IMPACT OF BIOFERTILIZER, NITROGEN AND PHOSPHORUS ON NODULATION, GROWTH AND YIELD OF CHICKPEA

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CERTIFICATE

*This is to certify that the thesis entitled **"IMPACT OF NITROGEN, PHOSPHORUS AND BIOFERTILIZER ON NODULATION GROWTH AND YIELD OF CHICKPEA"** 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 (M.S.)** in **AGRONOMY,** embodies the results of a piece of bona fide research work carried out by **DIPTI RANI ROY,** Registration. No. **11-04509** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated:
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IMPACT OF BIOFERTILIZER, NITROGEN AND PHOSPHORUS ON NODULATION, GROWTH AND YIELD OF CHICKPEA

ABSTRACT

An experiment was conducted during the period of November 2016 to April 2017 at Agronomy farm of Sher-e-Bangla Agricultural University Dhaka-1207, Bangladesh to evaluate the impact of nitrogen, phosphorus and biofertilizer on nodulation, growth and yield of chickpea. Treatment consisted of two levels of biofertilizer i.e. B0=without biofertilizer, B1= biofertilizer (80 g/1.2 kg seed); and six levels of fertilizer i.e. F0= all fertilizer (MoP=18 g/plot, Boric acid=5.4 g/plot) except N & P, F1=50% less N & P (urea=11.25 g/plot, TSP= 20.25g/plot, MoP==18 g/plot and boric acid=5.4g/plot), F2= 25% less N & P (urea=16.87 g/plot, TSP=30.37 g/plot, MoP=18 g/plot and boric acid=5.4 g/plot), F3= recommended dose of N & P with others (urea=22.5 g/plot, TSP=40.5 g/plot, MoP=18 g/plot and boric acid=5.4 g/plot), F4=25% higher N & P (urea=28.12 g/plot, TSP=50.62 g/plot, MoP=18 g/plot and boric acid=5.4 g/plot), F5= 50% higher N & P (urea=33.75 g/plot, TSP=60.75 g/plot, MoP=18 g/plot and 5.4 g/plot). The experiment was laid out in a spilt plot design with three replications. Result revealed that the highest values of vegetative growth i.e. plant height, number of branches plant^{-1}, plant dry weight, nodule number, nodule dry weight, and yield and yield contributing character i.e. number of seeds pod^{-1} (1.35), 1000 seeds weight (438.73 g), seed yield (2078.61 kg ha^{-1}), stover yield 2228.00 kg ha^{-1}) and harvest index (33.82%) were highest in B1 (biofertilizer) and F4 (1.75, 432.93g, 2055.00 kg ha^{-1}, 2251.33 kg ha^{-1} and 32.86 %, respectively) fertilizer. This combination also showed the best result for all vegetative and reproductive growth and development. Therefore, B1 (biofertilizer), F4 (25% higher than recommended N &P) and the combine effect B1F4 could be used to cultivate chickpea.

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AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAS	Days after sowing
^0C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
mg	Milligram
MoP	Muriate of Potash
N	Nitrogen
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate

CHAPTER I

INTRODUCTION

Chickpea *(Cicer arietinum* L.) is one of the suitable plants grown broadly in most of the arid regions and dry farming areas in developing countries. Chickpea is the third most widely grown grain legume in the world after bean and soybean (Soltani *et al*., 2006). It occupies an important role in human nutrition due to its high protein content (19-21%) and because of being a good source of carbohydrates, minerals and trace elements. It is used as feed for livestock and has a significant role in farming systems (Singh, 1997). The average yield of chickpea in our country is 7000 metric ton (BBS, 2013) which is much lower than world average production is 12.1 million tonnes. There are so many reasons of lower yield. Among them fertilization is one of them. A lot of nutrient is limited in our field and phosphorus (p) is the second limiting plant nutrient after nitrogen (Rudresh *et al*., 2005). Bio-fertilizers are living microorganisms, which when applied through seed or soil treatment, promote growth by increasing the supply or availability of nutrients to the host plant (Stephens and Rask, 2000; Moin Uddin *et al*., 2014). In plants, they also increase the content of growth hormones such as IAA and GA, leading to enhancement in the growth of plants (Asad *et al.*, 2004). These bio-fertilizers have the ability of N fixing, phosphate solubilizing and plant growth promoting microorganisms (Mahdi *et al*., 2010). Rhizobium bacteria (BNF) through biological N fixation, meet about 80-90% of total N requirements of legumes (Verma, 1993). They are known to increase P uptake and overall P-use efficiency resulting in better growth and higher yield of crop plants. Soils usually contain a high amount of total P, but its availability to plant is very low.

A low level of soil phosphorus is a great obstruction to the growth and development of leguminous crops (Walley *et al*., 2005). In leguminous crops, phosphorus promotes root nodulation, nitrogen fixation, nutrient-use efficiency, efficient partitioning of photosynthates between source and sink, and biomass production (Gitari and Mureithi, 2003; Ogola *et al*., 2012). However, phosphatic fertilizers are not only costly but also their supply is lower than their demand. Hence, it is highly desirable to explore the possibilities of improving phosphatic fertilizers use efficiency. In order to reduce the use of chemical fertilizers, biofertilizers could play a crucial role by fixing the atmospheric nitrogen for the crops and/or by increasing the availability of phosphorus and other nutrients to the crops (Selvakumar, *et al*. 2012). The bacteria (biofertilizers) that live within the root zone promote plant growth and nutrient uptake by releasing auxins and gibberellins. Additionally, they increase indole acetic acid and gibberellic acid contents in plants (Selvakumar *et al*., 2009), which are the potential growth hormones in plants. Pulse crops have unique properties of nodulation through Rhizobium bacteria (biological nitrogen fertilizer (BNF)). These bacteria, through biological nitrogen fixation, meet about 80%–90% of the total N requirements of legumes (Verma, 1993). Likewise, phosphate-solubilizing bacteria (biological phosphate fertilizer (BPF)) have the capability to solubilize the residual or fixed soil P, increase the availability of P in the soil (Singh *et al*., 2008), produce growth-promoting substances (Selvakumar *et al*., 2009), and thereby increase the overall P-use efficiency of the crops. Thus, application of biofertilizers to leguminous crops may help in sustainable crop production. Due to this, the need for research on this topic, the present experiment was carried out on chickpea. The experiment was conducted with the aim of improving the performance of chickpea in terms of nutrient uptake, yield, and quality of chickpea in a cost effective manner, employing graded levels of inorganic P fertilizer along with N and P biofertilizers. The combined inoculation of Rhizobium and phosphate solubilizing bacteria has been reported to increase the nodulation, growth and yield parameters in chickpea. (Rudresh *et al*., 2005). The experiment aimed at exploring the effect of P and N with bio-fertilizer on growth, yield attributes and yield of chickpea.

Objectives:

1. To study the effect of N and P with bio-fertilizer on the growth and yield of chickpea,
2. To observe the impact of different levels of N and P on chickpea, and
3. To observe the combined effect of bio-fertilizer, N and P in increasing the growth and yield of chickpea.

CHAPTER II

REVIEW OF LITERATURE

A field experiment was conducted at the Sher-e-Bangla Agricultural University farm to study the impact of nitrogen, phosphorus and bio-fertilizer on nodulation, growth and yield of chickpea. Some related research findings of different researchers of home and abroad have been discussed here.

3.1 Effect of nitrogen

Dar *et al*. (2016) reported that, nitrogen (N) fixing capacity of legumes varies greatly among species and due to soil conditions. Poor soil conditions may cause yield reduction of chickpea as a result of limited biological N fixation. A field experiment was conducted to evaluate impact of starter N levels on growth and yield of chickpea. Study was planned with four levels of starter N (0, 15, 30 and 45 kg N ha^{-1}) with three replications at Research Area, Agronomy Department, Rice Research Institute, Dokri during 2014-15 and 2015-16. The variety DG-92 was used in the experiment. Results show that plant height, number of pods per plant, seed index and seed yield were significantly improved with the various levels of starter N. The results of correlation coefficient in 2014-2015 and 2015-2016 years were positive and significant correlations of seed yield with majority traits.

Rani and Krishna (2016) conducted an experiment during rabi season of 2010-12 to study the response of chickpea varieties to nutrients levels on a calcareous vertisols. The experiment comprised of four varieties i.e., NBeG-3, NBeG-28, JG-11 and KAK-2 and with four nitrogen levels i.e., 0, 20, 30 and 40 kg/ha laid out in factorial randomized block design with three replications. They reported that among the varieties significantly higher dry matter production at harvest was recorded with JG-11 while it was lowest with KAK-2. More number of pods per plant and seed yield were recorded with JG-11 followed by NBeG-3 and NBeG-28, while lowest with KAK-2. Interaction effect among the different varieties and nitrogen levels was non-significant with yield attributes. Significantly higher seed yield was recorded with JG-11 @ 40 kg of N/ha but was at par with N @ 20 and 30 kg /ha, followed by NBeG-3 and NBeG-28.

Dhima *et al*. (2015) reported that, a 2-year field study was conducted in northern Greece to investigate the effect of nitrogen fertilization and irrigation on productivity of three Greek chickpea varieties ("Amorgos" "Serifos", "Andros"). Chickpea, grown under irrigation regime (30 + 30 mm of water) and fertilized with 50 $kg{\cdot}N{\cdot}ha^{-1}$ before planting and with 40 $kg{\cdot}N{\cdot}ha^{-1}$ at blossom growth stage, produced more total dry biomass and seed yield as compared with that grown under non-irrigated conditions and fertilized with 50 $kg{\cdot}N{\cdot}ha^{-1}$ before planting only. In particular, irrigation and nitrogen fertilization at blossom growth stage increased total dry weight of chickpea by 18.3% and 18.5%, respectively, as compared with that of non-irrigated and fertilized with N before planting. The corresponding increase of seed yield was 30.5% and 20%, respectively. The total dry biomass of "Amorgos" was 10% and 13% greater than that of "Serifos" and "Andros", while its respective seed yield increase was 5% and 16%. Finally, the quantum yield of photosystem II of chickpea was not affected by irrigation or fertilization. These results indicated that nitrogen fertilization at blossom growth stage combined with irrigation increased seed yield of all chickpea varieties, whereas the same treatments did not have any effect on plant quantum yield of photosystem II.

Tripathi *et al*. (2013) conducted an experiment and stated that, the balanced fertilizer use is the key to get maximum crop yield. The aim of the study was to find out proper nutrient management in chickpea using the different sources of nutrients. A field experiment was carried out 2012-13. The experiment was laid out in Randomized Block Design (4x4 factorial) with 16 treatments in thrice replications on different levels of nitrogen and phosphorus. The treatments included 4 levels of nitrogen (0, 9, 18 and 27 kg ha^{-1}) and 4 levels of phosphorus (0, 30, 60 and 90 kg ha^{-1}). The results revealed that the higher plant height (76.23 cm), number of branches plant^{-1} (15.67), number of nodules plant^{-1} (19.68), total number of pod plant^{-1} (79.67), grain yield (25 q ha^{-1}), test weight (284.66g) were recorded in treatment T 15-N 3 P 3-(N @ 27 kg ha^{-1} + P @ 90 kg ha^{-1}) and lowest value was found in treatment T 0 (control). This increase in yield occurred due to an increase in growth and development of chickpea crop with nitrogen and phosphorus application.

Kamithi (2013) found that, chickpea (*Cicer arietinum* L.), an annual grain legume is a hardy crop well adapted to semi arid areas. Information on optimum fertilizer rates and plant population density has not been developed for the semi arid areas of Kenya. This study conducted in Feb-June 2005 (1st season) and June-October 2005 (2nd season) at National Animal Husbandry Research Centre

(NAHRC), Naivasha, determined the effect of applying four different nitrogen fertilizer rates (0, 20, 40 and 60 kg/ha) and four plant population densities (74,074; 89889; 111,111 and 148,148) on growth and yield of chickpea. The general objective was to evaluate the performance of desi chickpea in the drylands of Kenya under varying levels of nitrogen (N)and plant population's (PPD). The experiment was laid out in a Randomized Complete Block Design (RCBD). Data was subjected to analysis of variance using MSTATC computer package and means separated by Duncan Multiple Range Test and Least Significant Difference. Results indicated that increase of nitrogen from 0 to 60 kg/ha significantly increased secondary leaves/m2, dry matter production at all stages of growth. Interactive effects of nitrogen and PPD had highest dry matter at highest N and PPD levels during crop growth and at final harvest. Application of 40kg N/ha produced highest number of pods/m2 (ranging between 1020-1549 pods/m2) and grain yields (1658.7 to 2574.4 kg/ha). Lowest grain yield (1099.6 kg/ha) was realized where no nitrogen was applied. Nitrogen and PPD interaction effects on grain yield were significantly higher under the highest PPD (148,148 plants/ha) and 20, 40 and 60 kg N/ha. It's advisable therefore, to apply 30kgN/ha during sowing and plant at a high plant population density of 148,148 plants/ha to realize over 3.3 tones/ha of grain yield per season. The same treatments gave net benefit ranging from Ksh 93,000.00 to 139,000.00/ha depending on rainfall and crop management

Namvar *et al*. (2011) reported that, to study the effects of organic and inorganic nitrogen (N) on yield and nodulation of chickpea (*Cicer arietinum* L.) cv. ILC

482, a spilt-plot experiment based on randomized complete block design with four replications was conducted in 2008 at the experimental farm of the Agriculture Faculty, University of Mohaghegh, Ardabili. Experimental factors were inorganic N fertilizer at four levels (0, 50, 75, and 100 kg ha^{-1}) in the main plots that applied in the urea form, and two levels of inoculation with *Rhizobium* bacteria (with and without inoculation) as subplots. Nitrogen application and *Rh.* inoculation continued to have positive effects on yield and its attributes. The greatest plant height, number of primary and secondary branches, number of pods per plant, number of filled and unfilled pods per plant, number of grains per plant, grain yield, and biological yield were obtained from the greatest level of N fertilizer (100 kg urea ha^{-1}) and *Rh*. inoculation. Application of 75 and 100 kg ha^{-1} urea showed no significant difference in these traits. Furthermore, the greatest rate of N usage (100 kg urea ha^{-1}) adversely inhibited nodulation of chickpea. Number and dry weight of nodules per plant decreased significantly with increasing N application rate. The lowest values of these traits recorded in application of 100 kg ha^{-1}urea. Results indicated that application of suitable amounts of N fertilizer (i.e., between 50 and 75 kg urea ha^{-1}) as starter can be beneficial to improve nodulation, growth, and final yield of inoculated chickpea plants.

