the starter doses of nitrogen on nodulation, yield and yield attributes of chickpea under irrigated conditions. *Intl. J. Agril. Sci*. **2**(1): 253-255.

Namvar A., Seyed, S. R., Sedghi, M., Asghari, Z. R., Khandan, T. and Eskandarpour, B. (2011). Study on the eff ects of organic and inorganic nitrogen fertilizer on yield, yield components and nodulation state of chickpea (*Cicer arietinum* L.). *Commun. Soil Sci. Pl. Anal.* **42**(9): 1097-1109.

Namvar, A., Sharifi, R. S., Khandan, T. and Moghadam, M. J. (2013). Seed inoculation and inorganic nitrogen fertilization effects on some physiological and agronomical traits of chickpea (*Cicer arietinum* L.) in irrigated condition. *J. Central European Agric*. **14**(3): 28-40.

Namwar, A. and Sharifi, R. S. (2011). Phonological and morphological response of chickpea (*Cicer arietinum* L.) to symbiotic and mineral nitrogen fertilization. *Zemdirbyste (Agriculture);* **98**(2): 121-130.

Nassar, K. E. M. (2005). Response of peanut crop to foliar application of some micronutrients under snady soil conditions. *Ann. Agril. Sci.* **43**(4): 2003-2014.

Nigamananda, B. and Elamathi, S. (2007). Studies on the time of nitrogen, application foliar spray of DAP and growth regulator on yield attributes, yield and economics of green gram (*Vigna radiata* L.). *Intl. J. Agril. Sci*. **3**(1): 168-169.

Padbhushan, R., and Kumar, D. (2014). Influence of soil and foliar applied boron on green gram in calcareous soils. *Int. J. Agric. Environ. Biotechnol*. **7**(1): 129-136.

Palta, J. A., Nandwal, A. S., Sunita, K. and Turner, N. C. (2005). Foliar nitrogen applications increase the seed yield and protein content in chickpea (*Cicer arietinum* L.) subject to terminal drought. *Australian J. Agril. Res*. **56**(2): 105-112.

Pandey, N. and Gupta, B. (2013). The impact of foliar boron sprays on reproductive biology and seed quality of blackgram. *J. Trace Elem. Med. Biol.* **27**(1): 58-64.

Prabakaran. K. (2002). Effect of foliar spray of nutrients and plant growth regulators on growth and yield of blackgram. M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Pradeep, M. D and Elamathi, S. (2007). Effect of foliar application of DAP, micronutrients and NAA on growth and yield of greengram (*Vigna radiate* L.). *Legume Res.* **30** (4): 305-307.

Quader, A. K. M. L. (2013). Time of nitrogen application in chickpea cultivars for maximum yield. M.S thesis. Department of Agronomy. Sher-e-Bangla Agricultural University, Dhaka-1207.

Quddus, M. A., Rashid, M. H., Hossain, M. A. and Naser, H. M. (2011). Effect of zinc and boron on yield and yield contributing characters of mungbean in low Ganges river floodplain soil at Madaripur, Bangladesh. *Bangladesh J. Agril. Res*. **36**(1): 75–85.

Rajendran, R. (1991). Response of greengram to soil and foliar nutrition. *Madras Agric. J.* **78**: 453-455.

Rao, K. L. N. (2015). Physiological effect of boron, brassinosteriod and salicylic acid on dry matter partitioning and yield of chickpea. M. Sc. Thesis. Acharya N.G. ranga Agricultural University,Guntur.

Rao, D. S., Naidu, T. C. M. and Ashokarani, Y. (2016). Effect of foliar nutrition on physiological and biochemical parameters application on yield and economics of transplanted pigeonpea, *Int. J. Sci. Nat.* **7**(3): 598-600.

Ravi N., Sharma, H. M. and Singh, R. N. P. (1998). Response of late-sown chickpea to irrigation and foliar nutrition in calcareous soil. *J. Appl. Biol.* **8**(2): 5-8.

