IMPACT OF DIFFERENT COMBINATIONS OF BIO FERTILIZER AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF CHICKPEA

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IMPACT OF DIFFERENT COMBINATIONS OF BIO FERTILIZER AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF CHICKPEA

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CERTIFICATE

*This is to certify that the thesis entitled**“Impact of Different Combinations of Bio Fertilizer and Inorganic Fertilizer on Growth and Yield of Chickpea”** submitted to theFaculty of Agriculture**,** Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **AGRONOMY,** embodies the results of a piece of bonafide research work carried out by* **Bushra Al Jannat** *Registration No.* ***11-04520*** *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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Dedicated To

My Beloved Parents

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IMPACT OF DIFFERENT COMBINATIONS OF BIO FERTILIZER AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF CHICKPEA

ABSTRACT

A field experiment was conducted at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka from November, 2016 to March 2017 to study the impact of different combinations of bio fertilizer and inorganic fertilizer on growth and yield of chickpea. Two varieties of chickpea *viz*. V_1: BARI Chola-5 and V_2: BARI Chola-9 and six combination of bio fertilizer and inorganic fertilizer treatments (F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer, F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer, F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer, F_4= Recommended dose of inorganic fertilizer + bio fertilizer, F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer and F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer, were used in the experiment where *Trichoderma* was considered as bio fertilizer. Results showed that the variety, V_2 (BARI Chola-9) showed the best performance on plant height, number of branches plant^{-1}, dry weight plant^{-1}, number of pods plant^{-1}, 1000 seed weight and grain yield compared to the variety, V_1 (BARI Chola-5). Again, considering the effect of bio-fertilizer and inorganic fertilizer combination, the treatment F_5 (25% higher recommended dose of inorganic fertilizer + bio fertilizer) gave the best performance on most of the parameters where the lowest was from the treatment, F_1 (75% less recommended dose of inorganic fertilizer + bio fertilizer). Considering the combined effect of variety and bio-fertilizer + inorganic fertilizer combination, the highest 1000 seed weight (234.02 g) and grain weight(2.83 t ha^{-1}) was recorded from the treatment combination of V_2F_5 where the lowest number of pods plant^{-1} (54.33), lowest 1000 seed weight(110.38 g) and lowest grain weight(1.57 t ha^{-1}) was recorded from the treatment combination of V_2F_1.

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ABBREVIATIONS AND ACRONYMS

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

CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and the third largest produced food legume globally, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). Chickpea is grown in more than 50 countries (89.7% area in Asia, 4.3% in Africa, 2.6% in Oceania, 2.9% in Americas and 0.4% in Europe) (Gaur *et al*., 2010). The other major chickpea producing countries include India, Pakistan, Turkey, Iran, Myanmar, Australia, Ethiopia, Canada, Mexico and Iraq. Chickpea is a temperate crop though it is well adapted in tropical and sub-tropical conditions (Kay, 1979). In the tropics and sub-tropics, chickpea is normally sown in the post monsoon i.e. during rabi season. In Bangladesh, chickpea is grown on well drained alluvial to clay loam soils having pH ranging from 6.0 to 7.0.

Chickpea is an important source of protein for millions of people in the developing countries, particularly in South Asia, who are largely vegetarian either by choice or because of economic reasons. In addition to having high protein content (20-22%), chickpea is rich in fiber, minerals (phosphorus, calcium, magnesium, iron and zinc) and β-carotene. Its lipid fraction is high in unsaturated fatty acids. Chickpea plays a significant role in improving soil fertility by fixing the atmospheric nitrogen. Chickpea meets 80% of its nitrogen (N) requirement from symbiotic nitrogen fixation and can fix up to 140 kg N ha^{-1} from air. It leaves substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improve soil health and fertility. Because of its deep tap root system, chickpea can withstand drought conditions by extracting water from deeper layers in the soil profile (Gaur *et al*., 2010).

Chickpea is one of the most important pulse crops in Bangladesh after grasspea and lentil occupying third position (BBS, 2008). The area coverage under pulses is about 233000 hectare while the contribution of chickpea is about 8233 hectare with seed production of 6605 metric ton (BBS, 2015). It contributes about 20% of the pulses. The average yield of chickpea is 0.76 mt ha^{-1} (BBS, 2008). Even though, the acreage of chickpea cultivation in Bangladesh is decreasing due to less return as compared to cereal crops and also due to increase in area under boro rice, maize and potato. The increasing gap between production and demand of pulse in Bangladesh has resulted in chronic problem of malnutrition mainly due to protein deficiency.

Despite its importance, few studies have been conducted to analyses the application of biofertilizers to chickpea with or without inorganic fertilizers. Biofertilizers contain large number of beneficial microorganisms in a live state incorporated in a sterilized carrier material like lignite or talc and its application to seed/seedling/plant or soil helps in mobilizing plant nutrients for crop growth through biological nitrogen fixation or by phosphorus solubilization or mobilization of any other plant nutrient required for the crop growth. Some of the biofertilizers also act as effective bio control agents in controlling many root borne pathogens.

Chemical fertilizers have played a key role in the green revolution. It has been established that there is positive correlation between fertilizer usage and agriculture productivity. Therefore, the current trend is to explore the possibility of supplementing chemical fertilizers with organic and biofertilizers. Organic manures have all the essential elements but their content is too low to satisfy the need of the fast growing and high yielding varieties of crops.

Biofertilizers are microbial inoculants of selective microorganisms like bacteria, algae, fungi already existing in nature. They may help in improving soil fertility by way of accelerating biological nitrogen fixation from atmosphere, solubilization of the insoluble nutrients already present in soil, decomposing plant residues, stimulating plant growth and production. The process is slow, consumes less energy and provides cheep nutrient to agriculture without polluting the nature. The seed inoculation with Rhizobium increases nodulation, influences seed yield and economies the input cost of fertilizers to some extent and protects against chances of soil deterioration and environmental pollution caused by heavy use of chemical fertilizers. The efficient strains of Rhizobium can fix about 90 kg of nitrogen per hectare in one season and enrich soil nitrogen (Gupta and Prasad, 1982). Several works indicated that Rhizobium inoculation integrated with the application of S, Zn, and other plant nutrients improved pulse crops production compared to Rhizobium inoculation alone (Togay *et al*., 2008; Bahure *et al*., 2016, Valenciano *et al*., 2011).

The present study was conducted to evaluate the impact of different combinations of biofertilizer and inorganic fertilizer on growth and yield of chickpea with the following objectives.

1. To observe the different combination of biofertilizer and inorganic fertilizer on chickpea,
2. To observe the varietal performance of chickpea under combine combination of biofertilizer and inorganic fertilizer, and
3. To observe the interaction of variety and combination impact of fertilizer on growth and yield of chickpea.

CHAPTER II

REVIEW OF LITERATURE

Excess and indiscriminate use of chemical fertilizers and pesticides has deteriorated the soil health in terms of causing acidic or alkaline/saline or sodic thus impairing the fertility status of soil, affecting porosity and water holding capacity, thus soil become unfit for crop cultivation. In addition to this in recent years there is fertilizer scarcity and escalation in their prices which has become unaffordable to farmers for their usage. In this context there is need to develop low cost, eco-friendly agriculture technologies. In nature certain microorganisms have the capacity to mobilize plant nutrients and helps in partial substitution of chemical fertilizers.