Namvar *et al*. (2011) stated that, growth analysis is still the most simple and precise method to evaluate the contribution of different ecological processes in plant development. In order to study the effects of organic and inorganic nitrogen on growth indices and yield components of chickpea (*Cicer arietinum* L.)

cv. ILC 482, a spilt plot experiment based on randomized complete block design with four replications was conducted at the Experimental Farm of the Agriculture Faculty, University of Mohaghegh Ardabili, Ardebil, Iran. Experimental factors were comprised of inorganic nitrogen fertilizer at four levels (0, 50, 75 and 100 kg ha^{-1}) in the main plots applied in the urea form, and two levels of inoculation with Rhizobium bacteria (with and without inoculation) as sub plots. Application of N and Rhizobium inoculation continued to have positive effect on growth indices and yield components of chickpea. Lower levels of nitrogen application and non-inoculated plants showed less growth indices including total dry matter (TDM), leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) while the highest values of these indices were observed at the high levels of nitrogen application and inoculated plants. The highest plant height, number of primary and secondary branches, number of pods per plant and number of grains per plant were obtained from the highest level of nitrogen fertilizer (100 kg urea ha^{-1}) and Rhizobium inoculation. Application of 75 and 100 kg urea ha^{-1}showed no significant difference in these traits. Moreover, the highest grain yield was recorded in the inoculated plants that were treated with 75 kg urea ha^{-1}. The results indicated that the application of suitable amounts of nitrogen fertilizer (i. e. between 50 and 75 kg urea ha^{-1}) as a starter can be beneficial in improving growth, development and total yield of inoculated chickpea.

Ali *et al*. (2010) stated that, performance of six brown chickpea (*Cicer arietinum* L.) genotypes viz. 90261, 93127, 97086, 98004, 98154 and Bittal-98 was tested under four NP levels (0-0, 12-30, 24-60, 30-90 kg/ha) at Agronomic Research Institute, AARI, Faisalabad, Pakistan during 2006-07 and 2007-08. Fertilizer levels had a significant but differential effect on seed yield of chickpea genotypes. Fertilizer @ 24-60 kg NP per hectare gave better results during both the years. There was a linear increase in yield of all genotypes from 0-0 to 24-60 kg NP level. The differences among varietal means were non-significant during first year but significant during second year. However, on the basis of average of two years, genotype 98004 expressed comparatively more plant height (90.23 cm) and pods per plant (77.58), whereas, chickpea genotype 97086 produced higher biological (7658 kg/ha) and economic yields (2222 kg/ha). Genotype 93127 excelled in 1000-grain weight (285.54 g).

Farzaneh *et al.* (2009) reported that, there is increasing evidence for the promoting effects of arbuscular mycorrhiza fungi (AMF) on the growth of practically important crops. The present study evaluates the effects of inoculating AMF on growth of chickpea and barley based on a series of pot experiments during 2 years. A range of soil biological and chemical conditions was used to test the AMF treatment in interaction with indigenous microbes (sterilized vs. non-sterilized soil), application of additional fertilizer N or co-inoculation of chickpea with nitrogen-fixing rhizobia. The effect of treatments on colonization by AMF, rhizobial nodule number and weight, plant dry matter and soil mineral N were determined in randomized complete block designs with five replications using a chernozem topsoil of silty loam in a 1:1 mixture with sand as basic substrate. Inoculated plants were effectively colonized by AMF and attained more dry matter than control plants in both sterilized and non-sterilized soil, but colonization levels varied substantially between years. Both, chickpea and barley showed similar growth enhancement, though the AMF colonization level was lower with barley than with chickpea. The non-sterilized soil contained no natural rhizobia strains suitable for chickpea infection, but with rhizobia inoculation nodules developed. However, no growth effect was obtained. The level of soil mineral N did not affect AMF performance. Presumably nitrogen was no growth limiting factor in our experiments. Our study confirms the growth enhancing potential of AMF inoculation on both chickpea and barley.

David and Khan (2001) stated that, a greenhouse experiment was conducted to study the effect of nitrogen application on the growth and nodulation in chickpea (*Cicer arietinum* L.). Inoculated chickpea variety Punjab-91 was applied with different doses of nitrogen i. e. 0 (control), 50, 100 and 150 kg N/ ha in the form of urea. Data regarding the plant height, oven dry root and shoot weights, and number of nodules per plants were recorded every 15 days after the germination (DAG) of seeds up to a period of 60 days. Results showed a marked increase in plant height and oven dry root and shoot weights of chickpea plants due to nitrogen application. Addition of nitrogen at 100 kg/ ha caused maximum increase followed by 150 and 50 kg N/ ha, respectively. However, this marked increase in plant growth was only evident at the early growth stage i. e. up to 45 DAG, and at the later growth stages, the differences became less evident. A marked decline in nodulation in chickpea was observed at all the levels of nitrogen application.

ElHadi and Elsheikh (1999) reported that, a field experiment was carried out for two consecutive seasons 1994/95 and 1995/96 at ElRwakeeb (a sandy clay loam) to study the effect of Rhizobium sp. (Cicer) inoculation and N fertilization on six chickpea cultivars (Baladi, Gabel marra, NEC 25–27, NEC 2010, ILC 1919, and Flip 85–108). Plants were either inoculated with three *Rhizobium* sp. (Cicer) strains (TAL 480, TAL 620 and TAL 1148) separately, or N fertilized (50 kg N ha^{-1}). The results of the two seasons indicated the absence of infective strains for chickpea in the soil. Rhizobium inoculation or N fertilization significantly increased the total nodule number per plant, 100 seed weight, yield and protein content of seeds. The results indicated that the three *Rhizobium* strains are infective and effective in nitrogen fixation. Inoculation with Rhizobium strain TAL 1148 resulted in a significant increment in most of the parameters studied, compared to other strains and untreated control. Cultivar ILC 1919 was the best yielding cultivar, whereas, cultivar NEC 2010 contained the highest protein content, however cultivar Gabel marra showed the highest amount of protein due to inoculation or N fertilization, in the two seasons. Inoculation with Rhizobium strain TAL 1148 increased yield by 72 and 70%, whereas, 50 kg N ha^{-1} increased it by 70 and 69% in the first and second seasons, respectively. The amounts of protein accumulated (kg ha^{-1}) due to N or Rhizobium inoculation were determined for all cultivars. The results obtained from the inoculation were comparable to those of 50 kg N ha^{-1}.

Laurie and Stewart (1993) conducted an experiment and reported that, chickpeas were grown with or without nitrate nitrogen feeding, or nodulated with *Rhizobium leguminosarum.* High [40°C day, 25°C night (HT)] and moderate [25°C day, 177°C night (LT)] temperature regimes were employed during growth. Growth rates, photosynthetic capacity and enzymes of carbon and nitrogen metabolism were monitored to assess the acclimatory capacity of the chickpea. Initial growth rates were stimulated by high temperatures, particularly in nitrate-fed and nodulated plants. Older HT plants had fewer laterals, smaller leaves, and fewer flowers were produced than in LT plants. There was some indication of an acclimation of photosynthesis to high temperatures and this was independent of nitrogen supply. Rubisco activity was increased by high growth temperatures. However, HT plants also had higher transpiration rates and lower water use efficiency than LT plants both in respective growth conditions and when compared in a common condition. High temperatures reduced shoot nitrate reductase activity but had little effect on root activity, which was the same if not greater than activity in LT roots. The amino acid, asparagine, was found at high concentrations in all treatments. Concentrations were maintained throughout growth in HT plants but declined with age in LT plants.

Jessop *et al*. (1984) stated that, a controlled environment experiment was used to examine the growth and nodulation response of chickpea to a range of soil nitrate (NO_3^-) levels (0, 0.75, 1.5, 3.0, 6.0 mM). Dry matter production, nodule mass and number, dinitrogen (N_2) fixation via the acetylene (C_2H_2) reduction method, total nitrogen content and NO$N_3^ - $ concentration were measured at 56 and 90 days from inoculated and uninoculated plants. It was found that chickpeas were less sensitive to the inhibitory effects of NO^{-}_{3} than soybeans. High NO^{-}_{3} appeared to inhibit the production of nodules early in growth, however, by the second harvest nodulation was stimulated by high NO^{-}_{3} levels. Increasing NO^{-}_{3} levels gave positive responses in tops and roots dry weight production but, proportionally, these effects were greatest with uninoculated plants. 3 and 6 mM NO^{-}_{3} gave similar root and tops dry weight in inoculated plants after 90 days. Nodule dry weight production per pot was maximised at 3.0 mM NO^{-}_{3} at both plant harvests. Whilst NO^{-}_{3} at 6 mM still gave a strong stimulation of acetylene reduction compared to 0 and 0.75 mM NO^{-}_{3}, there appeared to be a trend suggesting an inhibitory effect of 6 mM NO^{-}_{3} on C_2H_2 reduction compared to 1.5 and 3.0mM NO^{-}_{3}.

3.2 Effect of phosphorous

Kumar *et al*. (2017) was conducted a field experiment during the Rabi season of 2013-14 at the Crop Research Farm, Department of Agronomy, Allahabad School of Agriculture, SHIATS, Allahabad, Uttar Pradesh to find out the effect of different levels of phosphorus, sulphur and cultivars on growth and economics of chickpea (Cicer arietinum L). The experiment was laid out in randomized block design with three replications. The treatments consisted of three phosphorus levels (40, 60 and 80 kg/ha), 3 levels of sulphur (15, 20 and 25 kg/ha) and two cultivars (Pusa-362 and Radhey) with plot size of 3 x 3 m (9 m2). The results revealed that treatment comprising Pusa-362 + P2O5 60 kg/ha + sulphur 25 kg/ha recorded highest plant height (48.60 cm), number of branches per plant

(7.66), number of nodules per plant (58.23), dry weight (7.93 g), harvest index (38.15), gross return (Rs 107790), net return (Rs 84342.72) and B-C ratio (4.59).

Eltayeb (2016) reported that, a field experiment was conducted at the Experimental Farm of the Faculty of Agriculture, University of Khartoum, Shambat, during 2014/2015 season. The objective was to study the effect of phosphorus fertilizer and plant spacing on growth and yield of two chickpea (*Cicerarietinum* L.) cultivars under irrigation. Borgug and GYT10cultivars were sown at three spacings: 10, 20 and 30 cm, and subjected to four levels of fertilization: 0, 50, 100 and 200 kg P2O5/ha. The experiment was laid out in randomized complete block design with three replications. Data were collected on plant height, number of branches per plant, number of nodules per plant, shoot and root dry weight, days to 50% flowering, days to maturity, number of pods per plant, percentage of empty pods, number of seeds per pod, seed yield per plant, 100-seed weight, seed yield per unit area, harvest index and seed phosphorus content. The results showed that the two cultivars were significantly different in most of the characters. Borgug had more than double the yield of GYT 10. Phosphorus had a significant effect on the number of nodules per plant, time to maturity, shoot dry weight and seed phosphorus content. Seed yield was increased by phosphorus fertilizer, but the increase was not significant. Spacing between plants did not affect the studied parameters except plant density. Interactions between treatments were significant for all vegetative growth and yield attributes.

Biçer (2014) stated that, this study was conducted to investigate the effect of different phosphorus doses (0, 15, 30, 40 and 70 kg ha^{-1}) on chickpea (*Cicer arietinum* L.) cultivars at Diyarbakir, Southeast Anatolia of Turkey over two years at late spring. The effect of phosphorus on plant height and number of branches $plant^{-1}$ was non-significant. Number of branches $plant^{-1}$ was different response to phosphorus doses, although statistically was not significant. Number of pods and seeds $plant^{-1}$ were affected by phosphorus treatment. Although 100 seed weight was not affected by phosphorus applications, cultivar x doses interaction was important. Phosphorus doses were significant for yield but yield apparently did not increase. Start dose, 15 kg phosphorus ha^{-1}, was initially increased the yield, and 30 kg phosphorus ha^{-1} application slightly was increased. The highest number of pods and seeds at 30 and 70 kg P ha^{-1}, compared only one of these control and 15 kg P ha^{-1}. Grain yield was increased to 16 and 12% with the application of 30 and 40 kg P ha^{-1}, respectively, when compared with control dose. Chickpea cultivars showed low response to P application. Phosphorus fertilization could not be effective due to late sown. Early sown and irrigation supply can be advisable for more effectiveness phosphorus intake in this region.

Pingoliya *et al*. (2014) reported that, the effect of phosphorus (P) and iron (Fe) on growth and yield attributes of chickpea (*Cicer arietinum* L.) was studied during rabi season of 2010-2011 with four levels of P (control, 20, 40 and 60 kg P2O5 ha^{-1}) and Fe (control, 2.5, 5 and 7.5 kg Fe ha^{-1}). Increasing P and Fe levels, increased the plant height, branch plant-1, pods $plant^{-1}$, seed pod-1 and test weight; in 40 kg P2O5 ha^{-1} with 5 kg Fe ha^{-1} plot, significantly improved yield attributes compared to rest of the treatments. The effect of application of iron 5 and 7.5 kg Fe ha^{-1} was found at par on growth and, yield and yield attributes. Application of P and Fe fertilizer improved soil fertility status and crop yield, it can be a sustainable tool to enhanced chickpea production.

Dotaniya *et al*. (2014) stated that, India is a highly populated country under the category of developing nations. The protein requirement of most of the people is fulfilling through pulses. Production of pulse crops and their yield stagnation last so many years. It has been estimated that India's population would reach 1.68 billion by 2030 from the present level of 1.21 billion. Accordingly, vision of Indian Institute of Pulse Research, 2030, the projected pulse requirement by the year 2030 would be 32 million tons with an anticipated required growth rate of 4.2%. Apart from this, Indian pulse remains competitive to protect the indigenous pulse production. Among the pulses, chickpea (*Cicer arietinum* L.) play a vital role in total pulse production. This review paper highlights the role of phosphorus (P) in chickpea production.

Hussena *et al*. (2013) reported that, a field experiment was carried out to study the effect of varying levels of phosphorus (T_1= 0kg/ha, T_2= 30kg/ha, T_3= 60kg /ha, T_4=90kg/ha and T_5 =120kg/ha) on growth performance and yield of chickpea (Cicer –arietinum) variety Aratiy at the experimental field of Wollo University, Kelemmeda, during winter season in 2013. The results revealed that phosphorus levels significantly affected plant height, number of branches per plant and number of pods per plant. The maximum plant height (39.25cm) was recorded from plots that received 60kg P_2O_5 ha^{-1}, while the minimum plant height

(32.5cm) was recorded from the control. Similarly, higher number of branches per plant was recorded from the same treatment. The maximum number of pods per plant (49) was observed from the application of 60kg P_2O_5 ha^{-1}. Generally, the results revealed that the application of 60kg P_2O_5 ha^{-1} gave better performance in all the parameters studied. However, this research was conducted using irrigation, in one location and one season. Thus, it should be replicated in multi locations and seasons so as to assure the results of the experiment.