Rawashdeh, H. M. and Sala, F. (2015). The effect of foliar application of iron and boron on early growth parameters of wheat (*Triticum aestivum* L.). *Res. J. Agric. Sci.* **45** (1): 21-26.

Rawsthorne, S., Hadley, P., Roberts, E. H. and Summerfield, R. J. (1985). Effects of supplemental nitrate and thermal regime on the nitrogen nutrition of chickpea *(Cicer arietinum* L.). *Plant. Soil*. **83**: 265-277.

Raza S. A., Ali, S., Chahil, Z. S. and Iqbal, R. M. (2014). Response of foliar application of boron on wheat (*Triticum aestivum* L) crop in calcareous soils of Pakistan. *Acad. J. Agric. Res.* **2**(3): 106-109.

Reddy, B. H., Bulbule, A. V., Gajbhiye, P. N. and Patil, D. S. (2018). Effect of foliar application of plant nutrients on growth and yield of finger millet. *Int. J. Curr. Microbiol .App. Sci*. **7**(3): 2203-2209.

Renukadevi, A., Savithri, P. and Andi, K. (2002). Evaluation of B fertilizer for sunflower - greengram sequence in Inceptisols. *Acta Agron. Hung.* **50**(2): 163-168.

Roy, I. (2013). Influence of supplementary nitrogen, irrigation and hormones on flower droppings, growth and yield of chickpea. M.S thesis. Department of Agronomy. Sher-e-Bangla Agricultural University, Dhaka-1207.

Roy, P. D., Narwal, R. P. and Malik, R. S. (2011). Response and enrichment of green gram (*Vigna radiata* L.) genotypes with respect to boron application. Poster: *Plant Breeding and Mol. Biol*. pp. 1–2.

Roy, I., Biswas, P. K., Ali, M. H., Haque, M. N. and Achakzai, A. K. K. (2016). Effect of supplemental application of nitrogen, irrigation and hormone on the yield and yield components of chickpea. *World J. Agric. Sci.* **12**(1): 70-77.

Saini and Thakur (1996). Effect of nitrogen, phosphorous and sulphur on the micronutrient content of blackgram. Department of Soil Science, JN Krishi Vishwa Vidyalaya, Gwalior 474002, Madhya Pradesh, India. *SO: Crop Res. Hisar.* **9**(1): 54-58.

Salvagiotti, F., Cassman, K. G., Specht, J. E., Walters, D. T and Dobermann, A. (2008). Nitrogen uptake, fixation and response to N in soybeans. *Field Crops Res*. **108**: 1-13.

Sawan, Z. M., Mahmoud, M. H. and El-Guibali, A. H. (2008). Influence of potassium fertilization and foliar application of zinc and P on growth, yield and fiber properties of Egyptian cotton (*Gossypium barbadense* L.). *J. Plant Eco*. **1**: 259-270.

Saxena, H. K. and Mehrotra, O. N. (1995). Effect of boron and molybdenum in presence and absence of phosphorus and calcium of groundnut. *Indian J. Agric. Res.* **29**: 11-14.

Schon, M. K. and Blevins, D. G. (1990). Foliar boron applications increase the final number of branches and pods on branches of field grown soybeans. *Plant Physiol.* **92**: 602-607.

Shil, N. C., Noor, S., Hossain, M. A. (2007). Effects of boron and molybdenum on the yield of chickpea. *J. Agric. Rural Dev*. **5**: 17-24.

Shinde, P., Doddagoudar, S. R and Vasudevan, S. N. (2017). Influence of seed polymer coating with micronutrients and foliar spray on seed yield of chickpea (C*icer arietinum* L.). *Legume Res.* **40**(4): 704-709.

Shirani B., Khodambashi, M., Fallah, S.and Danesh, A. (2015). Effects of foliar application of nitrogen, zinc and manganese on yield, yield components and grain quality of chickpea in two growing seasons. *J. Crop. Prod. Proc.* **5**(16): 143-152.