The literature pertaining to the response of biofertilizers and bioprotectants on growth and yield of chickpea have been reviewed and presented in this chapter.

2.1 Effect of biofertilizers

Singh *et al.* (1990) stated thatin recent years, biofertilizers have emerged as a promising component of integrated plant nutrient system in agriculture. Integrated use of organics, inorganics and biofertilizers sustains productivity by improving soil physico chemical and biological properties and help to reduce the usage of costly inorganic fertilizers.

Microbial inoculants generally called as “Biofertilizers”, are carrier based preparations containing beneficial microorganisms in a viable state intended for seed or soil application designed to improve soil fertility and to help plant growth by increasing the number and biological activity of desired microorganisms in the root environment (Subba Rao, 1993). The most commonly used biofertilizers in crop cultivation are *Rhizobium, Azotobacter* and *Azospirillum* (Sethi and Subba Rao, 1968), phosphate solubilizing bacteria and fungi (Sperber, 1957). Arbuscular

Mycorrhizal (AM) fungi, *Trichoderma* sp. and *Pseudomonas* sp. are considered as plant growth promoters and as potential biocontrol agents (Smitha, 2005).

Biofertilizers are low cost, renewable resource of plant nutrients and their usage in agriculture assumed a special significance particularly in the present day context of organic farming, integrated farming and in nutrient management practices. Adesemoye and Kloepper (2009) reported that biofertilizers can be used in conjunction with chemical fertilizers as an economic input to increase crop productivity.

Low and unbalanced chemical fertilization without organic sources has lead to improper mineralization of nutrients resulting in reduction in crop productivity and low quality of the produce which will fetch low price in the market.

Application of beneficial microbial inoculants to seed or soil helps in improving seed germination, seedling vigour, plant growth and crop yield. It helps in obtaining quality produce due to secretion of plant growth promoting hormones and vitamins, Ram *et al.* (1992) stressed the need of using biofertilizers in complement with chemical fertilizers in view of reducing the input costs and to maintain soil health. Adesemoye and Kloepper (2009) reported that the microbial inoculants can be used as an economic input to increase crop productivity with chemical fertilizers.

Fages and Arsac (1991) studied the plant growth promoting effect of bacterial strains isolated from the rhizosphere of sunflower. *Azospirillum lipoferum* was screened for their ability to promote sunflower growth in 6-day old germinated seedlings in a pot culture study. Results showed that sunflower seedling root development was directly affected by bacterial inoculation and has a positive effect on shoot development.

Pawar and Pawar (1998) reported that seed inoculation with P solubilizer along with 100 per cent recommended dose of P_2O_5 ha^{-1} would be the best proposition for higher productivity of pigeon pea.

Kumar *et al.* (2001) reported that inoculation of phosphate solubilizing and phytohormone producing *Azotobacter chroococcum* mutants exerted a favourable influence on wheat as evidenced by increased grain, straw and biological yield, 1000 grain weight and root biomass compared to control.

Kader *et al.* (2002) studied the effect of *Azotobacter* inoculants on the yield and nitrogen uptake of wheat. It was found that the free living nitrogen fixer *Azotobacter* in the rhizosphere zone has the ability to synthesize and secrete some biologically active substances like B vitamins, nicotinic acid, pantothenic acid, biotin, auxins, gibberellins, etc. which enhances the root growth.

Shehata and El-Khawas (2003) studied the effect of two biofertilizers biogien and microbien on sunflower (*Helianthus annuus* L. cv. Vedock) vegetative growth, yield, nitrogen components, nucleic acid content, minerals, protein profiles and DNA banding pattern. The results showed that the highest stimulatory effect and the maximum enhancement were exerted in plants treated with biogien at 5 per cent recommended dose.

Wu *et al.* (2005) reported that biofertilizers not only supplements nitrogen, but also produces a variety of growth-promoting substances *viz.*, indole acetic acid, gibberellins and B vitamins.

Hamaoui and Sheikh (2001) studied the effects of the inoculation of chickpea *(Cicer arietinum* L.) and faba beans *(Vicia faba* L.) with *Azospirillum brasilense* strain Cd under different growth conditions. In greenhouse experiments with both legumes, inoculation with *A. brasilense* has significantly enhanced nodulation by native rhizobia and improved root and shoot development, when compared with non-inoculated controls. Moreover, the bacterial treatment showed significantly reduced negative effects on plant growth caused by irrigation with saline water. In field experiments, inoculation of chickpea with *A. brasilense* peat-based inoculants also resulted in a significant increase in nodulation, root and shoot growth and crop yield as compared to non-inoculated control plants.

Rokhzadi and Toashih (2011) studied the effects of single and combined inoculation of plant growth-promoting rhizobacteria *viz., Azospirillum, Azotobacter*, *Mesorhizobium* and *Pseudomonas* on nutrient uptake, growth and yield of chickpea plants under field conditions. Nodulation and nutrient concentration in shoots were significantly affected by the treatments at the beginning of flowering stage. The maximum dry weight of root nodules was recorded in combined inoculation of *Azospirillum* spp. + *Azotobacter chroococcum* 5 + *Mesorhizobium ciceri* SWRI7 + *Pseudomonas fluorescens* P21.

All inoculants were statistically superior over uninoculated control with respect to nitrogen concentration of shoots. The treatments containing *Azospirillum* + *Azotobacter* has significantly improved the phosphorus concentration in shoots. Grain yield, dry weight and nitrogen and phosphorus uptake of grains were statistically improved in inoculated plants compared to control plants.

Jida and Assefa (2012) reported that chickpea rhizobial isolates has diversity in C and N-sources utilization pattern and tolerance to salinity, high temperatures, acid and alkaline pH, heavy metals and antibiotics. Symbiotic and morphological characterization also showed a wide diversity among the tested isolates. Moreover, screening for PGP characteristics indicated that 44.4% of the isolates were phosphate solubilizer while 27.8% of them were found to be indole- 3-acetic acid (IAA) producer. Furthermore, 19.4% tested isolates showed antagonistic activity against *Fusarium oxysporum* in dual culture assay. Generally, the present study indicates that Ethiopian soils contain symbiotically effective chickpea nodulating rhizobia which are endowed with different PGP characteristics.

Narula *et al.* (1993) observed 44 to 89 per cent increase in seed yield in *Brassica juncea* cv. Kranti after inoculation with different mutants of *Azotobacter chroococcum* under irrigated conditions along with decreased disease incidence.

Sreeramulu *et al.* (1996) reported that amaranthus and methi showed an advantageous crop growth when inoculated with *Glomus fasciculatum* along with 50 per cent P fertilization. The yield obtained was almost on par with plants supplied with full dose of NPK.

Sawarkar and Thakur (2001) found that nodule number and its weight/plant, plant height, number of branches, number of pods and seed index has significantly improved with seed/soil inoculation of PSB in combination with chemical fertilizers. The yield was highest (1950 kg ha^{-1}) with the treatment of 100 per cent P_2O_5 and seed inoculation of PSB (2 kg ha^{-1}) followed by soil application + 100 per cent P_2O_5 (1867 kg ha^{-1}).

Sundara *et al.* (2002) reported that PSB application reduced the required P chemical fertilizers dosage by 25 percent, when used in conjunction with P fertilizers and the PSB application has improved the juice quality and yield of sugarcane.