Dutta and Bandyopadhyay (2009) reported that, the field experiments were conducted during the winter seasons of 2005–2006 and 2006–2007 at Sekhampur, West Bengal, India, to evaluate the performance of chickpea cultivar 'Mahamaya-2' with variable proportions of phosphorus (P) (0, 13.1, 26.2 and 39.3 kg/ha) and bio-fertilizers (no seed inoculation, inoculation with phosphobacterin [*Pseudomonas striata*] and co-inoculation of *Rhizobium* with phosphobacterin) in laterite soil (entisol) under rainfed conditions. P and bio-fertilizers application influenced significantly the growth attributes, nodulation, leghaemoglobin content, nitrogenase activity, yield components, seed and stover yields, harvest index and P uptake of chickpea, except test weight. The highest seed yield (1085 kg/ha) obtained with 39.3 kg P/ha, producing 40.7, 27.4 and 4.0% more yield, respectively, over control (no P input), 13.1 kg and 26.2 kg P/ha. The seed yield produced by 39.3 and 26.2 kg P/ha had no significant difference. Seed inoculation with *Rhizobium* and phosphobacterin was significantly superior over no inoculation or phosphobacterin inoculation alone. Combined application of P at 26.2 kg/ha and bio-fertilizers (*Rhizobium* and phosphobacterin) enhanced significantly all these characters compared to other levels of P with bio-fertilizer.

Basir *et al*. (2008) stated that, chickpea (*Cicer arietinum* L.) is one of the major legume crops grown in Pakistan having a considerable importance as a food, feed and fodder but due to imbalanced use of fertilizers its production is low. To find the optimum level of Phosphorus and FYM for chickpea and study their effect on agronomic characteristics an experiment was carried out at the Agricultural Research Farm of NWFP Agricultural University, Peshawar during winter season of 2002-03. The experiment was laid out in RCBD with split plot arrangement having four replications. Four Farm Yard Manure (FYM) levels (0, 5, 10, 15 t ha^{-1}) were applied to main plots and four phosphorus levels (0, 30, 60,kg P_2O_5 ha^{-1}) were evaluated in sub-plots of area 12 m^2. The experimental results showed that as compared to other P treatments 60 kg P2O5 ha^{-1}

significantly improved agronomic traits. Maximum plant height (94.7 cm), number of pods $plant^{-1}$ (81.9), thousand grain weight (241.5 g), number of nodules $plant^{-1}$ (87), above groud biomass yield (7793 kg ha^{-1}), straw yield (3475 kg ha^{-1}) and grain yield (1993 kg ha^{-1}) were recorded for 60 kg P2O5 ha^{-1}. Similarly, the results also showed that 15 t FYM ha^{-1} in comparison to other FYM treatments did not significantly increase all the parameters except number of pods $plant^{-1}$, biomass yield, and straw yield. Maximum number of pods plant-1 (76.3), biomass yield (7522 kg ha^{-1}), and straw yield (3180 kg ha^{-1}) were recorded for 15 t FYM ha^{-1}. The interaction of FYM and phosphorus was non-significant for all the parameters. These results suggested that the application of

FYM to chickpea did not affect its yield significantly while phosphorus fertilizer at the rate of 60 kg ha-1 proved effective for optimum production.

Shukla and Yadav (1982) stated that, a greenhouse study was conducted on the effect of P and Zn on nodulation and N fixation in chickpea (*Cicer arietinum* L.) in a loamy sand (Typic Torripsamments) using treatment combinations of five levels of P (0, 25, 50, 100 and 250 ppm), and six levels of Zn (0, 5, 10, 20, 40 and 100 ppm). The number, dry matter and leghaemoglobin content of nodules, and amount of N fixed generally increased with Zn alone upto 19 ppm and P alone upto 50 ppm, and decreased with their higher levels. Application of 25 to 50 ppm P and 5 to 10 ppm Zn counteracted to a greater extent the adverse effect of 40 and 100 ppm Zn, and 250 ppm P, resp. Maximum nodulation and N fixation (91 to 145% over zero P and Zn, at maturity) was recorded with 25 to 50 ppm P applied along with 5 to 10 ppm Zn. At 64 days, depletion in soil-N was noted, particularly when P was applied, whereas at maturity there was a gain in soil-N, ranging from 10.5 to 44.5 kg/2×10^6 kg soil depending upon P and Zn treatments. The increase in nodulation and N fixation with balanced P and Zn nutrition might be attributed to an increase in leghaemoglobin, and K and Fe concentration in nodules, and increased plant growth, resulting into enhanced activity of N fixing organisms. The results showed that balanced P and Zn nutrition is essential not only for plant growth but also for maximum activity of Rhizobium for N fixation.

3.3 Effect of bio-fertilizer

Bidyarani *et al*. (2016) reported that, the use of *Rhizobium* inoculants in chickpea is well established; however, meagre efforts have been directed towards the use of other microbial supplements for improving nutrient uptake and yields. A set of novel cyanobacterial and biofilmed inoculants were evaluated in chickpea under field conditions. A significant two-fold enhancement in leghaemoglobin content of nodules and plant biomass was recorded with Anabaena laxa treatment. The inoculants – Anabaena laxa and Anabaena – Rhizobium biofilmed formulation proved to be the top-ranking treatments. Soil chlorophyll, nitrogen-fixation and available N possessed high positive direct effects on grain yield through positive – correlations and – high direct effects and also had high positive indirect effects through other component traits. The cumulative effect of improved plant growth and nutrient uptake exhibited a positive correlation with microbiological activity, especially nitrogen fixation, soil chlorophyll and soil available nitrogen. This may account for the significantly higher yield parameters in the A. laxatreatment, which recorded 50% higher grain yield (1724 kg ha^{-1}) as compared to control (847 kg ha^{-1}).

Uddin *et al*. (2014) reported that, Leguminous crops suffer severely in soils poor in phosphorus. A 2-factor factorial experiment was conducted in a net-house to explore the effect of graded levels of P fertilizer (0, 30, and 60 kg P ha^{-1} or P_0, P_{30}, and P_{60}, respectively) together with rhizobium (biological nitrogen fertilizer (BNF)) and/or phosphate-solubilizing bacteria (biological phosphorus fertilizer (BPF)) in terms of nutrient uptake, yield, and quality of chickpea (*Cicer arietinum* L.). Phosphorus was applied as basal dose, while seeds were treated with respective biofertilizer(s) before sowing according to the treatments [BF_0 (control), BNF, BPF, and BNF+BPF]. Concerning the main effects, P_{60} proved superior or equivalent to P_{30}, while among the biofertilizer treatments, BNF+BPF gave the greatest values for nutrient uptake as well as for yield and quality parameters. The interaction between P levels and biofertilizer treatments was generally significant. 30 kg P ha^{-1} applied with N and P biofertilizers (P_{30} × BNF+BPF) was the most profitable interaction for N uptake as well as for yield and quality characteristics. Compared to P_{60} applied alone (P_{60} × BF_0), P_{30} × BNF+BPF resulted in greater N uptake (27.3%), seed yield (21.1%), and the content of seed protein (2.9%) and carbohydrate (5.6%). Furthermore, P_{30} × BNF+BPF was statistically equal to P_{60} × BNF+BPF with regard to N uptake, seed yield, and protein content as well as for most yield components. Thus, P_{30} × BNF+BPF saved 30 kg P ha^{-1} of the costly inorganic P fertilizer to achieve the greatest crop yield and quality.

Tagore *et al*. (2013) stated that, a field experiment was carried out during the rabi season of 2004-05 to find out the effect of Rhizobium and phosphate solubilizing bacterial (PSB) inoculants on symbiotic traits, nodule leghemoglobin, and yield of five elite genotypes of chickpea. Among the chickpea genotypes, IG-593 performed better in respect of symbiotic parameters including nodule number, nodule fresh weight, nodule dry weight, shoot dry weight, yield attributes and yield. Leghemoglobin content (2.55 mg g^{-1} of fresh nodule) was also higher under IG-593. Among microbial inoculants, the Rhizobium + PSB was found most effective in terms of nodule number (27.66 nodules $plant^{-1}$), nodule fresh weight (144.90 mg $plant^{-1}$), nodule dry weight (74.30 mg $plant^{-1}$), shoot dry weight (11.76 g $plant^{-1}$), and leghemoglobin content (2.29 mg g^{-1} of fresh nodule) and also showed its positive effect in enhancing all the yield attributing parameters, grain and straw yields.

Rabieyan *et al*. (2011) stated that, to evaluate the effects of nitrogenous and phosphorous biofertilizers on yield and yield components of chickpea under different irrigation levels a research was conducted in a split- split plot experiment with three replications based on complelely randomized block design at Research Field of Islamic Azad University Tabriz Branch in the spring of 2009. Irrigation levels (normal and deficit irrigation) were considered as a main factor and cultivars (ILC482 and Pirouz) and also fertilizers levels (control, nitragin, biosuper and nitragin + biosuper) as sub and sub-sub factors respectively. The results showed that application of biofertilizers moderated water deficit stress, but its effect was lower as compared to complete irrigation. The effect of nitragen+biosuper application was higher than their separate applications. Cultivars ILC482 and Pirouz produced 73/33 gr/m2 and 47/98 gr/m2 respectively.

Shukla *et al*. (2010) stated that, a field experiment was carried to study the performance of chickpea (*Cicer arietinum* L.) as influenced by FYM, Biofertilizers castor cake and levels of nitrogen and phosphorus during 2008-09. Chickpea plants exhibited significant responses to various bio-organics with respect to growth, yield and yield attributes. Application of FYM + castor cake and FYM + Rhizobium + Azotobacter + PSB gave the maximum values. Application of 100% RDF gave significantly the highest values for all the growth and yield attributes. Treatment combination B_3F_3 was at par with B_4F_3 produced significantly higher number of pods plant^{-1}. Significantly maximum grain yield was recorded under B_4F_3 which failed to statistically superior over B_4F_1, B_4F_2, B_4F_0 and B_3F_3.

Mohammadi *et al*. (2010) reported that, in order to evaluation the effects of soil organic matter and biofertilizer on chickpea quality and biological nitrogen fixation, field experiments were carried out in 2007 and 2008 growing seasons. In this research the effects of different strategies for soil fertilization were investigated on grain yield and yield component, minerals, organic compounds and cooking time of chickpea. Experimental units were arranged in split-split plots based on randomized complete blocks with three replications. Main plots consisted of (G_1): establishing a mixed vegetation of Vicia panunica and Hordeum vulgare and (G_2): control, as green manure levels. Also, five strategies for obtaining the base fertilizer requirement including (N1): 20 t. ha^{-1} farmyard manure; (N_2): 10 t. ha^{-1} compost; (N_3): 75 kg. ha^{-1} triple super phosphate; (N4): 10 t. ha^{-1} farmyard manure + 5 t. ha^{-1} compost and (N5): 10 t. ha^{-1} farmyard manure + 5 t. ha^{-1} compost + 50 kg. ha^{-1} triple super phosphate was considered in sub plots. Furthermore, four levels of biofertilizers consisted of (B_1): Bacillus lentus + Pseudomonas putida; (B_2): Trichoderma harzianum; (B_3): Bacillus lentus + Pseudomonas putida + Trichoderma harzianum; and (B_4): control (without biofertilizers) were arranged in sub-sub plots. Results showed that integrating biofertilizers (B_3) and green manure (G_1) produced the highest grain yield. The highest amounts of yield were obtained in $G_1 \times N_5$ interaction. Comparison of all 2-way and 3-way interactions showed that $G_1N_5B_3$ was determined as the superior treatment. Significant increasing of N, P_2O_5, K_2O, Fe and Mg content in leaves and grains emphasized on superiority of mentioned treatment because each one of these nutrients has an approved role in chlorophyll synthesis and photosynthesis abilities of the crops. The combined application of compost, farmyard manure and chemical phosphorus (N_5) in addition to having the highest yield, had the best grain quality due to high protein, starch and total sugar contents, low crude fiber and reduced cooking time

Singh and Mukherjee (2009) stated that, A field experiment was conducted for two consecutive years from 2003-04 during winter season at the Varanasi to find out an effective biofertilizer, fertility level and weed management practice on weed growth and yield of chickpea under late sown condition. Application of VAM exhibited significantly higher weed dry matter accumulation than the application of other bio-fertilizer sources. However, maximum seed and straw yields were recorded with the combined application of Rhizobium and VAM which was on par with inoculation of Rhizobium but significantly higher than the VAM alone in both the years. Application of 75% recommended NPK dose recorded the lowest weed dry weight than rest of the fertilizer levels. The highest chickpea seed I6. and 17.2 q/ha) and straw yields (36.2 and 37.3 q/ha) was noted under 125% recommended NPK dose. Pre-emergence application of pendimethalin 0.5 kg/ha coupled with one hoeing at 40 days after sowing significantly reduced the weed dry weight which resulted in 16.5 per cent and 15.3 per cent in 2002-03 and 2003-04, respectively higher seed yield over unweeded check condition.

So, this research review's purpose will help readers to understand the influence of biofertilizer, N & P on growth and yield of chickpea. These above reviews indicated that, worlds are working to improve the growth and yield of chickpea by different treatments procedure specially, biofertilizer, N & P. A lot of research related to the present study have been conducted worldwide, but in Bangladesh there have scanty of research. So, it is important to study the impact of nitrogen, phosphorus and bio-fertilizer on nodulation, growth and yield of chickpea in Bangladesh. Thus, this present study was conducted.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November 2016 to April 2017. Detailed of the experimental materials and methods followed in the study are presented in this chapter. The experiment was conducted to study impact of nitrogen, phosphorus and bio-fertilizer on nodulation, growth and yield of chickpea.

3.1 Site description

3.1.1 Geographical location

The experimental area was situated at 23 77 N latitude and 90 33 E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004).

3.1.2 Agro-ecological region

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

3.1.3 Climate

The area has sub-tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity and rainfall prevailed at the experimental site during the study period were presented in Appendix I.

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish-brown mottles. Soil pH ranged from 5.6-6.5 and had organic matter 0.84-1.00%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resources and Developmental Institute (SRDI), Dhaka. The physical and chemical properties of the soil were presented in Appendix II.

3.2 Details of the experiment

3.2.1 Treatments

The experiment consisted of 2 factors:

Factors A: Levels of biofertilizer

There were two levels of bio-fertilizer.

(a) B_0 = without biofertilizer

(b) B_1 = biofertilizer (80 g/plot)

Factors B: Levels of nitrogen and phosphorous

There were six levels of nitrogen and phosphorous.

(a) F_0 = all fertilizer except N & P (MoP=18 g/plot, Boric acid=5.4 g/plot)

(b) F_1 = 50% less N & P (urea=11.25 g/plot, TSP= 20.25g/plot, MoP==18 g/plot and boric acid=5.4g/plot)

(c) F_2= 25% less N & P (urea=16.87 g/plot, TSP=30.37 g/plot, MoP=18 g/plot and boric acid=5.4 g/plot)

(d) F_3= recommended dose of N & P with others (urea=22.5 g/plot, TSP=40.5 g/plot, MoP=18 g/plot and boric acid=5.4 g/plot)

(e) F_4= 25% higher N & P (urea=28.12 g/plot, TSP=50.62 g/plot, MoP=18 g/plot and boric acid=5.4 g/plot)

(f) F_5= 50% higher N & P (urea=33.75 g/plot, TSP=60.75 g/plot, MoP=18 g/plot and 5.4 g/plot)

Treatment combinations

B_0F_0, B_0F_1, B_0F_2, B_0F_3, B_0F_4, B_0F_5, B_1F_0, B_1F_1, B_1F_2, B_1F_3, B_1F_4, B_1F_5

3.2.2 Experimental design and layout

The experiment was laid out in a spilt plot design with three replications. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of unit plot was 2.25 m × 2.0 m. The distances between plot to plot and replication to replication were 0.75 m and 1.0 m, respectively.