Shruthi B. M. (2013). Effect of foliar application of micronutrients on seed yield, quality and storability in soybean [*Glycine max* (L.) Merrill]. M.S thesis. Department of seed science and technology, College of Agriculture Sciences, Dharwad.

Sims, T. T. (2000). Soil fertility evaluation. **In**: Summer mini Handbook of soil science. Boca Raton,Florida, USA, CRC Press. pp. 113-154.

Singh, G. and Sekhon, H. S. (2006). Effect of row spacing and seed rate on the growth and grain yield of desi chickpea (Cicer arietinum) genotypes. *Indian J. Agril. Sci*. **76**(6): 375-376.

Singh, S. K., Saxena, H. K. and Das, T. K. (1998). The effect of kind of micronutrients and their method of application on mungbean (*Vigna radiata* (L.) Wilczek) under zaid condition. *Ann. of Agric. Res.* **19**(4): 454-457.

Solaiman, A. R. M., Hossain, D. and Rabbani, M. G. (2007). Influence of *Rhizobium* inoculant and mineral nitrogen on some chickpea varieties. *Bangladesh J. Microbiol.* **24**(2): 146-150.

Sritharan, N., Rajavel, M. and Senthilkumar, R. (2015). Physiological approaches: Yield improvement in blackgram. *Legume Res.* **38**(1): 91-95.

Srivastava, G.P. and Srivastava, V.C. (1994). Effect of irrigation and foliar spray of nutrients on growth and seed yield of gram (*Cicer arietinum*). *Indian J. Agric. Sci*. **64**(4): 219-222.

Srivastava, S. P., Yadav, C. R., Rego, T. J., Johansen, C. and Saxena N. P. (1997). Diagnosis and alleviation of boron deficiency causing flower and pod abortion in chickpea (*Cicer arietinum* L.) in Nepal. **In**: Boron in soils and plants. Developments in Plant and Soil Sciences 76 (Bell R.W., Rerkasem B., eds). Kluwer Academic Publishers, Dordrecht, The Netherlands. pp. 95-99.

Surendar, K., Vincent, K., Vanagamudi, S. and Mallika, V. H. (2013). Plant growth regulators and nitrogen responses on improving nutrient content of Blackgram. *Plant Gene and Trait.* **4**(40): 12.

Tahir, M., Hyder, A., Tahir, S., Naeem, M. and Rehman, A. (2013). Production potential of mungbean (*Vigna radiata* L.) in response to sulphur and boron under agroecological conditions of Pakistan. *Intl. J. Mod. Agric.* 2(4): 166-172.

Tanwar, S. P. S., Rokadia, P. and Singh, A. K. (2014). Seed priming and foliar urea application for enhancing productivity of chickpea (*Cicer arietinum* L.) under rainfed conditions. *Natl. Acad. Sci. Lett.* **37**(5): 407-411. https://doi.org/10.1007/s40009-014-0257-0.

Tatar, O., Ozalkan, C. and Atasoy, G.D. (2013). Partitioning of dry matter, proline accumulation, chlorophyll content and antioxidant activity of chickpea

(*Cicer arietinum* l.) plants under chilling stress. *Bulgarian J. of Agric. Sci.* **19**(2): 260-265.

Tekale, R. P., Guhey, A. and Agrawal, K. (2009). Foliar application of boron, zinc and IAA on growth and yield of pigeonpea. *Agric. Sci. Digest*. **29** (4): 246-249.

Thakur, V., Patil, R. P., Patil, J.R., Suma, T. C. and Umesh, M. R. (2017a). Physiological approaches for yield improvement of blackgram under rainfed condition. *Int. J. Curr. Microbiol. App. Sci.* **6**(11): 4114-4122.

Thakur, V., Patil, R. P., Patil, J. R., Suma, T. C. and Umesh, M. R. (2017b). Influence of foliar nutrition on growth and yield of blackgram under rainfed condition. *J. Pharmacog. Phytochem*. **6**(6): 33-37.