Kramany *et al.* (2007) found that treatment of 25 percent recommended dose of NPK + 75 per cent FYM + biofertilizer (microbien) was best in improving the groundnut yield, yield components, oil yield (kg ha^{-1}), P (%), Fe and Zn (ppm) while number of seeds/pod and weight of straw (g $plant^{-1}$) was highest with 50 per cent NPK+ 50 per cent FYM + microbien.

Inoculation with mycorrhiza increased the yield of groundnut by 14.5 per cent in *Kharif* and by 27.8 per cent in *Rabi* in sandy- loam soils of Tirupathi. Similarly 26.4 per cent increase in soyabean and 20.9 per cent in groundnut yields were reported with inoculation of mycorrhiza, *Glomus fasciculatum* (Hegde and Babu, 2009).

Parmar and Dadarwal (1997) suggested that a mutualistic relationship exists between *Azotobacter* and *Azospirillum* where both interact with the *Rhizobium* to improve *Cicer arietinum* (chick pea) yields.

Rudresh *et al.*, (2005) studied the effect of combined inoculation of *Rhizobium*, a phosphate solubilizing bacterium *Bacillus megaterium* sub sp. *Phospaticum* strain-PB and a biocontrol fungus *Trichoderma* spp. on growth, nutrient uptake and yield of chickpea under glasshouse and field conditions. Combined inoculation of these three microorganisms showed increased germination, nutrient uptake, plant height, number of branches, nodulation, pea yield, and total biomass of chickpea compared to either individual inoculation or uninoculated control.

Dutta and Bandyopadhyay (2009) conducted field experiment to evaluate the performance of chickpea cultivar ‘Mahamaya-2’ with variable proportions of phosphorus and bio-fertilizers (co-inoculation of *Rhizobium* with phosphobacterin). Combined application of P at 26.2 kgha^{-1} and bio-fertilizers *(Rhizobium* and phosphobacterin) has enhanced significantly growth and yield of crop compared to other levels of P with bio-fertilizer.

Aslam *et al.* (2010) found that application of biofertilizer to chickpea has increased 25.0 and 27.77% yield over check (uninoculated) during study season 2004-05 and 2005-06 respectively. It was concluded that, fertilizer band placement and biofertilizer application was best for obtaining higher yield and increased grain protein content in chickpea.

Rai and Gaur (1988) reported that combined application of *Azotobacter chroococcum* and *Azospirillum lipoferum* resulted in increase in seed and stover yields of wheat compared to application of individual bacterium.

Kumar (1994) found that the use of *Azotobacter chroococcum* isolate 103 and its mutants Mac 27 and Mal 27 enhanced the oil yield to an extent of 12.00, 43.10 and 36.20 per cent, respectively, as compared to control which increased 1000-

seed weight and K content which has stimulatory effect on the storage capacity of assimilates.

Chauhan *et al.* (1996) reported significant interaction between biofertilizers and N levels in mustard. Mustard inoculated with either *Azotobacter* or *Azospirillum* and receiving moderate levels of fertilizer N (30 kg ha^{-1}) gave similar grain yield to the uninoculated crop receiving higher dose of N(60 kg ha^{-1}). Their results clearly showed that N requirement of the crop could be reduced when it was inoculated with the biofertilizers.

Singh and Saxena (1997) reported that in pearl millet inoculation of nitrogen fixing and phosphate solubilizing microorganisms alone or in combination has increased the plant height, number of tillers and ultimately the yield.

Thakare *et al.* (2003) found that the integrated nutrient management by bioorganic and chemical fertilizers recorded 35 per cent increase in summer groundnut yield.

Meshram *et al.* (2004) conducted a field trial to study the efficacy of bio fertilizers alone and in combination with chemical fertilizers in soybean and found that the introduced *Rhizobium* strains of RS-1 and SB-119 were highly effective under all circumstances without or with chemical fertilizers. The highest grain productivity was obtained in the treatment of RS-1 + 15 kg N ha^{-1} (15.32 q ha^{-1}) and SB-119 + 15 kg N ha^{-1} (15.04 q ha-1).

Jain and Trivedi (2005) found that the combined application of *Rhizobium* and PSB resulted in higher seed yield, oil yield and protein content in soybean.

Almas *et al.* (2006) evaluated the effects of nitrogen fixing *Bradyrhizobium sp.* (*Vigna* group) and phosphate solubilizing bacterium *Bacillus subtilis* on growth, chlorophyll content, nodulation and seed yield of cowpea and found that combined inoculation has improved nodulation and seed yield.

Yasari and Patwardhan (2007) reported that the combined inoculation of *Azotobacter chroococcum, Azospirillum brasiliense* and *Azospirillum lipoferum* helped in increasing the yield by 21.17 percent over the control, increased the number of pods per plant (16.05%), number of branches (11.78%), weight of 1000 grains (2.92%) and the oil content of seeds (1.73%) of canola *(Brassica napus* L.) cv. Hyola 401 hybrid.

Yasari *et al.* (2008) reported that treating canola *(Brassica napus* L.) with *Azotobacter* and *Azospirillum* inoculants resulted in maximum number of pods/plant and helped in obtaining maximum seed yield.

Das *et al.* (2008) studied the response of *Stevia rebaudiana* to the application of bio-fertilizers. The results showed that the amount of available N, P, K content of soil was found increased significantly up to third month and later decreased with the progress of the plant growth up to sixth month irrespective of treatments. The mean potassium content in soil was recorded highest in the treatment of FYM + PSB + *Azospirillum* + VAM. The per cent increase in plant bio-mass was highest when all the biofertilizers were used togather.

Basu and Bhadoria (2008) reported that the combined application of *Rhizobium* and phosphobacterium *(Bacillus polymyxa)* inoculants and cobalt applied at the rate of 0.21 kg ha^{-1} has significantly increased the yield and uptake of N, P and K in groundnut compared to single application of either inoculants or cobalt. The beneficial effects of application of microbial inoculants and cobalt were also reflected on the soil fertility status.

Latake *et al.* (2009) reported that the inoculation of bioinoculants *viz., Azotobacter chroococcum, Azospirillum lipoferum, Acetobacter sp.* and phosphate solubilizer *Bacillus megaterium* alone or in combination increased plant height, number of tillers and ultimately the yield of pearl millet.

Hegde and Babu (2009) reported that dual inoculation of *Azospirillum* and *Azotobacter* could able to substitute up to 50 per cent of the N requirement in sunflower under rainfed conditions.

Raja *et al.* (2009) conducted a field experiment to study the effect of VAM fungi and its interaction with other beneficial microbial inoculants, *Azospirillum spp., Azotobacter spp.* and phosphate solubilizing bacteria on plant biomass, nutrients and biochemical constituents in *Jatropha curcas.* Application of combined microbial inoculants has significantly enhanced the fresh biomass, total soluble protein and phenols as well as relative water content over other treatments and uninoculated control.

Mirzakhani *et al.* (2009) found that inoculating seeds of spring safflower *(Carthamus tinctorius* L.) with *Azotobacter* and *Glomus intraradices* under different levels of nitrogen and phosphorus fertilizers resulted in the improvement of yield and oil content. *Azotobacter* inoculation has significantly increased the grain yield whereas mycorrhiza could affect significantly on characters such as harvest index, root dry weight, root mycorrhizal colonization.