3.3 Crop/planting material

The cultivar BARI Chhola-9 were used as plant material.

3.3.1 Description of crop

BARI Chhola-9 was released by Bangladesh Agricultural Research Institute on 1996. Plant type is semi spreading. Flower colour is Pink and seed colour is Brown. This variety is BGM tolerant. Protein content (%) is about 19-21%. More suitable for late sowing. The 1000-seed weight around 155-165 g. Seed yield 1800-2000kg/ha. Duration 125-130 days.

3.3.2 Description of recommended chemical fertilizer

The recommended chemical fertilizer dose was 50, 100, 55 and 1 kg ha^{-1} of Urea, TSP, MOP and BA, respectively (Hussain *et al*., 2006). According to the treatments, all of the fertilizers were applied by broadcasting and was mixed with soil thoroughly at the time of final land preparation in each plot.

3.4 Crop management

3.4.1 Seed collection

Seeds were collected from Pulse Seed Section, BARI, Joydebpur, Gazipur, Bangladesh.

3.4.2 Seed sowing

The seeds of chickpea having more than 80% germination were sown by hand in 40-50 cm apart from lines with continuous spacing at about 3 cm depth on 29 November, 2016.

3.4.3 Collection and preparation of initial soil sample

The soil sample of the experimental field was collected before fertilizer application. The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were removed. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.4.4 Preparation of experimental land

A pre-sowing irrigation was given on 15 November, 2016. The land was open with the help of a tractor drawn disc harrow on 25 November, 2016, then ploughed with rotary plough twice followed by laddering to achieve a medium tilth required for the crop under consideration. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on November 29, 2016 according to experimental specification. Individual plots were cleaned and finally prepared the plot.

3.4.5 Fertilizer application

The specific plots area was fertilized according to the treatments variables.

3.4.6 Intercultural operations

3.4.6.1 Thinning

The plots were thinned out on 15 days after sowing to maintain a uniform plant stand.

3.4.6.2 Weeding

The crop was infested with some weeds during the early stage of crop establishment. Two hand weeding were done, first weeding was done at 15 days after sowing on 14 December 2016 followed by second weeding at 15 days after first weeding on 30 December 2016.

3.4.6.3 Application of irrigation water

Irrigation water was added to each plot, first irrigation was done as pre-sowing and other two were given 4 days before weeding. The 1st irrigation was done at 12 December 2016, 2nd irrigation was done 14 December 2016 and 3rd irrigation was done at 21 December 2016.

3.4.6.4 Drainage

There was a heavy rainfall during the experimental period. Drainage channel were properly prepared to easy and quick drained out of excess water.

3.4.6.5 Plant protection measures

The crop was infested by insects and diseases, those were effectively and timely controlled by applying recommended insecticides and fungicides. To control fusarium Autostine 1 time (13 December 2016) and Mstartop 1 time (25 December 2016) at the rate of 0.3%.

3.4.7 Harvesting and post-harvest operation

Maturity of crop was determined when 80-90% of the pods become blackish in color. The harvesting of chickpea was on 03 April, 2017. Five pre-selected plants per plot were harvested and yield attributing data were collected from that plants. An area of 1.0 m^2 from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. The grains were cleaned and sun dried to a moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields $plot^{-1}$ were determined and converted to kg ha^{-1}.

3.4.8 Recording of data

Emergence of plants were counted from starting to a constant number of plants m^{-2} area of each plot. Experimental data were determined from 30 days of growth duration and continued until harvest. Dry weights of plant were collected by harvesting respective number of plants at different specific dates from the inner rows leaving border rows and harvest area for grain. The following data were recorded during the experimentation.

A. Crop growth characters

i. Plant height (cm)

ii. Number of branches $plant^{-1}$

iii. Plant dry weight (g)

iv. Number of nodules $plant^{-1}$

v. Nodules dry weight $plant^{-1}$

B. Yield and other crop characters

i. Number of pods $plant^{-1}$

ii. Number of seeds pod^{-1}

iii. Weight of 1000 seeds (g)

iv. Pod yield (kg ha^{-1})

v. Seed yield (kg ha^{-1})

vi. Stover yield

vii. Harvest index (%)

3.4.9 Detailed procedures of recording data

A brief outline of the data recording procedure followed during the study given below:

A. Crop growth characters

3.4.9.1 Plant height

Plant height of 5 selected plants from each plot was measured at 30, 60, 90 days after sowing (DAS) and at harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf of main shoot.

B. Yield and other crop characters

3.4.9.2 Number of branches plant^{-1}

Branches number was counted from five pre-selected plants and the mean value was determined.

3.4.9.3 Dry weight of plant

The sub-samples of 5 plant plot^{-1} uprooted from second line and oven dried until a constant leveled, from which the weights of above ground dry matter were recorded at 30 days intervals and at harvest.

3.4.9.4 Number of nodules

The 5 plants plot^{-1} from second line was uprooted with the help of spade. The roots of the sample plants were washed gently and total number of nodules from five plants was counted at 55, 70 and 85 DAS and then mean value determined**.**

3.4.9.5 Nodules dry weight

Nodules taken from five plants were oven dried and then dry weight of nodules was measured in milligram at 55 DAS, 70 DAS and 85 DAS.

3.4.9.6 Number of pods plant^{-1}

Pods of five selected plants were counted and the average pods for each plant was determined.

3.4.9.7 Seeds pod^{-1}

Pods from each of five plants plot^{-1} were separated from which ten pods were selected randomly. The number of seeds pod^{-1} was counted and average number of seeds pod^{-1} was determined.

3.4.9.8 Weight of 1000-seeds

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 12% moisture and the mean weight were expressed in gram.

3.4.9.9 Seed yield

Grain yield was determined from the central 1.0 m^2 area of each plot and expressed as t ha^{-1} and adjusted with 12% moisture basis. Moisture content was measured by using a digital moisture tester.

3.4.9.10 Stover yield

Stover yield (without seeds) was determined from the selected plants that was used to take seeds yield.

3.4.9.11 Harvest index

Harvest index denotes the ratio of economic yield (seed yield) to biological yield and was calculated with following formula.

$$\text{Harvest index} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

3.4.12 Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using a statistical computer software statistix 10 (and the means were adjusted by Tukey's Test at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter represent the result and discussion for the impact of bio-fertilizer, nitrogen and phosphorus and on nodulation, growth and yield of chickpea.

4.1 Impact of bio-fertilizer, nitrogen and phosphorus

4.1.1 Plant height

4.1.1.1 Impact of biofertilizer

Plant height of chickpea significantly influenced by biofertilizer on plant height at all sampling dates (Figure 1, Appendix III). The figure shows that in respective of biofertilizer, plant height showed an increasing trend with the advances of growth stage up to 90 DAS, after that the height reduced slightly. The rate of increase much higher from 60 DAS to 90 DAS than earlier growth stages up to 60 DAS. However, the tallest plant height was found in B_1 (14.76 cm, 24.71 cm, 50.73 cm and 37.77 cm at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The shortest plant was recorded in B_0 (12.69 cm, 18.73 cm, 38.73 cm and 29.77 cm at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The present finding agreed with the finding of different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.1.2 Impact of nitrogen and phosphorous

Nitrogen and phosphorus showed positively significant impact on plant height of chickpea (Figure 1, Appendix III). It can be inferred from the figure that the plant height exerted a steady increasing trend with the increases of growth stages up to 90 DAS after that the height reduced marginally irrespective of fertilizer doses. However, the highest values obtained for plant height in F_4 that were 15.79 cm, 24.76 cm, 47.26 cm and 36.2 cm at 30 DAS, 60 DAS, 90 DAS and harvest times, respectively. The lowest values of plant height were in F_0 and that was 12.69 cm, 18.73 cm, 38.73 cm and 29.77 cm at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively. The present finding is agreed with the findings of different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al.*, 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008).

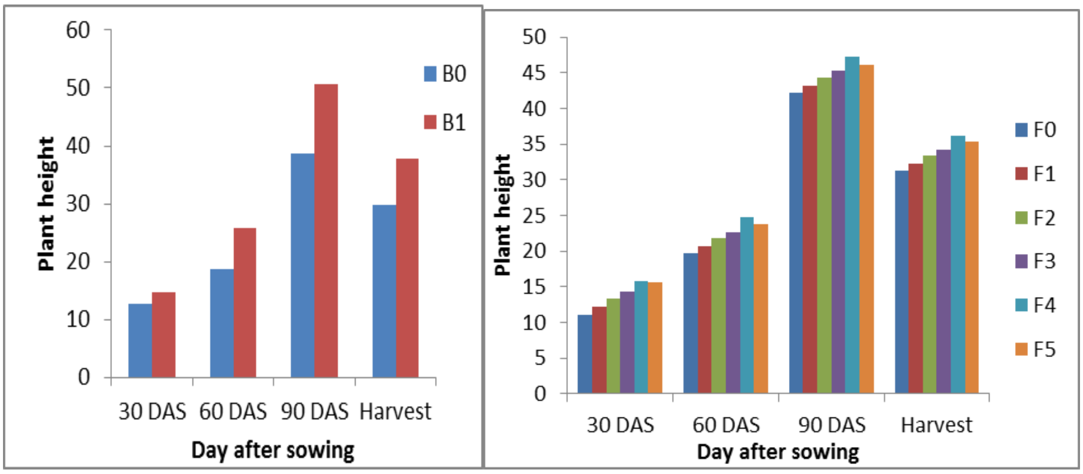

Figure 1. Impact of biofertilizer, nitrogen and phosphorous on plant height of chickpea (SE=0.043, 0.032, 0.042, 0.044 and 0.075, 0.056, 0.074, 0.076 of biofertilizer and fertilizer**)**

DAS= Days after sowing, B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.1.3 Combine effect of biofertilizer, nitrogen and phosphorous

The combine effect of biofertilizer, nitrogen and phosphorous showed variations on plant height of chickpea at all sampling dates (Table 1, Appendix III). The tallest plant was found in B_1F_4 and shortest plant in B_0F_0 combination at 30, 60, 90 DAS and at harvest, respectively.

Table 1. Combine effect of biofertilizer, nitrogen and phosphorous on plant height chickpea

Treatments	Plant height (cm) at			
	30 DAS	**60 DAS**	**90 DAS**	**Harvest**
B_0F_0	10.10 h	16.30 l	36.17 l	27.20 l
B_0F_1	11.23 g	17.17 k	37.22 k	28.29 k
B_0F_2	12.33 f	18.21 j	38.28 j	29.33 j
B_0F_3	13.23 e	19.25 i	39.34 i	30.23 i
B_0F_4	14.16 d	21.24 g	41.20 g	32.22 g
B_0F_5	15.09 c	20.22 h	40.15 h	31.31 h
B_1F_0	12.51 f	23.18 f	48.28 f	35.37 f
B_1F_1	13.17 e	24.22 e	49.18 e	36.22 e
B_1F_2	14.29 d	25.26 d	50.25 d	37.33 d
B_1F_3	15.33 c	26.16 c	51.16 c	38.20 c
B_1F_4	17.42 a	28.27 a	53.31 a	40.17 a
B_1F_5	16.18 b	27.18 b	52.18 b	39.32 b
SE (±)	**0.134**	**0.079**	**0.104**	**0.107**
CV (%)	**5.14**	**5.44**	**4.29**	**3.39**

DAS= Days after sowing, B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.2 Number of branches plant^{-1}

4.1.2.1 Impact of biofertilizer

The application of biofertilizer exerted significant impact on number of branches plant^{-1} of chickpea at all sampling dates except 30 DAS (Figure 2, Appendix IV). The branch number showed increasing trend up to 90 DAS and then decreased slightly. The maximum number of branches was recorded in B_1 (1.5, 5.84, 16.75 and 11.77 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively) and lowest in B_0 (1.17, 3.84, 7.76 and 5.78 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The present finding agreed with the finding of different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.2.2 Impact of nitrogen and phosphorous

Application of nitrogen and phosphorous had a positive effect on number of branches plant^{-1} (Figure 2, Appendix IV). The values showed positively significant impact throughout the growth stage except at 30 DAS. The treatment F_4 produced maximum number of branches plant^{-1} (2.5, 7.26, 15.77 and 11.31 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively) where F_0 produced lowest number of branches (1.0, 2.68, 10.75 and 7.27 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The similar finding is also reported by the different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al*., 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008) on number of branches plant^{-1}.

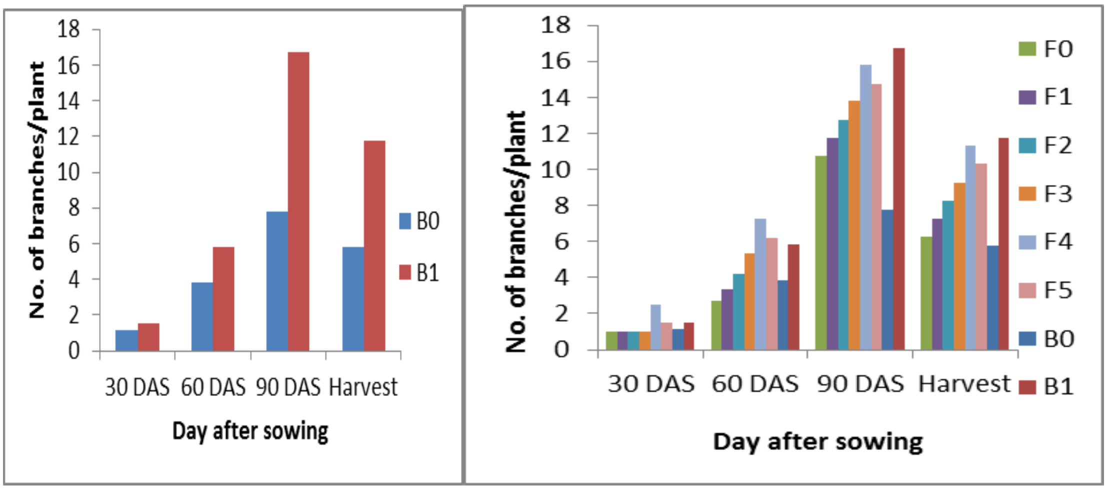

Figure 2. Impact of biofertilizer, nitrogen and phosphorous on number of branches plant^{-1} of chickpea (SE= 0.012**,** 0.051, 0.038, 0.034 and 0.031, 0.088, 0.066, 0.065 of biofertilizer and fertilizer)

DAS= Days after sowing, B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.2.3 Combine effect of biofertilizer, nitrogen and phosphorous

Number of branches plant^{-1} showed variations due to combine effect of biofertilizer, nitrogen and phosphorous at all sampling dates (Table 2, Appendix IV). The maximum number of branches plant^{-1} was recorded in B_1F_4 (3.00, 8.38, 19.21 and 14.32 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively) and lowest in B_0F_0 (1.00, 2.03, 7.25 and 3.32 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively).