Thalooth, A. T., Tawfik, M. M and Magda Mohamed, H. (2006). A comparative study on the effect of foliar application of zinc, potassium and magnesium on growth, yield and some chemical constituents of mungbean plants grown under water stress conditions. *World J. Agric. Sci.* **2** (1): 37-46.

Thandapani, V. (1985). Leaf growth attributes as comparative physiological factors for the genotypes of greengram in relation to yield. *Madras Agric. J.* **72**: 126-132.

Thimmegowda, S. (1983). Nitrogen nutrition to greengram (*Phaseolus aureus* L.). *Acta Agron.* **32**: 139-142.

Tickoo, J. L., Naresh, C., Gangaiah, B. and Dikshit, H. K. (2006). Performance of mungbean (*Vigna radiata*) varieties at different row spacings and nitrogenphosphorus fertilizer levels. *Indian J. Agric. Sci*. **76**(9): 564-565.

Uddin, M. S. (2010). Performance of chickpea as affected by different by different levels of nitrogen and phosphorus with *rizobium* inocula. MS Thesis in Agronomy, July-Dec/2010, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207.

Ullah, A., Bakht, J., Shafi, M., Shah, W. A. and Islam, Z. U. (2002). Effect of various irrigation levels on different chickpea varieties. *Asian J. Plant Sci.* **1**(4): 355-357.

Uma M. M. and Karthik, A. (2017). Effect of foliar nutrition on growth, yield attributes and seed yield of pulse crops. *Adv. Crop Sci. Tech.* **5**: 278. doi:10.4172/2329-8863.1000278.

Vadavia, A. T., Kalaria, K. K., Patel, J. C. and Baldha, N. M. (1991). Influence of organic, inorganic and biofertilizers on growth, yield and nodulation of chickpea. *Indian J. Agron*. **36**(2): 263-264.

Valenciano, J. B., Boto, J. A. and Marcelo, V. (2011). Chickpea (*Cicer arietinum L.*) response to zinc, boron and molybdenum application under field conditions, New Zealand. *J. Crop Hortic. Sci.* **39**(4): 217-229.

Valenciano, J. B., Boto, J. A. and Marcelo, V. (2010). Response of chickpea (*Cicer arietinum* L.) yield to zinc, boron and molybdenum application under pot conditions. *Spanish J. Agril. Res.* **8**(3): 797-807.

Venkatesh, M. S. and Basu, P. S. (2012). Effect of foliar application of urea on growth, yield and quality of chickpea under rainfed condition. *J. Food Legumes Res.* **24**(2): 110-112.

Verma, C. B., Yadav, R. S., Singh, I. J. and Singh, A. K. (2009). Physiological trials and productivity of rainfed chickpea in relation to urea spray and genotypes. Legume Res. **32**(1): 103-107.

Verma, C. K., Yadav, R.B., Dhyani, B. P. and Tomar, S.S. (2011). Effect of seed rates and foliar spray of urea on performance of blackgram (*Vigna mungo*) varieties. *Indian J. Agric. Sci.* **81**(9): 881-882.

Vikman, P. and Vessey, J.K. (1992). The decline in N_2 fixation rate in common bean with the outset of pod filling: Fact or antifact. *Plant soil Sci.* **147**(1): 95- 105.

Wallace, T. C., Murray, R., Kathleen, M. and Zelman, K. (2016). The nutritional value and health benefits of chickpeas and humus. *Nutrients*. **8**(12): 766.

Wankhade, S. G., Dakhore, R. C., Wanjari, S. S., Patil, D. B., Potdukhe, N. R. and Ingle, R.W. (1996). Response of crops to micronutrients. *Indian J. Agric.Res.* **30**: 164-168.

Wasaya, A., Muhammad, S. S., Hussain, M. and Ahmad, I. (2017). Foliar application of zinc and boron improved the productivity and net returns of maize grown under rainfed conditions of pothwar plateau. *J. Soil Sci. Plant Nutr.* **17:** 105-112.