Megawer and Mahfouz (2010) determined the effect of *Azotobacter* and *Azospirillum* as free living nitrogen fixers and *Trichoderma* as phosphate solubilizing fungi in combination with mineral N fertilizer (50%, 100%) on yield and quality of two canola (*Brassica napus* L.) lines (L6 and H2). The highest productivity was recorded in H_2T_{10} (N_2 + *Trichoderma* + *Azotobacter),* H_2T_{11} (N_2 + *Azotobacter* + *Azospirillum*) and L6T8 (N_2 + *Azotobacter*) which out yielded the corresponding control by 39.3, 31.8 and 23 per cent respectively thus helped in saving 50 percent of the recommended dose of N- fertilizer.

2.2 Effect of chemical fertilizer with biofertilizer

Verma *et al.* (1987) conducted a long term experiment on sandy loam soil at Masodha (Faizabad) with wheat. Results revealed that maximum decrease in available nitrogen by about 25 per cent was noted in no nitrogen plots. The decreasing trend in depletion of available nitrogen was found with increased N levels in surface and sub surface soil.

While working at Udaipur (Rajasthan) on clay loam soil, Khanpara (1989) reported that application of nitrogen did not influence the available N, P and K contents of soil after harvest the mustard crop.

Upadhyay *et al.* (1991) conducted a field study on a sandy loam soil at Research Farm, Kanpur during *Kharif* season of 1981 and 1982 with black gram. They reported that the effect of N application was significant in respect of total and organic phosphorus during the first year only.

An experiment was conducted on clayey soils of Junagadh during Kharif season of two 1999 and 2000 on groundnut, Rao (2001) reported that that available N, P and K were significantly increased with 100 % RDF + IBA @ 50 ppm + urea (1 %) spray at 40 and 60 DAS.

From the results of the experiments were conducted at farmers plot of Birbhum district of West Bengal, India during winter season of 1998-99 Puste *et al.* (2001) reported that seed yield of pulses (lentil, gram and lathyrus) were more pronounced in the treatment inoculated with *Rhizobium* with a saving of 42.6 to 48.4 Kg N ha^{-1}. They also concluded that the combined application of inorganic and organic N in a 75:25 ratio is a superior N-management practice with regards to crop yield as well as improvement of soil fertility.

Patil (2002) conducted a field experiment on clayey soil during *Kharif* season of 2001-02 at Junagadh (Gujarat) on pigeonpea. He reported that available N, P and K were significantly increased with 25 kg N ha^{-1}.

2.3 Effect of variety on growth and yield

2.3.1 Plant height

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

Kabir *et al.* (2009) conducted a study to see the effect of sowing time and cultivars on the growth and yield performance of chickpea under rainfed condition. The varieties showed significant difference in case of plant height and insignificant in case of total dry matter production and crop growth rate. BARI Chola-4 produced the tallest plants (32.30 cm) being closely followed by BARI Chola-2 (30.9 cm). The shortest plants (29.26 cm) were found in BARI Chola-6.

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

2.3.2 Total dry weight plant^{-1}

Das (2006) showed total dry matter is the sum of the dry matter accumulated in the various components of the plant namely leaf, petiole, stem and the reproductive parts of the plant. The pattern of dry matter production in the varieties BU Chola-1, BARI Chola-6 and BARI Chola-7 is almost similar.

2.3.3 Nodules plant^{-1}

Das *et al.* (2009) reported the number of nodules plant^{-}across the varieties to be ranged from 5.13 to 9.88, the highest number of nodules plant^{-}was found in the variety BARI Chola-6 and the lowest number of nodules were observed in the variety BU Chola-1.

Bhuiyan *et al.* (2009) conducted a study at a Regional Agricultural Research Station (RARS), Rahmatpur, Barisal, Bangladesh for two consecutive rabi seasons in 2002-03 and 2003-04 with a view to assessing the effect of *Rhizobium* inoculation on four cultivars of chickpea. Four chickpea cultivars, namely BARI Chola-3, BARI Chola-4, BARI Chola-5 and BARI Chola-6, were used in these trials. The variety BARI Chola-3 produced significantly higher nodule numbers (42.6). Zai *et al.* (1999) also found significantly more nodules in variety BARI Chola-6.

2.3.4 Nodule dry weight plant^{-1}

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

Solaiman *et al.* (2007) conducted an experiment at the research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh to study the response of five chickpea *(Cicer arietinum* L) varieties to Rhizobium inoculant and mineral nitrogen on nodulation, nitrogen fixation, dry matter production, nitrogen (N) uptake, yield and quality of the crop. Among the treatments, BARI chola-5 performed best in recording number and dry weight of nodules.

2.3.5 Pods plant^{-1}

Ali *et al.* (2010) experimented the 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^{-1}) at Agronomic Research Institute, AARI, Faisalabad, Pakistan during 2006-07 and 2007-08. There was a linear increase in yield of all genotypes from 0-0 to 2460 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 pods per plant (77.58).

2.3.6 Seeds pod^{-1}

Das (2006) showed the average number of seed pod^{-}across the varieties to be ranged from 1.20 to 1.42 pod^{-1}. The BARI Chola-7 produced the highest and BU Chola-1 produced the lowest number of seed pod^{-}respectively.

2.3.7 1000-seed weight

Karasu *et al.* (2009) reported that the effects of cultivars were statistically significant at 1% probability level on the 1000 seed weight. While maximum 1000 seed weight was obtained from Canitez- 87 cultivar (498.2 g) and popular local genotype Yerli (497.9 g), ILC-114 line had fewer 1000 seed weight (446.8 g).

2.3.8 Seed yield

Bhuiyan *et al.* (2009) conducted a trial at a Regional Agricultural Research Station (RARS), Rahmatpur, Barisal, Bangladesh for two consecutive rabi seasons in 2002-03 and 2003-04 with a view to assessing the effect of *Rhizobium* inoculation on four cultivars of chickpea. Four chickpea cultivars, namely BARI Chola-3, BARI Chola-4, BARI Chola-5 and BARI Chola-6, were used in these trials. The seed yields of the BARI Chola-5 and BARI Chola-6 variety (1.80 t/ha and 1.85 t/ha) were increased by 20.0% and 19.4% over uninoculated treatments for two consecutive rabi seasons in 2002-03 and 2003-04.

Das (2006) showed that the average yield ha^{-1}among the varieties was 608.18 kg in BU Chola-1, 641.87 kg in BARI Chola-6 and 661.16 kg in BARI Chola-7 respectively.

Kabir *et al.* (2009) found that the heaviest seed weight was observed in BARI Chola-6 and lowest seed weight was observed in BARI Chola-4, which was statistically at par with BARI Chola-2, which might be due to genotypic variation. The highest seed yield per plant was found in BARI Chola-4, which was statistically similar with BARI Chola-2.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from November, 2016 to March, 2017 to study the impact of different combinations of bio fertilizer and inorganic fertilizer on growth and yield of chickpea. The details materials and methods of this experiment are presented below under the following headings:

3.1 Description of the experimental site

3.1.1 Location

The location of the experimental field was in Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 90°33´E longitude and 23°77´N latitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

3.1.2 Soil

The soil belongs to "The Modhupur Tract", AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 6.1 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix II.

3.1.3 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by 3 distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix III.

3.2 Test crop

The variety, BARI Chola-5 and BARI Chola- 9 were used as test crops collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur.

3.3 Experimental details

3.3.1 Treatments

The experiment comprised two factors.