Table 2. Combine effect of biofertilizer, nitrogen and phosphorous on number of branches

Treatments	Number of branches plant^{-1} at			
	30 DAS	**60 DAS**	**90 DAS**	**Harvest**
B_0F_0	1.00	2.03 g	7.25 l	3.32 l
B_0F_1	1.00	2.27 g	8.26 k	4.29 k
B_0F_2	1.00	3.12 f	9.20 j	5.32 j
B_0F_3	1.00	4.28 e	10.28 i	6.25 i
B_0F_4	2.00	6.13 c	12.32 f	8.26 f
B_0F_5	1.00	5.23 d	11.23 h	7.37 h
B_1F_0	1.00	3.32 f	14.26 f	9.35 f
B_1F_1	1.00	4.39 e	15.23 e	10.27 e
B_1F_2	1.00	5.35 d	16.32 d	11.19 d
B_1F_3	1.00	6.37 c	17.31 c	12.32 c
B_1F_4	3.00	8.38 a	19.21 a	14.32 a
B_1F_5	2.00	7.23 b	18.19 b	13.21 b
SE (±)	**NS**	**0.156**	**0.093**	**0.098**
CV (%)	**4.33**	**3.17**	**2.86**	**5.31**

DAS= Days after sowing, B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.3 Plant dry weight

4.1.3.1 Impact of bio-fertilizer

Plant dry weight of chickpea influenced significantly due to biofertilizer treatments at all sampling dates except 30 DAS (Figure 3, Appendix V). The highest plant dry weight was found in B_1 (1.55 g, 8.86 g, 22.87 g and 15.89 g at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The lowest plant dry weight was recorded in B_0 (1.12 g, 3.77 g, 16.84 g and 10.86 g at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The present finding agreed with the finding of different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.3.2 Impact of nitrogen and phosphorous

Nitrogen and phosphorus showed positively significant impact on plant dry weight of chickpea except 30 DAS (Figure 3, Appendix V). The highest plant dry weight was obtained in fertilizer application area. The highest value obtained for plant dry weight in F_4 are 1.65 g, 7.93 g, 22.36 g and 15.88 g at 30 DAS, 60 DAS, 90 DAS and harvest times, respectively. The lowest value of plant dry weight was in F_0 and that was 1.05 g, 2.67 g, 17.26 g and 10.90 g at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively. The similar finding is also reported by the different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al*., 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008) in terms of plant dry weight.

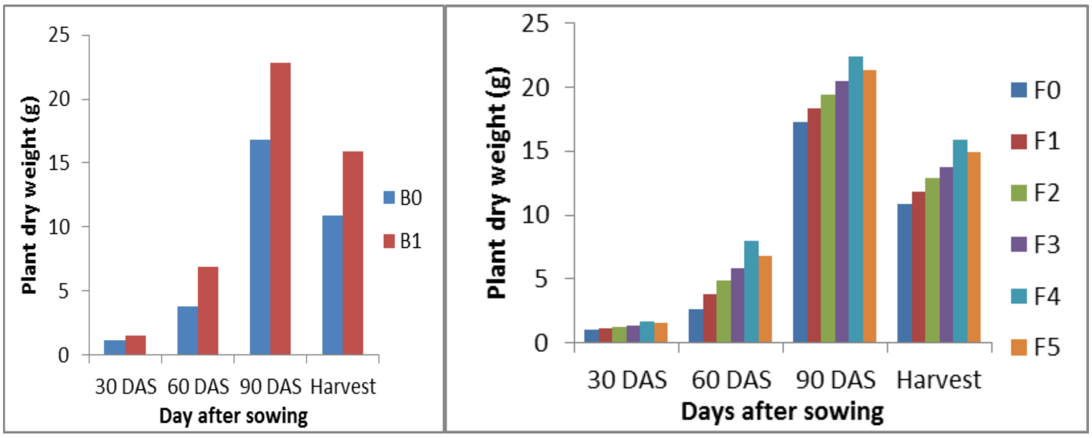

Figure 3. Impact of biofertilizer, nitrogen and phosphorous on plant dry weight of chickpea (SE= 0.051, 0.048, 0.036, 0.037 and 0.045, 0.083, 0.063, 0.037 of biofertilizer and fertilizer)

DAS= Days after sowing, B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.3.3 Combine effect of biofertilizer, nitrogen and phosphorous

For the combine effect of biofertilizer, nitrogen and phosphorous showed variations on plant dry weight (Table 3, Appendix V). For the combine effect the highest plant dry weight was found in B_1F_4 and lowest in B_0F_0 combination compared to other combinations.

Table 3. Combine effect of biofertilizer, nitrogen and phosphorous on plant dry weight of chickpea

Treatments	Plant dry weight (g) at			
	30 DAS	**60 DAS**	**90 DAS**	**Harvest**
B_0F_0	0.90	1.17 i	14.20 l	8.33 k
B_0F_1	1.00	2.23 h	15.28 k	9.40 j
B_0F_2	1.10	3.33 g	16.39 j	10.41 i
B_0F_3	1.20	4.37 f	17.50 i	11.24 h
B_0F_4	1.30.	6.30 d	19.37 g	13.38 f
B_0F_5	1.20	5.26 e	18.26 h	12.41 g
B_1F_0	1.20	4.17 f	20.31 f	13.47 f
B_1F_1	1.30	5.36 e	21.33 e	14.33 e
B_1F_2	1.40	6.33 d	22.47 d	15.38 d
B_1F_3	1.50	7.40 c	23.35 c	16.31 c
B_1F_4	2.00	9.56 a	25.34 a	18.38 a
B_1F_5	1.90	8.37 b	24.40 b	17.48 b
SE (±)	**NS**	**0.117**	**0.089**	**0.091**
CV (%)	**1.33**	**2.71**	**3.55**	**4.83**

DAS= Days after sowing, B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.4 Number of nodules plant^{-1}

4.1.4.1 Impact of biofertilizer

The application of biofertilizer showed significant impact on number of nodules plant^{-1} of chickpea at all sampling dates (Figure 4, Appendix VI). The nodules number showed increasing trend up to 55 DAS and then decreased gradually with the advances of growth period. The maximum number of nodules plant^{-1} was recorded in B_1 (19.87, 16.38 and 14.77 at 55 DAS, 70 DAS and 85 DAS, respectively) and lowest in B_0 (11.84, 9.83 and 6.71 at 55 DAS, 70 DAS and 85 DAS, respectively). The present finding agreed with the finding of different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.4.2 Impact of nitrogen and phosphorous

Application of nitrogen and phosphorous had a positive effect on number of nodules $plant^{-1}$ (Figure 4, Appendix VI). Figure indicated that the values of nodule numbers had a decreasing trend with the advances of plant ages. The treatment F4 produced maximum number of nodules $plant^{-1}$ (18.42, 15.96 and 13.32 at 55 DAS, 70 DAS and 85 DAS, respectively) where F_0 produced lowest number of nodules (13.27, 10.32 and 8.21 at 55 DAS, 70 DAS and 85 DAS, respectively). The similar finding is also reported by the different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al.*, 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008).

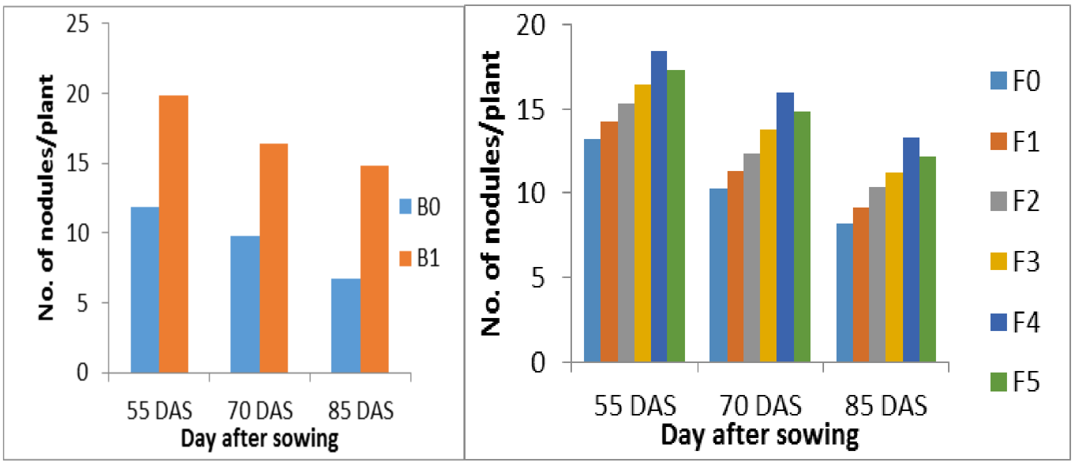

Figure 4. Impact of biofertilizer, nitrogen and phosphorous on nodules number plant^{-1} of chickpea (SE=0.050, 0.030, 0.035 and 0.086, 0.052, 0.060 of biofertilizer and fertilizer)

DAS= Days after sowing, B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.4.3 Combine effect of biofertilizer, nitrogen and phosphorous

Number of nodules plant^{-1} had a non-significant effect due to combine effect of biofertilizer, nitrogen and phosphorous at all sampling dates except at 70 DAS (Table 4, Appendix VI). Although having non-significant effect, the maximum number of nodules plant^{-1} was recorded in the combination of B_1F_4 (22.36, 19.59 and 16.24 at 55 DAS, 70 DAS and 85 DAS, respectively) and lowest in the combination of B_0F_0 (9.23, 7.30 and 4.15 at 55 DAS, 70 DAS and 85 DAS, respectively).

Table 4. Combine effect of biofertilizer, nitrogen and phosphorous on number nodules plant^{-1}

Treatments	Number of nodules plant^{-1} at		
	55 DAS	**70 DAS**	**85 DAS**
B_0F_0	9.23 l	7.30 l	4.15 l
B_0F_1	10.36 k	8.35 k	5.14 k
B_0F_2	11.27 j	9.38 j	6.37 j
B_0F_3	12.37 i	10.36 i	7.18 i
B_0F_4	14.46 g	12.32 g	9.27 g
B_0F_5	13.37 h	11.27 h	8.16 h
B_1F_0	17.30 f	13.34 f	12.27 f
B_1F_1	18.28 e	14.30 e	13.22 e
B_1F_2	19.40 d	15.39 d	14.32 d
B_1F_3	20.54 c	17.31 c	15.21 c
B_1F_4	22.36 a	19.59 a	17.36 a
B_1F_5	21.33 b	18.37 b	16.24 b
SE (±)	**0.122**	**0.074**	**0.086**
CV (%)	**2.95**	**1.69**	**3.98**

DAS= Days after sowing, B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.5 Nodules dry weight

4.1.5.1 Impact of bio-fertilizer

Nodules dry weight of chickpea was not significantly influenced by biofertilizer (Figure 5, Appendix VII). In spite of non-significant effect, the highest nodules dry weight was found in B_1 (0.045 g, 0.625 g and 0.073 g at 55 DAS, 70 DAS and 85 DAS, respectively). The lowest nodules dry weight was recorded in B_0 (0.112 g, 0.392 g and 0.048 g at 55 DAS, 70 DAS and 85 DAS, respectively). The present finding is not agreed with the finding of different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.5.2 Impact of nitrogen and phosphorous

Nitrogen and phosphorus didn't show positively significant impact on nodules dry weight of chickpea (Figure 5, Appendix VII). Although having non-significant impact, the highest nodules dry weight was obtained in fertilizer application area. The highest value obtained for nodules dry weight in F_4 is 0.15 g, 0.65 g and 0.075 g at 55 DAS, 70 DAS and 85 DAS, respectively. The lowest value of nodules dry weight was in F_0 and that was 0.115 g, 0.392 g and 0.048 g at 55 DAS, 70 DAS and 85 DAS, respectively. The finding was reported by the different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al*., 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008) is not supported the present finding.

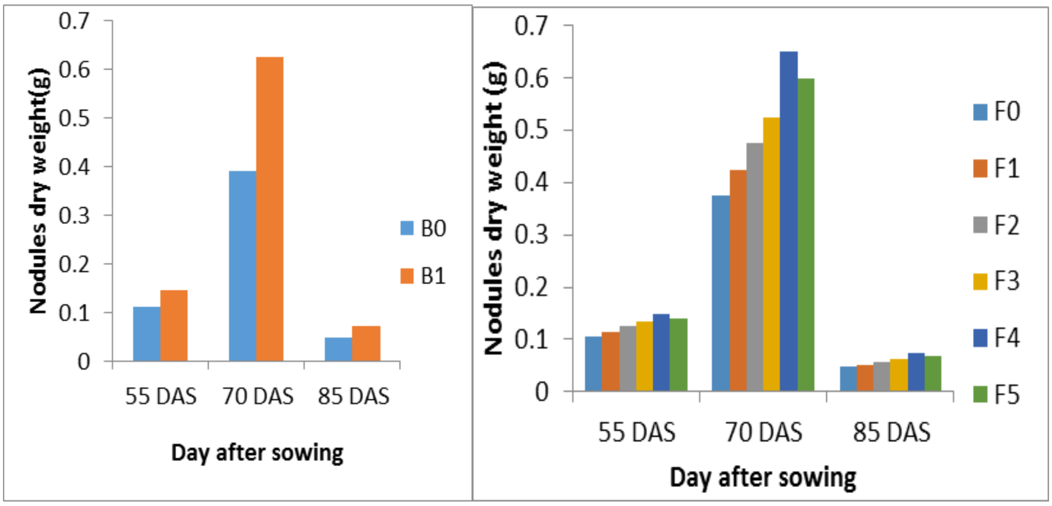

Figure 5. Impact of biofertilizer, nitrogen and phosphorous on nodules dry weight plant^{-1} of chickpea (SE=0.00 of biofertilizer and fertilizer)

DAS= Days after sowing, B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.5.3 Combine effect of biofertilizer, nitrogen and phosphorous

The combine effect of biofertilizer, nitrogen and phosphorous on nodules dry weight showed non-significant impact (Table 4, Appendix VII). Though having non-significant impact, the highest nodules dry weight was found in B_1F_4 and lowest in B_0F_0 combination.

Table 5. Combine effect of biofertilizer, nitrogen and phosphorous on dry weight plant^{-1} of chickpea

Treatments	**Nodules dry weight plant^{-1} (g) at**		
	55 DAS	**70 DAS**	**85 DAS**
B_0F_0	0.09	0.25	0.035
B_0F_1	0.10	0.30	0.040
B_0F_2	0.11	0.35	0.045
B_0F_3	0.12	0.40	0.050
B_0F_4	0.13	0.55	0.065
B_0F_5	0.12	0.50	0.055
B_1F_0	0.12	0.50	0.060
B_1F_1	0.13	0.55	0.065
B_1F_2	0.14	0.60	0.070
B_1F_3	0.15	0.65	0.075
B_1F_4	0.17	0.75	0.085
B_1F_5	0.16	0.70	0.080
SE (±)	-	-	-
CV (%)	**2.13**	**5.51**	**3.06**

DAS= Days after sowing, B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.6 Number of pods plant^{-1}

4.1.6.1 Impact of biofertilizer

The application of biofertilizer showed significant impact on number of pods plant^{-1} of chickpea (Figure 6, Appendix VIII). The maximum number of pods was recorded in B_1 (21.58) and lowest in B_0 (17.84) which was 20.96% higher in biofertilizer applied. The present finding corroborates with the finding of different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.6.2 Impact of nitrogen and phosphorous

Application of nitrogen and phosphorous had a significant effect on number of pods plant^{-1} of chickpea (Figure 6, Appendix VIII). The figure indicated that the values of number of pods plant^{-1} increased gradually with the applied higher doses of N and P fertilizers. The highest increment was observed with F4 treatment (22.31) and further increased dose was not able to increase further. The values pod number plant^{-1} range is 17.84 to 22.31. The treatment F_0 produced lowest number of pods (17.84). The similar finding is also reported by the different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al.*, 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008).