Witte, C. P., Tiller, S. A., Taylor, M. A. and Davies H. V. (2002). Urease activity profile and patterns of recovery and distribution of 15 N after foliar urea applications in wild-tipy and ureaseantisense transgenics of potato. *Plant Physiol*. **128**: 1129-1136.

Yadav, L. R. and Choudhary, G. L. and Kumar, P. R. (2011). Effect of fertility levels and foliar nutrition on profitability, nutrient content and uptake of chickpea (*Cicer arietinum* L.), *Legume Res.* **35**(3): 258-260.

Yakubu, H., Kawari, J. D. and Tekwa, J. A. (2010). Nodulation and fixation by grain legumes as affected by boron fertilizer in Sudano-Sahelian zone of north-eastern Nigeria. *Eurasian J. Agric. Environ. Sci.* **8**: 514-519.

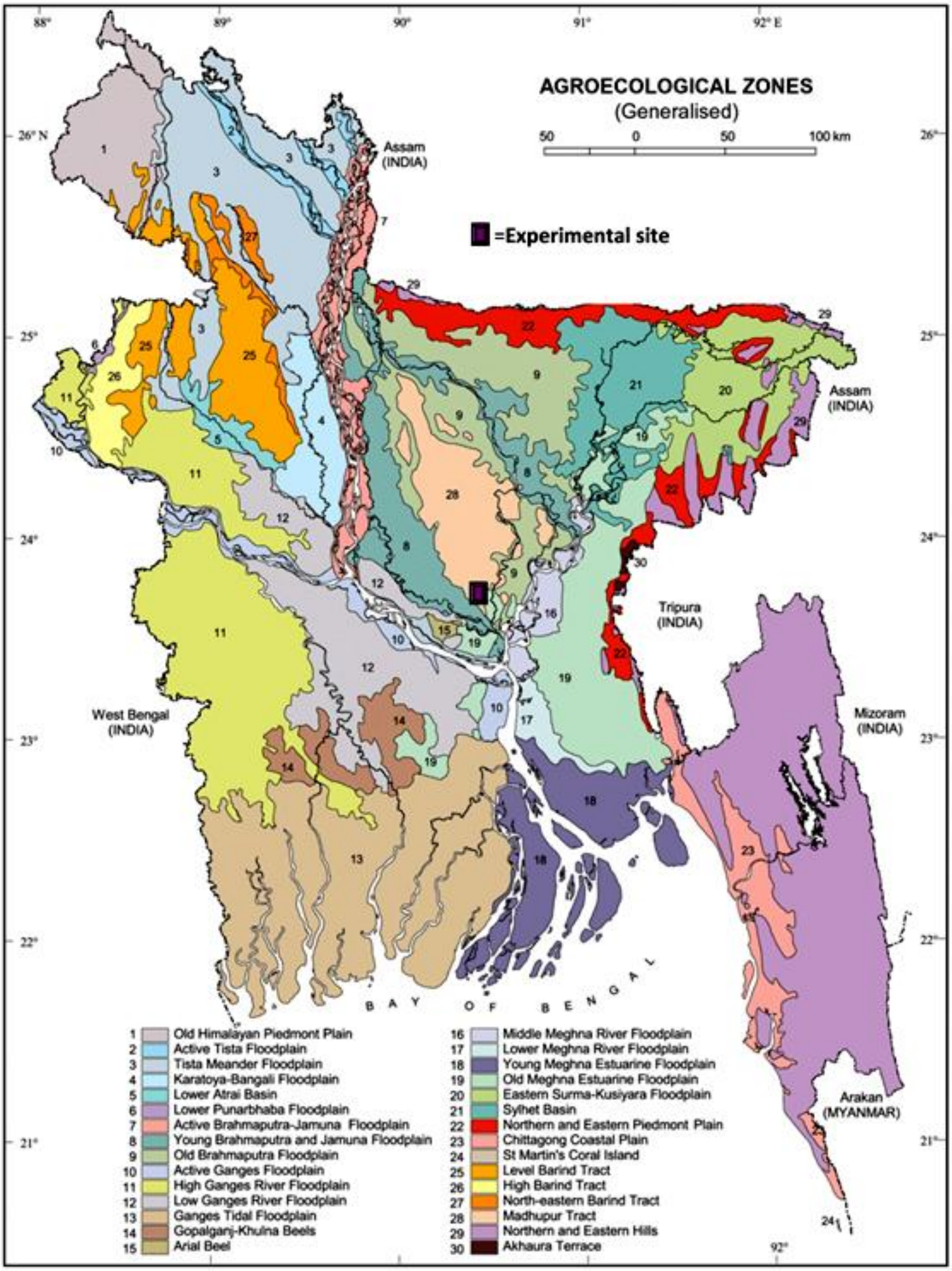
Yasari E. and Patwardhan, A. M. (2006). Physiological analysis of the growth and development of canola (*Brassica napus* L.) under different chemical fertilizer application. *Asian J. Plant. Sci*. **5**(5): 745-752.