Factor A: Variety– two varieties

1. V_1= BARI Chola-5
2. V_2= BARI Chola- 9

Factor B: Bio-fertilizer and inorganic fertilizer combination – six levels**

1. F_1= Bio fertilizer + 75% less recommended dose of inorganic fertilizer
2. F_2= Bio fertilizer + 50% less recommended dose of inorganic fertilizer
3. F_3= Bio fertilizer + 25% less recommended dose of inorganic fertilizer
4. F_4= Bio fertilizer + Recommended dose of inorganic fertilizer
5. F_5= Bio fertilizer + 25% higher recommended dose of inorganic fertilizer
6. F_6= Bio fertilizer + 50% higher recommended dose of inorganic fertilizer

** *Trichoderma* was considered as Bio fertilizer.

3.3.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of variety and Bio fertilizer + inorganic fertilizer combination. The 12 treatment combinations of the experiment were assigned at random into 36 plots. The size of each unit plot 2.0 m× 1.5 m. The distance between blocks and plots were 0.75 m and 0.5 m, respectively.

3.4 Growing of crops

3.4.1 Seed collection

The seeds of the test crop *i.e.*, BARI Chola-5 and BARI Chola- 9 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the first week of November, 2016 with a power tiller, and was exposed to the sun for a week, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for sowing.

3.4.3 Seed sowing

Seeds are sown in well prepared land @ 15 kg ha^{-1} of each variety on 5 December, 2016 according to the layout and treatments selected.

3.4.4 Fertilizers and bio fertilizer application

The fertilizers were applied according to the treatments assigned under the present study. The recommended doses of fertilizer was 32, 28, 48, 24, 3.0 and 1.5 kg ha^{-1} for N, P, K, S, Zn and B respectively. *Trichoderma* was considered as bio fertilizer and applied @ 20 mg $plot^{-1}$.

3.4.5 Intercultural operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the chickpea.

3.4.5.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening. Further irrigation was done when needed. Stagnant water was effectively drained out at the time of heavy rains.

3.4.5.2 Weeding

Several weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. First weeding was done at 20 days after sowing (DAS), 2nd and 3rd weeding was done at 35 and 50 DAS, respectively.

3.4.5.3 Plant protection

At seedling stage, to protect the plants used Autostin @ 0.3% on 13 December, 2016 and Mstar @ 0.3% on 25 December, 2016. At early stage of growth few hairy caterpillar and virus vectors (jassid) attacked the young plants and at later stage of growth pod borer attacked the plant. Hairy caterpillar and pod borer were successfully controlled by the application of Diazinon 50 EC and Ripcord @ 1 L ha^{-1} on the time of 50% pod formation stage.

3.5 Harvesting, threshing and cleaning

The crop was harvested at full maturity from 9 March, 2017. Harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of checkpea seed. Fresh weight of seed and stover were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The stover was sun dried and the yields of seed and stover plot^{-1} were recorded and converted to t ha^{-1}.

3.6 Data Collection and Recording

Ten plants were selected randomly from each unit plot for recording data on crop parameters and the yield of grain and straw were taken plot wise.

The following parameters were recorded during the study:

1. Plant height

2. Number of branches plant^{-1}
3. Dry weight plant^{-1}
4. Number of nodules plant^{-1}
5. Nodule dry weight plant^{-1}
6. Number of pods plant^{-1}
7. 1000 seed weight
8. Grain yield

3.7 Procedure of recording data

3.7.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at different days after sowing of crop duration. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the leaves. Plant height was taken at 30, 50, 70, 85 DAS and at harvest.

3.7.2 Number of branches plant^{-1}

The branches were counted from the 10 randomly selected plant at different days after sowing started at 30 DAS at an interval of 20 days to at harvest and mean value was determined.

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

Five sample plants in each plot were selected at random in the sample rows outside the centeral 1 m^2 of effective harvesting area and cut close to the ground surface at different days of crop duration. They were first air dried for one hour, then oven dried at 70±5°C till a constant weight was attained. Mean dry weight was expressed as per plant basis.

3.7.4 Number of nodules plant^{-1}

Nodules were collected from ten randomly selected plants. The nodules per plant were calculated from their mean values.

3.7.5 Nodule dry weight plant^{-1}

Counted nodules were dried in an oven and the nodule dry weight plant^{-1} was measured.

3.7.6 Number of pods plant^{-1}

Number of total pods of 10 plants from each plot was noted and the mean number was expressed per plant basis.

3.7.7 Weight of 1000 seeds (g)

One thousand cleaned and dried seeds were counted randomly from 1m^2 area and weight by using a digital electric balance and the weight was expressed in gram.

3.7.8 Grain yield (t ha^{-1})

The plants of the central 1.0 m^2 from the plot were harvested for taking grain yield. The grains were threshed from the plants, cleaned, dried and then weighed. The yield of grain in kg plot^{-1} was adjusted at 12% moisture content of grain and then it was converted to t ha^{-1}.

3.8 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Deferent Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSIN

This chapter comprises presentation and discussion of the results obtained from the study to evaluate the impact of different combinations of bio fertilizer and inorganic fertilizer on growth and yield of chickpea. The results of the growth and yield characters of the production of the crop as influenced by different nutrient treatments have been presented and discussed in this chapter.

4.1 Growth parameters

4.1.1 Plant height

Effect of variety

Significant variation was observed on plant heightof chickpea influenced by different variety (Fig. 1). It was found that the highest plant height (14.26, 25.42, 36.57, 41.02 and 34.87 cm at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from V_2 (BARI Chola-9) where the lowest plant height (10.94, 18.93, 30.24, 34.51 and 30.12 at 30, 50, 70, 85 DAS and at harvest, respectively) was obtained from V_1 (BARI Chola-5).

Effect bio-fertilizer and inorganic fertilizer combination

Considerable variation was remarked on pant heightinfluenced by bio-fertilizer and inorganic fertilizer combination (Fig. 2). It was noted that the highest plant height (14.45, 25.05, 37.69, 42.29 and 36.22 cm at 30, 50, 70, 85 DAS and at harvest, respectively) was achieved from F_6 (50% higher recommended dose of inorganic fertilizer + bio fertilizer) which was statistically identical with F_5 (25% higher recommended dose of inorganic fertilizer + bio fertilizer) at all growth stages. The lowest plant height (10.66, 20.06, 28.84, 34.69 and 28.84 cm at 30, 50, 70, 85 DAS and at harvest, respectively) was found from the treatment, F_1 (75%

less recommended dose of inorganic fertilizer + bio fertilizer) which was statistically identical with F_2 (50% less recommended dose of inorganic fertilizer + bio fertilizer) at all growth stages. Similar result was also observed by Rudresh *et al.*, (2005) and Hamaoui and Sheikh (2001).