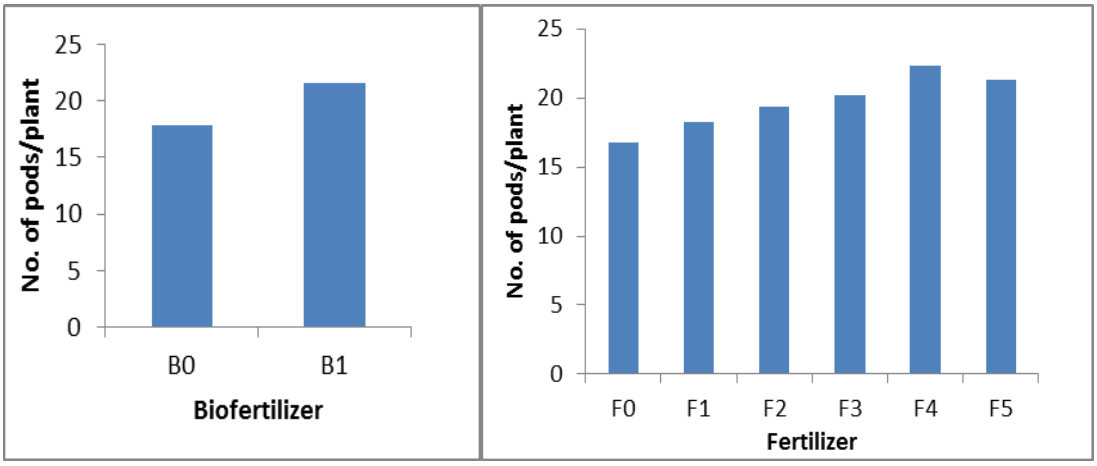

Figure 6. Impact of biofertilizer, nitrogen and phosphorous on number of pods plant^{-1} of chickpea (SE=0.046 and 0.080 of biofertilizer and fertilizer)

B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.6.3 Combine effect of biofertilizer, nitrogen and phosphorous

Number of pods plant^{-1} influenced significantly due to combine effect of biofertilizer, nitrogen and phosphorous of chickpea (Table 5, Appendix VIII). The maximum number of pods plant^{-1} was recorded in B_1F_4 (24.27) which was significantly higher than others combinations and lowest in B_0F_0 (15.32).

4.1.7 Number of seeds pod^{-1}

4.1.1.7 Impact of bio-fertilizer

Number of seeds pod^{-1} of chickpea didn't positively influenced by biofertilizer treatment (Figure 7, Appendix VIII). But numerically the highest number of seeds pod^{-1} was found in B_1 (1.35). The lowest number of seeds pod^{-1} was recorded in B_0 (1.18). The present finding is not agreed with the finding of different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.7.2 Impact of nitrogen and phosphorous

Nitrogen and phosphorus didn't show positively significant impact on number of seeds pod^{-1} of chickpea (Figure 7, Appendix VIII). The highest value obtained for number of seeds pod^{-1} in F_4 (1.74). The lowest value of number of seeds pod^{-1} was in F_0 and that was 1.0. The opposite finding is reported by the different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al.*, 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008).

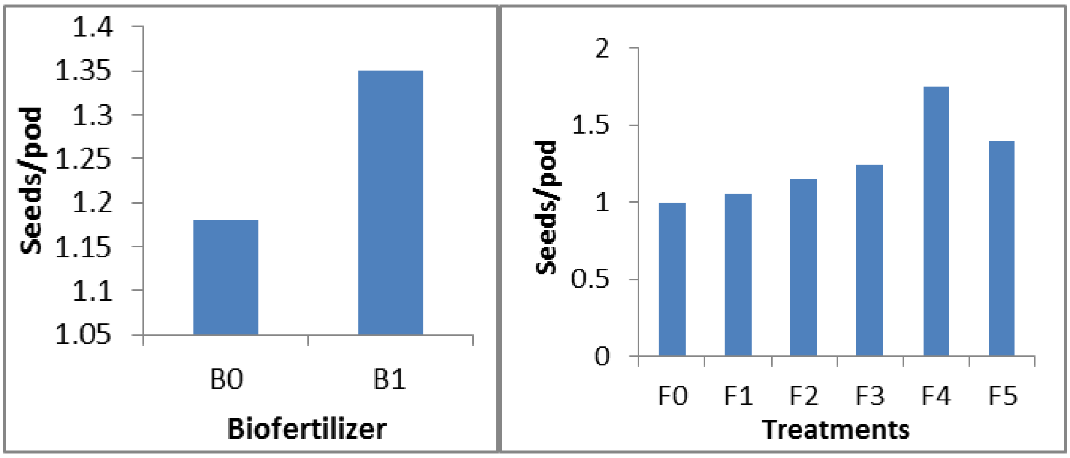

Figure 7. Impact of biofertilizer, nitrogen and phosphorous on seeds pod^{-1} of chickpea (SE=0.00 of biofertilizer and fertilizer)

B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.7.3 Combine effect of biofertilizer, nitrogen and phosphorous

The combine effect of biofertilizer, nitrogen and phosphorous showed non-significant variations on seeds pod^{-1} of chickpea (Table 5, Appendix VIII). In spite of having non-significant variation numerically the highest number of seeds pod^{-1} was found in B_1F_4 (2.00) and lowest in B_0F_0 combination (1.00).

Table 6. Combine effect of biofertilizer, nitrogen and phosphorous on pod number, seeds pod^{-1}, 1000 seeds weight and seed yield of chickpea

Treatments	Pod number plant^{-1}	Seeds Pod^{-1}	1000 Seed weight (g)	Seed yield (kg ha^{-1})
B_0F_0	15.32 j	1.00	190.12 l	827.5 l
B_0F_1	16.36 i	1.00	192.69 k	855.00 k
B_0F_2	17.44 h	1.10	195.20 j	879.17 j
B_0F_3	18.20 g	1.20	197.68 i	898.67 i
B_0F_4	20.35 e	1.50	205.16 g	952.5 g
B_0F_5	19.37 f	1.30	200.20 h	927.5 h
B_1F_0	18.19 g	1.00	212.64 f	976.83 f
B_1F_1	20.17 e	1.10	215.26 e	1001.5 e
B_1F_2	21.26 d	1.20	217.69 d	1025.83 d
B_1F_3	22.27 c	1.30	220.20 c	1051.5 c
B_1F_4	24.27 a	2.00	227.76 a	1102.5 a
B_1F_5	23.34 b	1.50	222.64 b	1077.5 b
SE (±)	**0.174**	**-**	**0.209**	**2.985**
CV (%)	**5.71**	**3.27**	**5.04**	**9.17**

B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.8 The 1000 seeds weight

4.1.8.1 Impact of biofertilizer

The application of biofertilizer showed significant effect on 1000 seeds weight of chickpea (Figure 8, Appendix VIII). The highest 1000 seeds weight (438.73 g) was recorded in B_1 and lowest (393.67 g) in B_0 which indicated that biofertilizer produced 11.45% heaver seed than without biofertilizer plot. The present finding agreed with the finding of different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.8.2 Impact of nitrogen and phosphorous

Application of nitrogen and phosphorous had a positive effect on 1000 seeds weight of chickpea (Figure 8, Appendix VIII). The figure showed an increasing trend with the increased dose of N & P fertilizer up to F_4 treatment. A further increase of fertilizer dose reduced 1000 seeds weight slightly. However, the treatment F_4 produced highest 1000 seeds weight (432.93 g) where F_0 produced lowest number of branches (402.77 g) compared to other treatments. The similar finding is also reported by the different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al*., 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008).

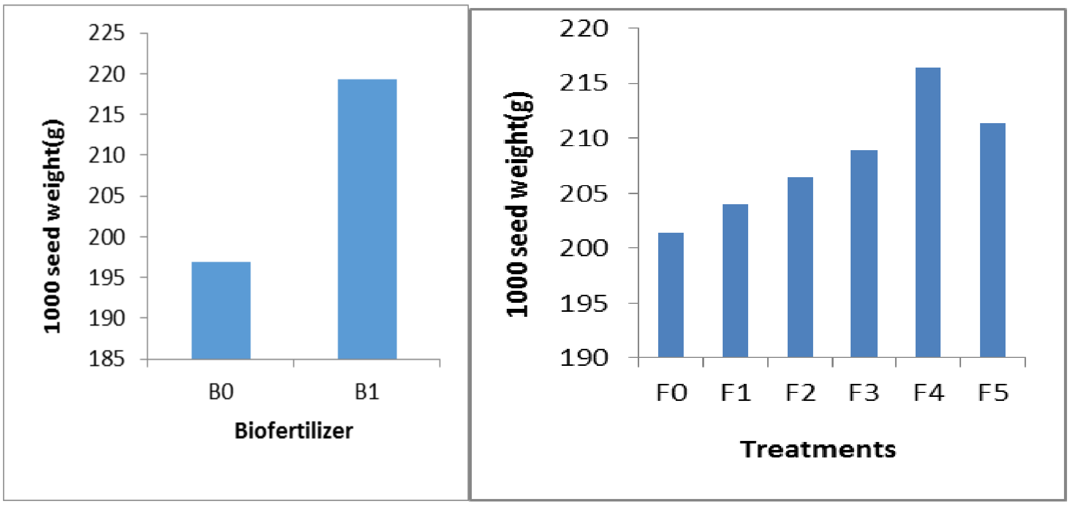

Figure 8. Impact of biofertilizer, nitrogen and phosphorous on 1000 seeds weight of chickpea (SE=0.085 and 0.148 of biofertilizer and fertilizer)

B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.8.3 Combine effect of biofertilizer, nitrogen and phosphorous

Thee 1000 seeds weight showed non-significant impact due to combine effect of biofertilizer, nitrogen and phosphorous (Table 5, Appendix VIII). Although having non-significant effect, the highest value of 1000 seeds weight was recorded in B_1F_4 (455.52 g) and lowest in B_0F_0 (380.25 g).

4.1.9 Seed yield

4.1.9.1 Impact of bio-fertilizer

Seed yield of chickpea showed significant influences by the application of biofertilizer and application of biofertilizer (Figure 9, Appendix VIII). The highest seed yield was found in B_1 (1856.5 kg ha^{-1}). The lowest seed yield was recorded in B_0 (1780.1 kg ha^{-1}) which indicated that the biofertilizer put yielded by 76.4% than control (without biofertilizer). The present finding agreed with the finding of different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.9.2 Impact of nitrogen and phosphorous

Nitrogen and phosphorus showed significant impact on seed yield of chickpea (Figure 9, Appendix VIII). Seed yield values showed a gradual increasing trend with the higher doses pf fertilizer up to F_4 (2055.00 kg ha^{-1}) treatment after that the value reduced marginally. Among the fertilizer doses seed yield ranges from 1804.3 kg ha^{-1} to 2055.00 kg ha^{-1}. It can be infrared from the data that F_4 treatment showed 13.89% higher yield over control (F_0) treatment. The result corroborated with finding of the different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al*., 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008).

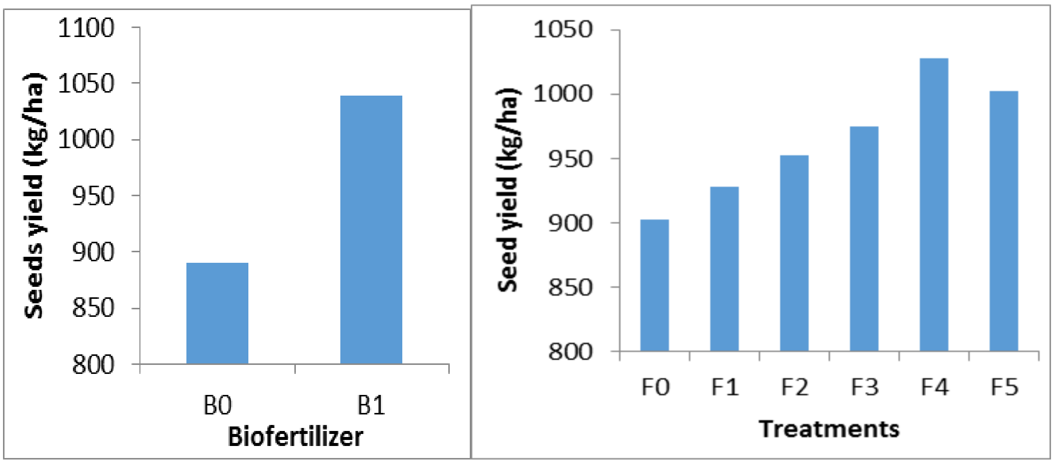

Figure 9. Impact of biofertilizer, nitrogen and phosphorous on seed yield ha^{-1} of chickpea (SE=1.075 and 1.862 of biofertilizer and fertilizer)

B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.9.3 Combine effect of biofertilizer, nitrogen and phosphorous

The combine effect of biofertilizer, nitrogen and phosphorous showed non-significant impact on seed yield (Table 5, Appendix VIII). In spite of having non-significant impact the highest seed yield was found in B_1F_4 (2205.00 kg ha^{-1}) and lowest in B_0F_0 (1655.00 kg ha^{-1}) combination.

4.1.10 Stover yield

4.1.10.1 Impact of biofertilizer

The application of biofertilizer showed positively significant impact on stover yield of chickpea (Figure 10, Appendix IX). The highest stover yield was recorded in B_1 (2228 kg ha^{-1}) and lowest in B_0 (2028.7 kg ha^{-1}). The present finding agreed with the finding of different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.10.2 Impact of nitrogen and phosphorous

Application of nitrogen and phosphorous had a positive effect stover yield (Figure 10, Appendix IX). The treatment F_4 produced the highest stover yield (2251.3 kg ha^{-1}) where F_0 produced lowest stover yield (2003.5 kg ha^{-1}). The similar finding is also reported by the different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al*., 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008).