Zajac, T., Grzesiak, S., Kulig, B. and Polacek, M. (2005). The estimation of productivity and yield of linseed (*Linum usitatissimum* L.) using the growth analysis. *Acta Physiol. Plant*. **27**(4A): 549-55.

Zeidan, M. S. (2003). Effect of sowing dates and urea foliar application on growth and seed yield of determinate faba bean (*Vicea faba* L.) under Egyptian conditions. *Egyptian J. Agron*. **24**: 93-102.

APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, 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 N (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

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

Appendix III. Analysis of variance of the data on plant height of chickpea as influenced by combined effect of variety and supplementary foliar spray

Source of variation	df	Mean square of plant height (cm) at different days after sowing (DAS)				
		30	60	90	120	At harvest
Replication	2	4.194	10.890	17.436	13.480	3.568
Variety (A)	1	293.344*	82.734*	49.975*	382.204^{NS}	426.764^{NS}
Error	2	1.491	2.709	1.324	38.302	67.244
Supplementary foliar spray (B)	4	4.516*	8.988^{NS}	18.698*	64.660*	39.971*
Variety(A) X Supplementary foliar spray (B)	4	1.110*	0.465*	6.993*	25.647*	9.229*
Error	16	1.577	5.626	9.122	20.977	13.469

*Significant at 5% level of significance

^{NS} Non significant

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

Source of variation	df	Mean square of branches plant^{-1} (no.) at different days after sowing (DAS)				
		30	60	90	120	At harvest
Replication	2	0.057	1.134	3.399	4.517	13.810
Variety (A)	1	0.768^{NS}	74.324*	44.896*	130.625*	98.500*
Error	2	0.196	0.078	0.002	3.397	0.931
Supplementary foliar spray (B)	4	0.170*	7.718*	203.676*	53.209*	19.240*
Variety(A) X Supplementary foliar spray (B)	4	0.298*	3.621*	6.033*	31.069*	8.706*
Error	16	0.065	0.546	2.183	1.776	4.023

*Significant at 5% level of significance

^{NS} Non significant

Appendix V. Analysis of variance of the data on above ground dry weight plant^{-1} of chickpea as influenced by combined effect of variety and supplementary foliar spray

Source of variation	df	Mean square of above ground dry weight plant^{-1}(g) at different days after sowing (DAS)				
		30	60	90	120	At harvest
Replication	2	0	0.015	0.295	0.247	1.024
Variety (A)	1	0.057*	9.487*	2.488*	14.049^{NS}	26.021*
Error	2	0.001	0.008	0.024	1.482	0.522
Supplementary foliar spray (B)	4	0.006*	0.292*	2.227*	11.720*	21.238*
Variety(A) X Supplementary foliar spray (B)	4	0.004*	0.060*	0.069*	0.996*	1.671*
Error	16	0.001	0.048	0.349	0.414	0.720