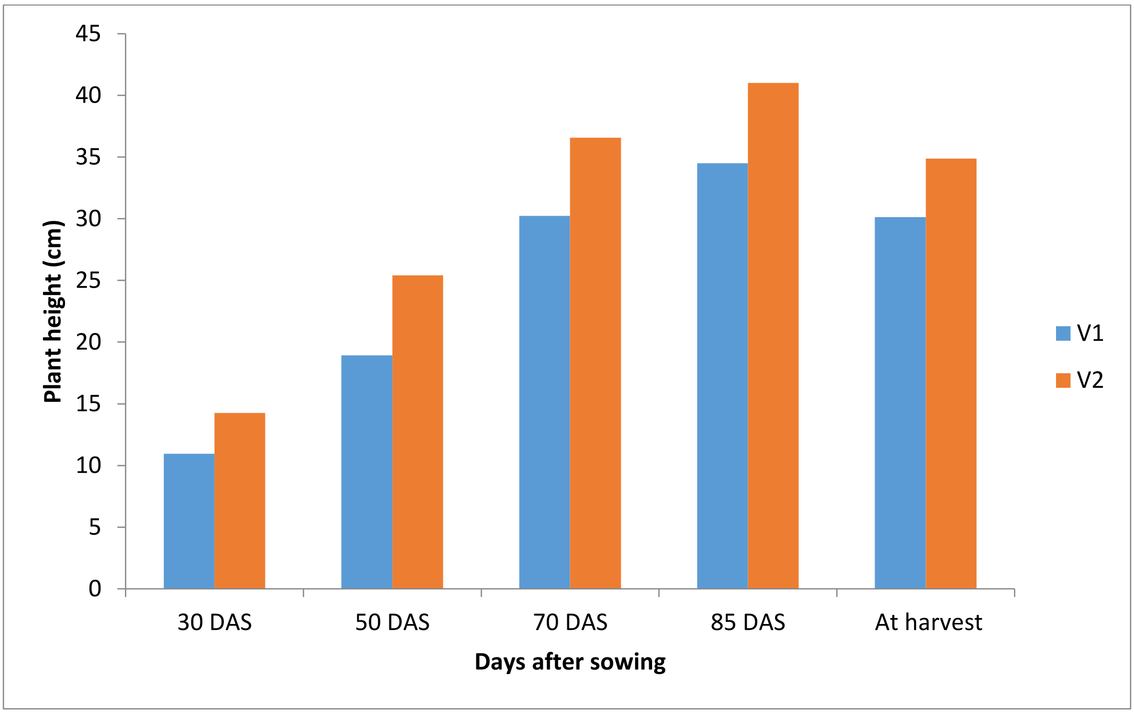

Fig. 1. Plant height of chickpea influenced by different variety ($LSD_{0.05}$ = 1.046, 2.319, 2.024, 3.109 and 1.036 at 30, 50, 70, 85 DAS and at harvest respectively)

V_1= BARI Chola-5, V_2= BARI Chola- 9

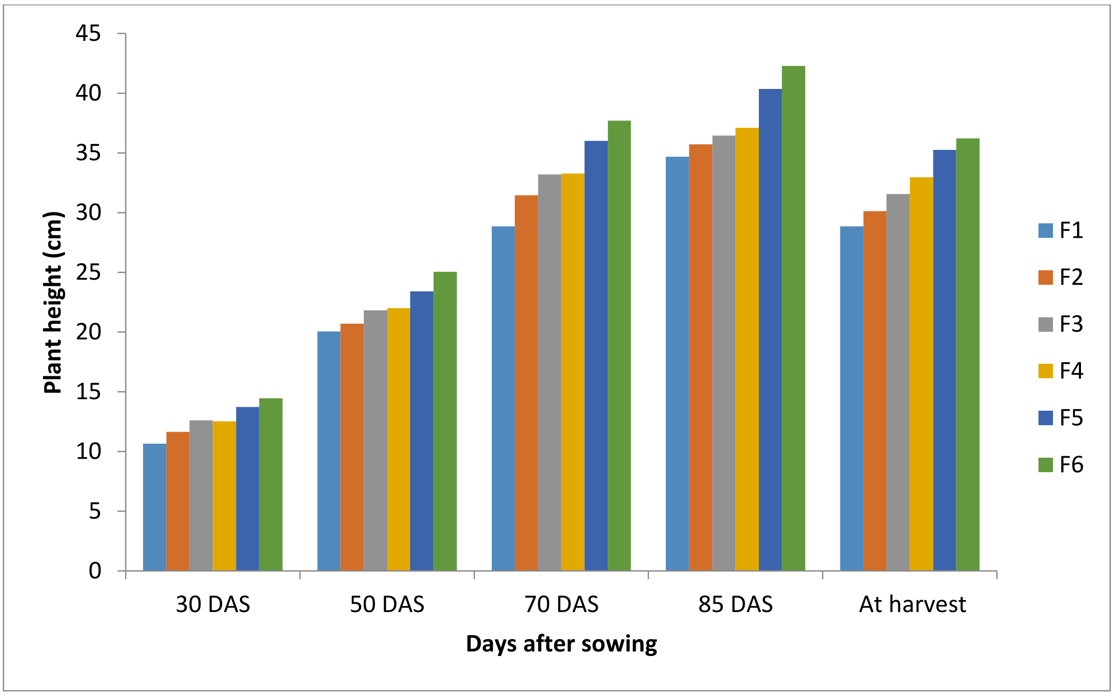

Fig. 2. Plant height of chickpea influenced by different combinations of bio fertilizer and inorganic fertilizer ($LSD_{0.05}$ = 0.214, 1.352, 2.026, 1.522 and 1.714 at 30, 50, 70, 85 DAS and at harvest respectively)

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination had significant influence on plant height(Fig. 3). Results indicated that the highest plant height(15.83, 28.07, 40.27, 44.63 and 37.45 cm at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from the treatment combination of V_2F_6 which was statistically identical with V_2F_5 at all growth stages. Similarly, the lowest plant height (9.02, 16.45, 24.58, 30.67 and 25.67 cm at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from the treatment combination of V_1F_1 which was statistically identical with V_1F_2 at all growth stages.

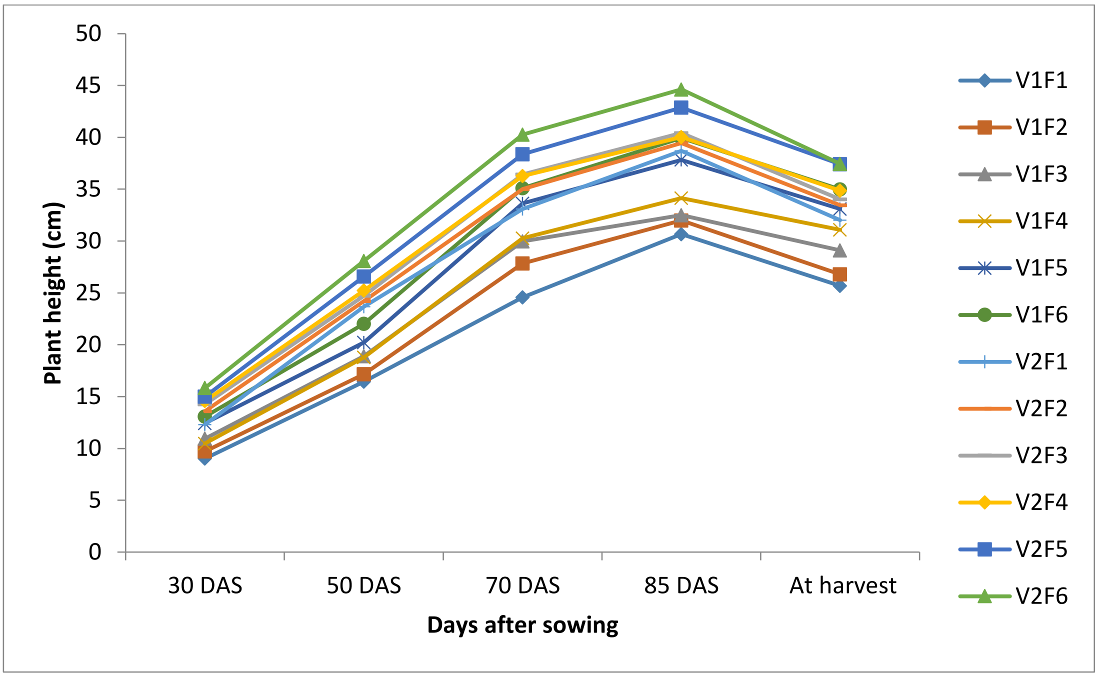

Fig. 3. Plant height of chickpea influenced by combined effect of variety and combinations of bio fertilizer and inorganic fertilizer ($LSD_{0.05}$ = 1.124, 2.052, 2.117, 2.314 and 1.156 at 30, 50, 70, 85 DAS and at harvest respectively)