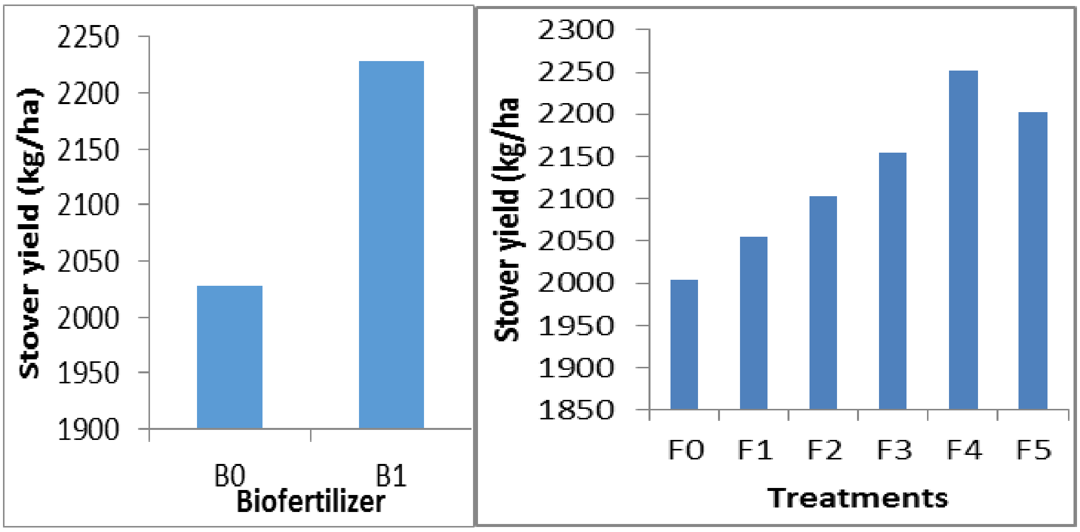

Figure 10. Impact of biofertilizer, nitrogen and phosphorous on stover yield of chickpea (SE=0.753 and 1.305 of biofertilizer and fertilizer)

B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.10.3 Combine effect of biofertilizer, nitrogen and phosphorous

The stover yield showed non-significant impact due to combine effect of biofertilizer, nitrogen and phosphorous (Table 6, Appendix IX). Although having non-significant effect, the highest stover yield was recorded in B_1F_4 (2351.00 kg ha^{-1}) and lowest in B_0F_0 (1902.33 kg ha^{-1}).

Table 7. Combine effect of biofertilizer, nitrogen and phosphorous on stover yield and harvest index

Treatments	Stover yield (kg ha^{-1})	Harvest index (%)
B_0F_0	1902.33 j	16.28 l
B_0F_1	1955.33 i	17.37 k
B_0F_2	2005.00 h	18.25 j
B_0F_3	2055.00 g	20.28 i
B_0F_4	2151.00 e	25.31 g
B_0F_5	2103.00 f	22.19 h
B_1F_0	2104.67 f	26.29 f
B_1F_1	2155.00 e	30.32 e
B_1F_2	2202.00 d	32.22 d
B_1F_3	2252.33 c	35.32 c
B_1F_4	2351.00 a	40.41 a
B_1F_5	2302.67 b	38.37 b
SE (±)	**1.845**	**0.161**
CV (%)	**5.11**	**3.38**

B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.11 Harvest index

4.1.11.1 Impact of bio-fertilizer

Harvest index of chickpea influenced significantly by biofertilizer application (Figure 11, Appendix IX). The highest value (33.82%) of harvest index was found in B_1. The lowest value (19.95%) of this trait was recorded in B_0. The similar finding reported by different authors (Bidyarani *et al*., 2016; Uddin *et al*., 2014; Tagore *et al*., 2013; Rabieyan *et al*., 2011; Shukla *et al*., 2010; Mohammadi *et al*., 2010; Singh and Mukherjee, 2009).

4.1.11.2 Impact of nitrogen and phosphorous

Nitrogen and phosphorus showed positively significant impact on harvest index of chickpea (Figure 11, Appendix IX). The figure indicated that F4 fertilizer doses produced highest harvest index (32.86%). Fertilizer applied lower and higher doses than F_4 treatment reduced the value of harvest index. Fertilizer dose lower than F_4 treatment showed a gradual decreasing trend and the lowest decrease (21.29%) was found in F_0 (control treatment). The similar finding is also reported by the different authors (Dar *et al*., 2016; Rani and Krishna, 2016; Dhima *et al*., 2015; Tripathi *et al*., 2013; Kamithi, 2013; Namvar *et al*., 2013; Namvar *et al*., 2011; Ali *et al*., 2010; Farzaneh *et al.*, 2009; David and Khan, 2001; Kumar *et al*., 2017; Eltayeb, 2016; Biçer, 2014; Pingoliya *et al*., 2014; Dotaniya *et al*., 2014; Hussena *et al*., 2013; Dutta and Bandyopadhyay, 2009 and Basir *et al*., 2008).

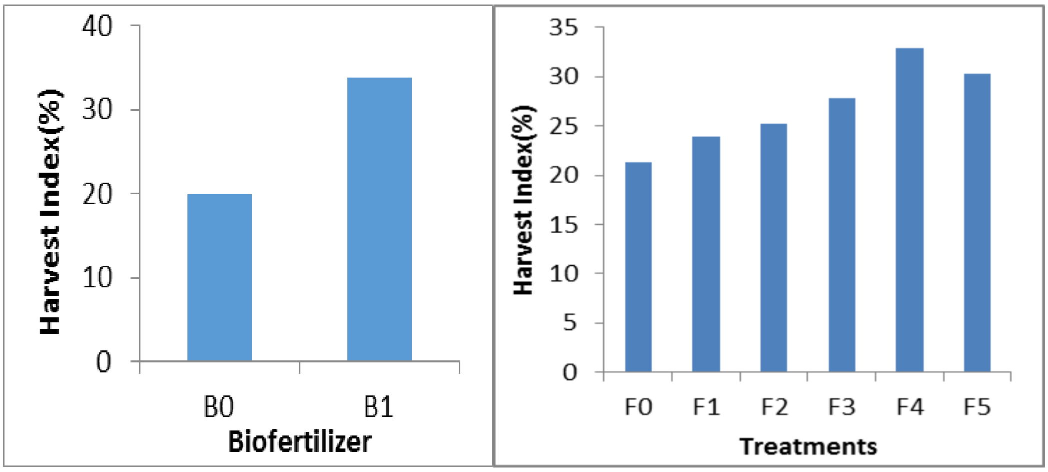

Figure 11. Impact of biofertilizer, nitrogen and phosphorous on harvest index of chickpea (SE=0.066 and 0.114 of biofertilizer and fertilizer)

B_0= without biofertilizer, B_1= biofertilizer, F_0= all fertilizer except N & P, F_1=50% less N & P, F_2= 25% less N & P, F_3= recommended dose of N & P with others, F_4=25% higher N & P, F_5= 50% higher N & P

4.1.11.3 Combine effect of biofertilizer, nitrogen and phosphorous

The combine effect of biofertilizer, nitrogen and phosphorous showed significant impact on harvest index (Table 11, Appendix IX). The highest value of harvest index was found in B_1F_4 (40.41 %) and lowest in B_0F_0 combination (16.28 %).

CHAPTER V

SUMMARY AND CONCLUSION

The investigation was conducted at the Agronomy field at Sher-e-Bangla Agricultural University to study impact of nitrogen, phosphorus and bio-fertilizer on nodulation, growth and yield of chickpea. Summary and conclusion of the study are presented in this chapter.

The tallest plant was found in B_1 (14.76 cm, 24.71 cm, 50.73 cm and 37.77 cm at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The shortest plant was recorded in B_0 (12.69 cm, 18.73 cm, 38.73 cm and 29.77 cm at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The highest value obtained for plant height in F_4 is 15.79 cm, 24.76 cm, 47.26 cm and 36.2 cm at 30 DAS, 60 DAS, 90 DAS and harvest times, respectively. The lowest value of plant height was in F_0 and that was 12.69 cm, 18.73 cm, 38.73 cm and 29.77 cm at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively. In spite of having non-significant impact the highest plant height was found in B_1F_4 and lowest in B_0F_0 combination.

The maximum number of branches was recorded in B_1 (1.5, 5.84, 16.75 and 11.77 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively) and lowest in B_0 (1.17, 3.84, 7.76 and 5.78 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The treatment F_4 produced maximum number of branches plant-1 (2.5, 7.26, 15.77 and 11.31 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively) where F_0 produced lowest number of branches (1.0, 2.68, 10.75 and 7.27 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). Although having non-significant effect, the maximum number of branches plant^{-1} was recorded in B_1F_4 (3.00, 8.38, 19.21 and 14.32 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively) and lowest in B_0F_0 (1.00, 2.03, 7.25 and 3.32 at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively).

The highest plant dry weight was found in B_1 (1.55 g, 8.86 g, 22.87 g and 15.89 g at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The lowest plant dry weight was recorded in B_0 (1.12 g, 3.77 g, 16.84 g and 10.86 g at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively). The highest value obtained for plant dry weight in F_4 is 1.65 g, 7.93 g, 22.36 g and 15.88 g at 30 DAS, 60 DAS, 90 DAS and harvest times, respectively. The lowest value of plant dry weight was in F_0 and that was 1.05 g, 2.67 g, 17.26 g and 10.90 g at 30 DAS, 60 DAS, 90 DAS and harvest time, respectively. In spite of having non-significant impact the highest plant dry weight was found in B_1F_4 and lowest in B_0F_0 combination.

The maximum number of nodules was recorded in B_1 (19.87, 16.38 and 14.77 at 55 DAS, 70 DAS and 85 DAS, respectively) and lowest in B_0 (11.84, 9.83 and 6.71 at 55 DAS, 70 DAS and 85 DAS, respectively). The treatment F4 produced maximum number of nodules plant^{-1} (18.42, 15.96 and 13.32 at 55 DAS, 70 DAS and 85 DAS, respectively) where F_0 produced lowest number of nodules (13.27, 10.32 and 8.21 at 55 DAS, 70 DAS and 85 DAS, respectively). Although having non-significant effect, the maximum number of nodules plant^{-1} was recorded in B_1F_4 (22.36, 19.59 and 16.24 at 55 DAS, 70 DAS and 85 DAS, respectively) and lowest in B_0F_0 (9.23, 7.30 and 4.15 at 55 DAS, 70 DAS and 85 DAS, respectively).

In spite of non-significant effect, the highest nodules dry weight was found in B_1 (0.045 g, 0.625 g and 0.073 g at 55 DAS, 70 DAS and 85 DAS, respectively). The lowest nodules dry weight was recorded in B_0 (0.112 g, 0.392 g and 0.048 g at 55 DAS, 70 DAS and 85 DAS, respectively). Although having non-significant impact, the highest nodules dry weight was obtained in fertilizer application area. The highest value obtained for nodules dry weight in F_4 is 0.15 g, 0.65 g and 0.075 g at 55 DAS, 70 DAS and 85 DAS, respectively. The lowest value of nodules dry weight was in F_0 and that was 0.115 g, 0.392 g and 0.048 g at 55 DAS, 70 DAS and 85 DAS, respectively. In spite of having non-significant impact the highest nodules dry weight was found in B_1F_4 and lowest in B_0F_0 combination.

The maximum number of pods was recorded in B_1 (21.58) and lowest in B_0 (17.84). The treatment F_4 produced maximum number of pods plant^{-1} (22.31) where F_0 produced lowest number of pods (17.84). The maximum number of pods plant^{-1} was recorded in B_1F_4 (24.27) and lowest in B_0F_0 (15.32).

The highest number of seeds pod^{-1} was found in B_1 (1.35). The lowest number of seeds pod^{-1} was recorded in B_0 (1.18). The highest value obtained for number of seeds pod^{-1} in F_4 is 1.74. The lowest value of number of seeds pod^{-1} was in F_0 and that was 1.0. In spite of having non-significant impact the highest number of seeds pod^{-1} was found in B_1F_4 (2.00) and lowest in B_0F_0 combination (1.00).

The highest 1000 seeds weight was recorded in B_1 (438.73 g) and lowest in B_0 (393.67 g). The treatment F_4 produced highest 1000 seeds weight (432.93 g) where F_0 produced lowest number of branches (402.77 g) compared to other treatments. Although having non-significant effect, the highest value of 1000 seeds weight was recorded in B_1F_4 (455.52 g) and lowest in B0F0 (380.25 g).

The highest seed yield was found in B_1 (1856.5 kg ha^{-1}). The lowest seed yield was recorded in B_0 (1780.1 kg ha^{-1}). The highest value obtained for seed yield in F_4 is 2055.00 kg ha^{-1}. The lowest value of seed yield was in F_0 and that was 1804.3 kg ha^{-1}. In spite of having non-significant impact the highest seed yield was found in B_1F_4 (2205.00 kg ha^{-1}) and lowest in B_0F_0 (1655.00 kg ha^{-1}) combination.

The highest stover yield was recorded in B_1 (2228 kg ha^{-1}) and lowest in B_0 (2028.7 kg ha^{-1}). The treatment F_4 produced the highest stover yield (2251.3 kg ha^{-1}) where F_0 produced lowest stover yield (2003.5 kg ha^{-1}). Although having non-significant effect, the highest stover yield was recorded in B_1F_4 (2351.00 kg ha^{-1}) and lowest in B_0F_0 (1902.33 kg ha^{-1}).

The highest value of harvest index was found in B_1 (33.82 %). The lowest value of this trait was recorded in B_0 (19.95 %). The highest value obtained for harvest index in F_4 is 32.86 %. The lowest value of plant height was in F_0 and that was 21.29 %. The highest value of harvest index was found in B_1F_4 (40.41 %) and lowest in B_0F_0 combination (16.28 %).

So, in the conclusion, with the application of biofertilizer and 25% higher nitrogen and phosphorous helped to get higher vegetative growth i.e. plant height, number of branches, plant dry weight, nodules number, nodules dry weight. It also helped to get higher yield and yield contributing character i.e. pod number, number of seeds per pod, 1000 seeds weight, pod yield, seed yield, stover yield and harvest index. Therefore, it can be concluded that, biofertilizer and 25% higher nitrogen and phosphorous can be used to get higher vegetative growth and yield of chickpea.

Recommendation

The present experiment was conducted only one season even in a single location. So, it is difficult to recommend this finding without further study. By considering the results of the present experiment, further studies in the following areas are suggested below

I. Studies of similar nature could be carried out in different agro-ecological zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability.

II. In this study, few levels of biofertilizer and fertilizer was used, it is recommended to increase the fertilizer levels and biofertilizer to get accurate result.

Therefore, it can be concluded that, along with 25% higher N & P than the recommended doses of fertilizer and biofertilizer can be used to get higher vegetative growth and yield of chickpea.

REFERENCES

Ali, A., 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.

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

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

Anonymous. (2004). Annual Internal Review for 2000-2001. Effect of seedling throwing on the grain yield of wet land rice compared to other planting methods. Crop Soil Water Management Program, Agronomy Division, BRRI, Gazipur-1710.

Asad, S. A., Bano, A, Farooq, M., Aslam, M. and Afzal, A. (2004). Comparative study of the effects of bio-fertilizers on nodulation and yield characteristics of mung bean (*Phaseolus vulgaris* l.) *Intl. J. Agric. Biol.* **6**: 837-843.

Basir, A., Shah, Z., Naeem, M., Bakht, J. and Khan, Z. H. (2008). Effect of phosphorus and farm yard manure on agronomic traits of chickpea (*Cicer arietinum* L.). *Sarhad J. Agric.* **24**(4): 567-572.