*Significant at 5% level of significance

^{NS} Non significant

Appendix VI. Analysis of variance of the data on nodules plant^{-1} of chickpea as influenced by combined effect of variety and supplementary foliar spray

Source of variation	df	Mean square of nodules plant^{-1} (no.) at different days after sowing (DAS)		
		60	75	90
Replication	2	0.450	1.893	0.842
Variety (A)	1	14.770*	53.333*	4.189^{NS}
Error	2	0.693	0.724	1.053
Supplementary foliar spray (B)	4	93.002*	133.148*	94.226*
Variety(A) X Supplementary foliar spray (B)	4	3.640*	2.879*	9.971*
Error	16	0.779	0.860	0.815

*Significant at 5% level of significance

^{NS} Non significant

Appendix VII. Analysis of variance of the data on nodules dry weight plant^{-1} of chickpea as influenced by combined effect of variety and supplementary foliar spray

Source of variation	df	Mean square of nodules dry weight plant^{-1} (g) at different days after sowing (DAS)		
		60	75	90
Replication	2	0.002	0.005	0.001
Variety (A)	1	0.086*	0.195*	0.062*
Error	2	0.002	0.004	0.000
Supplementary foliar spray (B)	4	0.084*	0.097*	0.055*
Variety(A) X Supplementary foliar spray (B)	4	0.010*	0.008*	0.006*
Error	16	0.001	0.001	0.000

*Significant at 5% level of significance

NS Non significant

Appendix VIII. Analysis of variance of the data on leaf area index of chickpea as influenced by combined effect of variety and supplementary foliar spray

Source of variation	df	Mean square of leaf area index at different days after sowing (DAS)		
		60	90	120
Replication	2	0	0	0
Variety (A)	1	0.322*	0.645*	1.336*
Error	2	0	0	0
Supplementary foliar spray (B)	4	0.055*	0.147*	0.019*
Variety(A) X Supplementary foliar spray (B)	4	0.009*	0.019*	0.012*
Error	16	0.001	0	0

*Significant at 5% level of significance

NS Non significant

Appendix IX. Analysis of variance of the data on crop growth rate of chickpea as influenced by combined effect of variety and supplementary foliar spray

Source of variation	df	Mean square value of crop growth rate ($g\ m^{-2}\ d^{-1}$)			
		30-60 DAS	60-90 DAS	90-120 DAS	120 DAS-Harvest
Replication	2	0.011	0.188	0.249	0.000
Variety (A)	1	5.590*	1.573*	3.247 ^{NS}	1.285*
Error	2	0.005	0.000	0.329	0.007
Supplementary foliar spray (B)	4	0.157*	0.913*	3.259*	1.665*
Variety(A) X Supplementary foliar spray (B)	4	0.051*	0.037*	0.564*	0.383*
Error	16	0.033	0.097	0.143	0.001

*Significant at 5% level of significance

^{NS} Non significant

Appendix X. Analysis of variance of the data on relative growth rate of chickpea as influenced by combined effect of variety and supplementary foliar spray

Source of variation	df	Mean square value of relative growth rate ($g\ g^{-1}d^{-1}$)			
		30-60 DAS	60-90 DAS	90-120 DAS	120DAS-Harvest
Replication	2	0.000	0.000	0.000	0.000
Variety (A)	1	0.001^{NS}	0.002*	0.000^{NS}	0.001*
Error	2	0.000	0.000	0.000	0.000
Supplementary foliar spray (B)	4	0.000^{NS}	0.000^{NS}	0.000^{NS}	0.001*
Variety(A) X Supplementary foliar spray (B)	4	0.000*	0.000*	0.000^{NS}	0.000*
Error	16	0.000	0.000	0.000	0.000