V_1= BARI Chola-5, V_2= BARI Chola- 9

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

4.1.2 Number of branches plant^{-1}

Effect of variety

Significant variation was observed on number of branches plant^{-1} of chickpea influenced by different variety (Fig. 4). It was found from the figure that the highest number of branches plant^{-1} (2.13, 3.58, 5.55, 4.30 and 4.03 at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from V_2 (BARI Chola-9) where the lowest number of branches plant^{-1} (11.78, 3.47, 5.47, 4.11 and 3.60 at 30, 50, 70, 85 DAS and at harvest, respectively) was obtained from V_1 (BARI Chola-5).

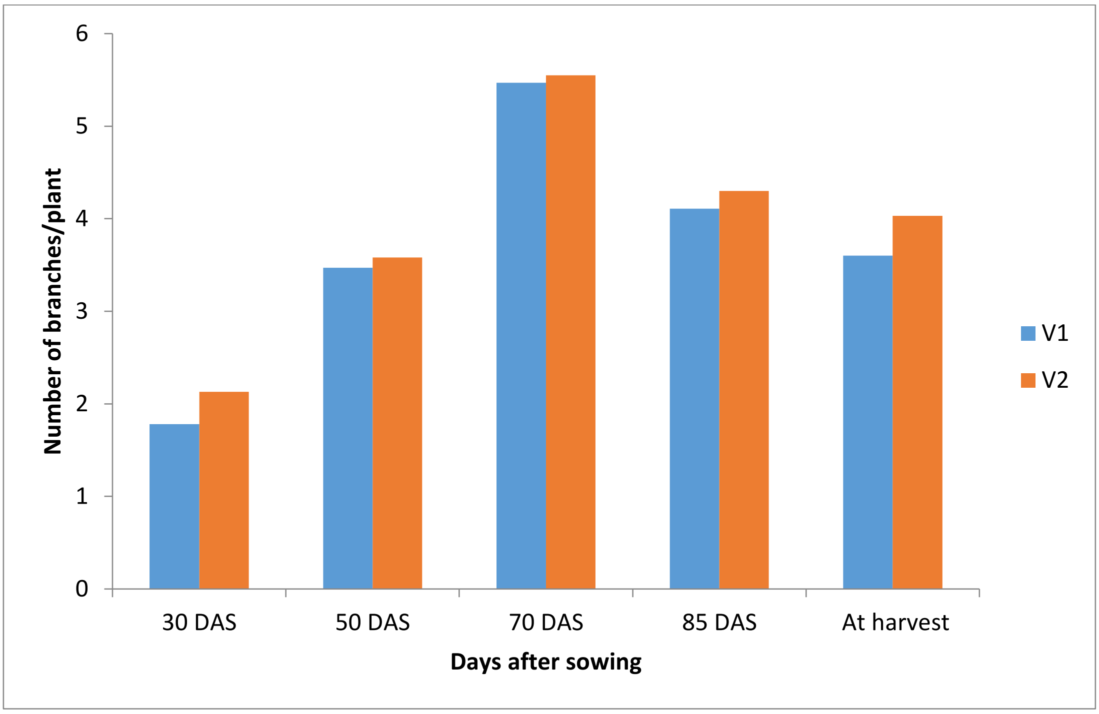

Fig. 4. Number of branches plant^{-1} of chickpea influenced by different variety ($LSD_{0.05}$ = 0.036, 0.062, 0.071 and 0.066 at 30, 50, 70, 85 DAS and at harvest respectively)

V_1= BARI Chola-5, V_2= BARI Chola- 9

Effect bio-fertilizer and inorganic fertilizer combination

Considerable variation was remarked on number of branches plant^{-1} influenced by bio-fertilizer and inorganic fertilizer combination (Fig. 5). It was examined that the highest number of branches plant^{-1} (2.03, 4.29, 6.73, 4.98 and 4.57 at 30, 50, 70, 85 DAS and at harvest, respectively) was achieved from F_6 (50% higher recommended dose of inorganic fertilizer + bio fertilizer) which was closely followed by F_5 (25% higher recommended dose of inorganic fertilizer + bio fertilizer) at all growth stages. The lowest number of branches plant^{-1} (1.95, 2.60, 4.25, 3.63 and 3.15 cm at 30, 50, 70, 85 DAS and at harvest, respectively) was found from the treatment, F_1 (75% less recommended dose of inorganic fertilizer + bio fertilizer) which was statistically similar with F_2 (50% less recommended dose of inorganic fertilizer + bio fertilizer) at all growth stages. Similar results were also observed by Yasari and Patwardhan (2007) and Sawarkar and Thakur (2001).

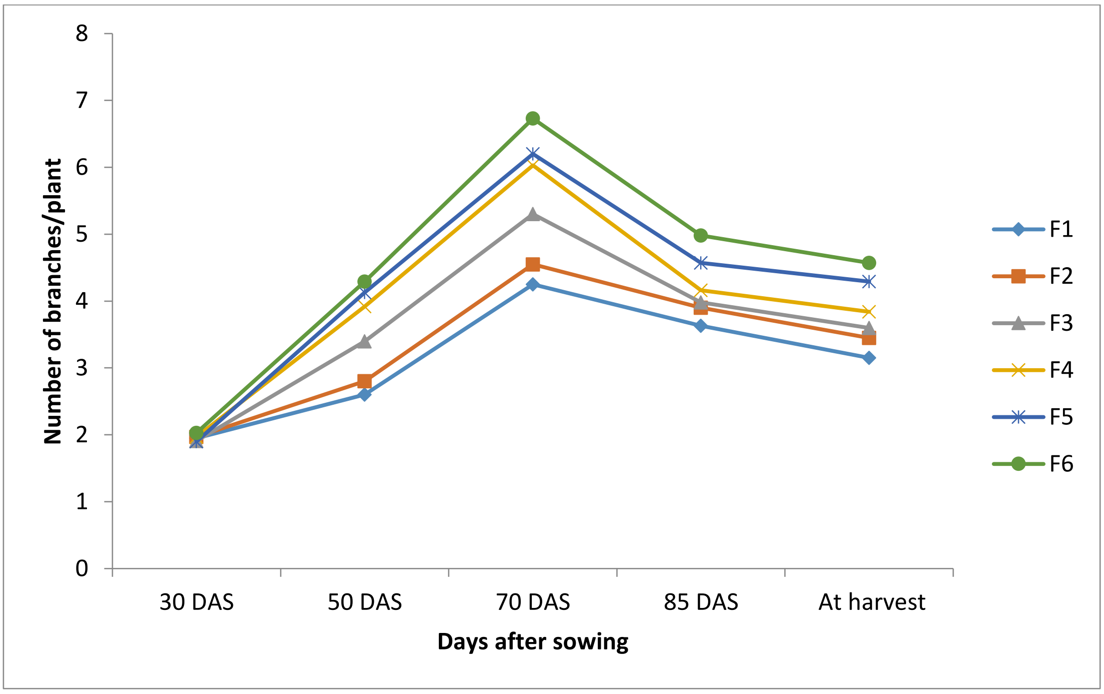

Fig. 5. Number of branches plant^{-1} of chickpea influenced by different combinations of bio fertilizer and inorganic fertilizer ($LSD_{0.05}$ = 0.107, 0.116, 0.253, 0.314 and 0.266 at 30, 50, 70, 85 DAS and at harvest respectively)