BBS, 2013. Bangladesh Bureau of Statistics. The Government of the People's Republic of Bangladesh.

Biçer, B. T. (2014). The Effect of Phosphorus Doses on Chickpea Cultivars Under Rainfall Conditions. *Cercetari Agron. Moldova*. **47**(2): 89-95.

Bidyarani, N., Prasanna, R., Babu, S., Hossain, F. and Saxena, A. K. (2016). Enhancement of plant growth and yields in Chickpea (*Cicer arietinum* L.) through novel cyanobacterial and biofilmed inoculants. *Microbiol. Res.* **188**: 97-105.

Dar, J. S., Rehmani, M. I. A., Abbassi, Z. A. and Magsi, A. G. (2016). Effect of starter nitrogen on yield and yield components of chickpea (*Cicer arietinum* L.) at Dokri, Larkana. *Pure Appl. Biol.* **5**(4): 1296-1303.

David, J. and Khan, K. S. (2001). Effect of nitrogen application on nodulation in inoculated chickpea (*Cicer arietinum* L.). *J. Biol. Sci.* **1**(3): 87-89.

Dhima, K., Vasilakoglou, I., Stefanou, S., and Eleftherohorinos, I. (2015). Effect of cultivar, irrigation and nitrogen fertilization on chickpea (*Cicer arietinum* L.) productivity. *Agric. Sci.* **6**(10): 1187.

Dotaniya, M. L., Pingoliya, K. K., Lata, M., Verma, R., Regar, K. L., Deewan, P. and Dotaniya, C. K. (2014). Role of phosphorus in chickpea (Cicer arietinum L.) production. *African J. Agric. Res.* **9**(51): 3736-3743.

Dutta, D. and Bandyopadhyay, P. (2009). Performance of chickpea (*Cicer arietinum* L.) to application of phosphorus and bio-fertilizer in laterite soil. *Archives Agron. Soil Sci.* **55**(2): 147-155.

ElHadi, E. A. and Elsheikh, E. A. E. (1999). Effect of Rhizobium inoculation and nitrogen fertilization on yield and protein content of six chickpea (*Cicer arietinum* L.) cultivars in marginal soils under irrigation. *Nutr. Cycling Agroecosys.* **54**(1): 57-63.

Eltayeb, M.S. (2016). Effect of Phosphorus and Plant Spacing on Growth and Yield of Two Chickpea (*Cicer arietinum* L.) Cultivars Under Irrigation. M.S. thesis, University of Khartoum.

Farzaneh, M., Wichmann, S., Vierheilig, H. and Kaul, H. P. (2009). The effects of arbuscular mycorrhiza and nitrogen nutrition on growth of chickpea and barley. *Pflanzen bauwissens chaften*. **13**(1): 15-22.

Giaquenta, R. T. and Quebedeaux, B. (1980). Phosphate induced changes in assimilate partitioning in soybean leaves during pod filling. *Plant Physiol*. **65**: 119.

Gitari, J. N. and Mureithi, J. G. (2003). Effect of phosphorus fertilisation on legume nodule formation and biomass production in Mount Kenya Region. *East Afr. Agric. For. J.* **69**(2): 183-187.

Hussain, M. S., Rahman, M. M., Harun-ur-rashid, M., Farid, A. T. M., Quyyum, M. A., Ahamed, M., Alam, M. S. and Salahuddin, K. M. (2006). Krishi Projukti Hatboy (Handbook on Agro-tecnology), 4th edition, Bangladesh Aricultural Researh Institute, Gazipur 1701.pp. 123-142.

Hussena, S., Yirga, F. and Tibebu, F. (2013). Effect of phosphorus fertilizer on yield and yield components of chickpea (*Cicer arietinum*) at Kelemeda, South Wollo, Ethiopia. *Int. J. Soil Crop Sci.* **1**(1): 1-4.

Jessop, R. S., Hetherington, S. J. and Hoult, E. H. (1984). The effect of soil nitrate on the growth, nodulation and nitrogen fixation of chickpeas (*Cicer arietinum*). *Plant Soil*. **82**(2): 205-214.

Kamithi, D. (2013). *Effects of nitrogen levels and plant Populations on growth and yield of chickpea (Cicer arietinum l.) Under dryland conditions in Kenya* (Doctoral dissertation).

Kumar, P., Prajapat, O. and Parihar, R. (2017). Effect of different levels of phosphorus, sulphur and cultivars on growth and economics of chickpea (*Cicer arietinum* L). *Int. J. Farm Sci.* **7**(2): 57-59.

Laurie, S. and Stewart, G. R. (1993). Effects of nitrogen supply and high temperature on the growth and physiology of the chickpea. *Plant Cell Environ.* **16**(6): 609-621.

Mahdi S. S., Hassan G. I., Samoon S. A., Rather H. A., Dar S. A. and Zehra B (2010). Bio-fertilizers in organic agriculture. *J. Phytol*. **2**: 42-54.

Mohammadi, K., Ghalavand, A. and Aghaalikhani, M. (2010). Effect of organic matter and biofertilizers on chickpea quality and biological nitrogen fixation. *World Academy Sci. Eng. Technol.* **4**(8): 1154-1159.

Namvar, A., Sharif, R. S. and Khandan, T. (2011). Growth analysis and yield of chickpea (Cicer arietinum L.) in relation to organic and inorganic nitrogen fertilization. *Ekologija*. **57**(3):97-108.

Namvar, A., Sharifi, R. S., Sedghi, M., Zakaria, R. A., Khandan, T. and Eskandarpour, B. (2011). Study on the effects of organic and inorganic nitrogen fertilizer on yield, yield components, and nodulation state of Chickpea (*Cicer arietinum* L.). *Communications Soil Sci. Plant Anal.* **42**(9): 1097-1109.

Ogola, A. H., Odhiambo, G. D., Okalebo, J. R. and Muyekho, F. N. (2012). Influence of phosphorus on selected desmodium growth and nodulation parameters. *ARPN J. Agric. Biolo. Sci.* **7**: 294-301.

Pingoliya, K. K., Mathur, A. K., Dotaniya, M. L., Jajoria, D. K. and Narolia, G. P. (2014). Effect of phosphorus and iron levels on growth and yield attributes of chickpea (*Cicer arietinum* L.) under agroclimatic zone IV A of Rajasthan, India. *Legume Res*. **37**(5): 537-541.

Rabieyan, Z., Yarnia, M. and Kazemi-e-Arbat, H. (2011). Effects of Biofertilizers on Yield and Yield Components of Chickpea (*Cicer arietinum* L.) under Different Irrigation Levels. *Aus. J. Basic Appl. Sci*. **5**(12): 3139-3145.

Rani, B. S. and Krishna, T. G. (2016). Response of chickpea (Cicer arietinum L.) varieties to nitrogen on a calcareous vertisols. *Indian J. Agric. Res.* **50**(3): 278-281.

Rudresh D. L., Shivaprakash M. K., and Prasad R. D (2005). Effect of combined application of Rhizobium, phosphate solubilizing bacterium and Trichoderma spp. on growth, nutrient uptake and yield of chickpea (*Cicer aritenium* L.) *Appl. Soil Ecol*. **28**: 139-146.

Selvakumar, G., Lenin, M., Thamizhiniyan, P. and Ravimycin, T. (2009). Response of biofertilizers, on the growth and yield of blackgram (*Vigna mungo* L.). *Recent Res. Sci. Technol.* **1**(4):169-175.

Selvakumar, G., Reetha, S. and Thamizhiniyan, P. (2012). Response of biofertilizers on growth, yield attributes and associated protein profiling changes of blackgram (*Vigna mungo L. Hepper*). *World App. Sci. J.* **16**(10): 1368-1374.

Shukla, M. Patel, R.H. Verma, R., Deewan, P. and Dotaniya, M. L. (2010). Effect of bio-organics and chemical fertilizers on growth and yield of chickpea *(Cicer arietinum L.)* under middle Gujarat conditions. *Vegetos-An Int. J. Plant Res*. **26**(1):183-187.

Shukla, U. C. and Yadav, O. P. (1982). Effect of phosphorus and zinc on nodulation and nitrogen fixation in chickpea (*Cicer arietinum* L.). *Plant Soil*. **65**(2): 239-248.

Singh K. B (1997). Chickpea (Cicer arietinum L.). Field Crops Res. **53**: 161-170. Singh, R. K. and Mukherjee, D. (2009). Influence of biofertilizers, fertility levels and weed management practices on chickpea (*Cicer arietinum* L.) under late sown condition. *Ann. Agric. Res. New Series*. **30**(3&4): 116-120.

Singh, R. P., Gupta, S. C. and Yadav, A. S. (2008). Effect of levels and sources of phosphorus and PSB on growth and yield of blackgram (*Vigna mungo* L. Hepper). *Legume Res.* **31**(2): 139-141.

Soltani A, Robertson M. J, Mohammad-Nejad Y, and Rahemi-Karizaki A (2006). Modeling chickpea growth and development: Leaf production and senescence. *Field Crops Res*. **99**: 14-23.

Tagore, G. S., Namdeo, S. L., Sharma, S. K. and Kumar, N. (2013). Effect of Rhizobium and phosphate solubilizing bacterial inoculants on symbiotic traits, nodule leghemoglobin, and yield of chickpea genotypes. *Int. J. Agron.* **2013**:18

Tripathi, L., Thomas, T. and Kumar, S. (2013). Impact of nitrogen and phosphorus on growth and yield of chickpea (*Cicer arietinum* L.). *An Asian J. Soil Sci*. **8**(2):260-263.

Uddin, M., Hussain, S., Khan, M. M. A., Hashmi, N., Idrees, M., Naeem, M. and Dar, T. A. (2014). Use of N and P biofertilizers reduces inorganic phosphorus application and increases nutrient uptake, yield, and seed quality of chickpea. *Turkish J. Agric. For.* **38**(1): 47-54.

Verma L. N (1993). Organic in soil health and crop production. In: Tree Crop Development Foundation, (Ed. PK Thampan), Cochin, India, pp. 151-184.

Walley, F. L., Kyei-Boahen, S., Hnatowich, G. and Stevenson, C. (2005). Nitrogen and phosphorus fertility management for desi and kabuli chickpea. *Can. J. Plant Sci.* **85**(1): 73-79.

APPENDIX

Appendix I. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from November 2016 to April 2017.

Month	Air temperature (^{o}C)		Relative humidity	Total rainfall	Sunshine
	Maximum	Minimum	(%)	(mm)	(hr)
November, 2016	29.6	19.2	77	34.4	5.7
December, 2016	26.4	14.1	69	12.8	5.5
January, 2017	25.4	12.7	68	7.7	5.6
February, 2017	28.1	15.5	68	28.9	5.5
March, 2017	32.5	20.4	64	65.8	5.2
April, 2017	33.7	23.6	69	165.3	5.9

Source: Sher-e-Bangla Agricultural University Weather Station

Appendix II. Physical characteristics & chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
pH	5.6-6.5
Organic mater (%)	0.84-1.0
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41meq / 100 g soil

Source: Soil resource and development institute (SRDI), Dhaka

Appendix III. Effect of biofertilizer, nitrogen and phosphorous on plant height

Sources of variation	DF	Mean Square			
		Plant height (cm) at			
		30 DAS	60 DAS	90 DAS	Harvest
Replication	2	0.4628	0.451	0.48	0.650
Biofertilizer	1	38.4813	438.344	1295.52	576.240
Fertilizer	5	20.9796	21.048	21.06	20.570
Biofertilizer×Fertilizer	5	0.7192	0.010	0.02	0.011
Error	22	0.0170	0.010	0.02	0.017

Appendix IV. Effect of biofertilizer, nitrogen and phosphorous on number of branches plant^{-1}

Sources of variation	DF	Mean Square			
		Number of branches plant^{-1} at			
		30 DAS	60 DAS	90 DAS	Harvest
Replication	2	1.012E-31	0.6145	0.793	0.711
Biofertilizer	1	1.00000	35.9600	440.860	323.400
Fertilizer	5	2.20000	18.4159	21.033	21.169
Biofertilizer×Fertilizer	5	0.40000	0.1956	0.009	0.022
Error	22	1.447E-33	0.0235	0.013	0.013

Appendix V. Effect of biofertilizer, nitrogen and phosphorous on plant dry weight

Sources of variation	DF	Mean Square			
		Plant dry weight (g) at			
		30 DAS	60 DAS	90 DAS	Harvest
Replication	2	5.259E-31	0.9344	1.126	1.295
Biofertilizer	1	1.69000	85.8711	327.489	227.809
Fertilizer	5	0.32200	22.7691	21.696	21.011
Biofertilizer×Fertilizer	5	0.06400	0.0158	0.016	0.009
Error	22	5.976E-33	0.0208	0.012	0.012

Appendix VI. Effect of biofertilizer, nitrogen and phosphorous on number of nodules plant^{-1}

Sources of variation	DF	Mean Square		
		Number of nodules plant^{-1} at		
		55 DAS	70 DAS	85 DAS
Replication	2	1.204	1.174	0.534
Biofertilizer	1	579.525	386.319	584.431
Fertilizer	5	22.155	27.655	21.540
Biofertilizer×Fertilizer	5	0.020	0.569	0.006
Error	22	0.023	0.008	0.011

Appendix VII. Effect of biofertilizer, nitrogen and phosphorous on nodule dry weight

Sources of variation	DF	Mean Square		
		Nodule dry weight (g) at		
		55 DAS	70 DAS	85 DAS
Replication	2	4.245E-33	8.025E-32	8.847E-34
Biofertilizer	1	0.01000	0.49000	5.256E-03
Fertilizer	5	1.660E-03	0.06550	6.063E-04
Biofertilizer×Fertilizer	5	4.000E-05	1.000E-03	6.250E-06
Error	22	8.025E-36	1.529E-33	4.924E-36

Appendix VIII. Effect of biofertilizer, nitrogen and phosphorous on pods number, seeds pod^{-1}, 1000 seeds weight and seed yield

Sources of variation	DF	Mean Square			
		Pod number	Seeds pods^{-1}	1000 Seeds weight (g)	Seeds yield (kg ha^{-1})
Replication	2	0.872	5.937E-31	1.26750	206
Biofertilizer	1	125.926	0.25000	18257.0	801920
Fertilizer	5	24.853	0.46000	703.156	52198
Biofertilizer×Fertilizer	5	0.289	0.04600	0.01953	34
Error	22	0.019	6.536E-33	0.02741	10

Appendix IX. Effect of biofertilizer, nitrogen and phosphorous on stover yield and harvest index

Sources of variation	DF	Mean Square	
		Stover yield (kg ha^{-1})	Harvest index (%)
Replication	2	104	0.82
Biofertilizer	1	357604	1732.50
Fertilizer	5	51449	109.64
Biofertilizer×Fertilizer	5	6	7.22
Error	22	5	0.01

Plate 1. Field view

Plate 2. Sample collection for plant dry weight

Plate 3. Nodule data collection

Plate 4. Data collection

Plate 5. Matured plant