*Significant at 5% level of significance

^{NS} Non significant

Appendix XI. Analysis of variance of the data on yield contributing characters of chickpea as influenced by combined effect of variety and supplementary foliar spray

Source of variation	df	Mean square value of		
		Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000 seed weight (g)
Replication	2	14.025	0.010	959.177
Variety (A)	1	18.770^{NS}	1.723*	176690.786*
Error	2	3.238	0.003	293.473
Supplementary foliar spray (B)	4	21.659*	0.139*	1196.562*
Variety(A) X Supplementary foliar spray (B)	4	0.469*	0.014*	93.839*
Error	16	1.735	0.004	480.262

*Significant at 5% level of significance

^{NS} Non significant

Appendix XII. Analysis of variance of the data on yield contributing characters of chickpea as influenced by combined effect of variety and supplementary foliar spray

Source of variation	df	Mean square value of			
		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.026	0.052	0.142	3.269
Variety (A)	1	0.190^{NS}	3.021*	4.728*	132.804*
Error	2	0.017	0.025	0.075	2.142
Supplementary foliar spray (B)	4	0.225*	0.281*	0.944*	30.629*
Variety(A) X Supplementary foliar spray (B)	4	0.005*	0.488*	0.401*	89.130*
Error	16	0.013	0.031	0.049	6.328

*Significant at 5% level of significance

^{NS} Non significant

LIST OF PLATES

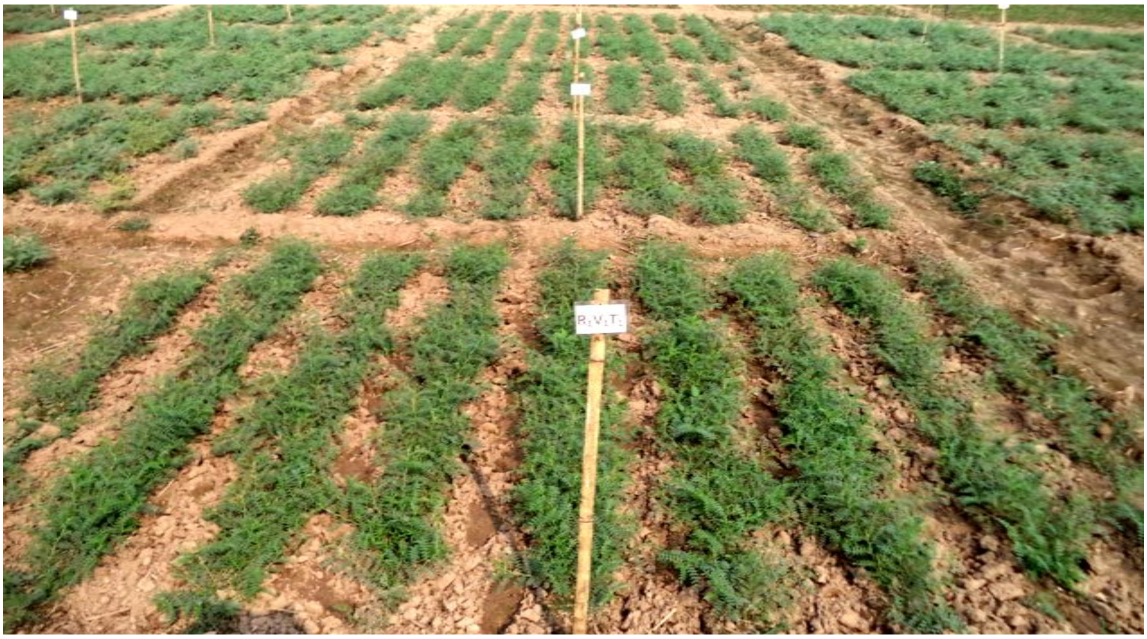


Plate 1. Photograph showing general view of experimental plot

$R_1V_1T_1$ (control) $R_2V_1T_3$

$R_1V_2T_3$

Plate 2. Comparable performance of chickpea variety under supplementary foliar management over control