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination had significant influence on number of branches plant^{-1} (Table 1). Results indicated that the highest number of branches plant^{-1} (2.46, 4.40, 6.80, 5.20 and 4.73 at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from the treatment combination of V_2F_6 which was closely followed by V_1F_6 and V_2F_5 at all growth stages. Similarly, the lowest number of branches plant^{-1} (1.60, 2.53, 4.17, 3.53 and 2.86 at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from the treatment combination of V_1F_1 followed by V_1F_2 at all growth stages.

Table 1. Number of branches plant^{-1} of chickpea influenced by combined effect of variety and combinations of bio fertilizer and inorganic fertilizer at different days after sowing

Treatment	Number of branches plant^{-1} at				
	30 DAS	**50 DAS**	**70 DAS**	**85 DAS**	**Harvest**
V_1F_1	1.60 d	2.53 g	4.17 g	3.53 f	2.86 h
V_1F_2	1.67 cd	2.80 f	4.80 f	3.73 e	3.17 g
V_1F_3	1.80 b	3.20 e	5.20 de	3.83 e	3.26 fg
V_1F_4	1.87 b	3.80 bc	5.73 c	4.26 c	3.60 de
V_1F_5	1.80 b	3.93 b	5.93 bc	4.53 bc	4.32 bc
V_1F_6	1.93 ab	4.17 ab	6.65 a	4.76 ab	4.40 ab
V_2F_1	2.06 ab	2.67 g	4.33 g	3.73 e	3.43 f
V_2F_2	2.13 ab	2.80 f	4.30 d	4.06 d	3.73 de
V_2F_3	2.14 ab	3.60 cd	5.40 d	4.13 d	3.93 d
V_2F_4	2.00 ab	4.03 b	6.33 b	4.06 d	4.07 cd
V_2F_5	2.00 ab	4.33 a	6.46 ab	4.60 ab	4.26 ab
V_2F_6	2.46 a	4.40 a	6.80 a	5.20 a	4.73 a
$LSD_{0.05}$	**0.324**	**0.172**	**0.276**	**0.211**	**0.171**
CV (%)	**4.589**	**5.384**	**7.042**	**6.317**	**5.388**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly

V_1= BARI Chola-5, V_2= BARI Chola- 9

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

4.1.3 Dry weight plant^{-1}

Effect of variety

Significant variation was observed on dry weight plant^{-1} of chickpea as influenced by different variety (Fig. 6). It was found that the highest dry weight plant^{-1} (0.21, 1.14, 2.92, 4.91 and 4.51 g at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from V_2 (BARI Chola-9) where the lowest dry weight plant^{-1} (0.14, 0.78, 1.84, 3.82 and 3.55 g at 30, 50, 70, 85 DAS and at harvest, respectively) was obtained from V_1 (BARI Chola-5).

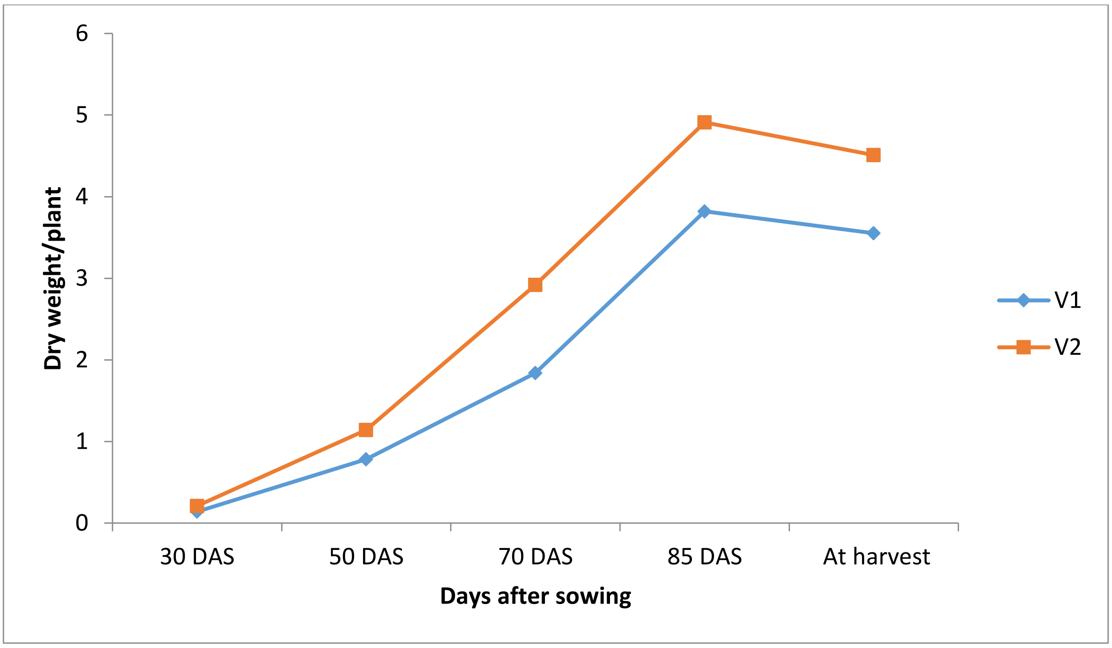

Fig. 6. Dry weight plant^{-1} of chickpea influenced by different variety ($LSD_{0.05}$ = 0.042, 0.085, 0.136, 0.214 and 0.236 at 30, 50, 70, 85 DAS and at harvest respectively)

V_1= BARI Chola-5, V_2= BARI Chola- 9

Effect of bio-fertilizer and inorganic fertilizer combination

Significant variation was found on dry weight plant^{-1} influenced by bio-fertilizer and inorganic fertilizer combination (Fig. 7). It was observed that the highest dry weight plant^{-1} (0.21, 0.99, 3.11, 5.24 and 4.66 g at 30, 50, 70, 85 DAS and at harvest, respectively) was achieved from F_6 (50% higher recommended dose of inorganic fertilizer + bio fertilizer) which was statistically identical with F_5 (25% higher recommended dose of inorganic fertilizer + bio fertilizer) at all growth stages. The lowest dry weight plant^{-1} (0.13, 0.77, 1.80, 3.51 and 3.23 g at 30, 50, 70, 85 DAS and at harvest, respectively) was found from the treatment, F_1 (75% less recommended dose of inorganic fertilizer + bio fertilizer) which was closely followed by F_2 (50% less recommended dose of inorganic fertilizer + bio fertilizer) at all growth stages. Rokhzadi and Toashih (2011) and Mirzakhani *et al.* (2009) also found similar results with the present study.

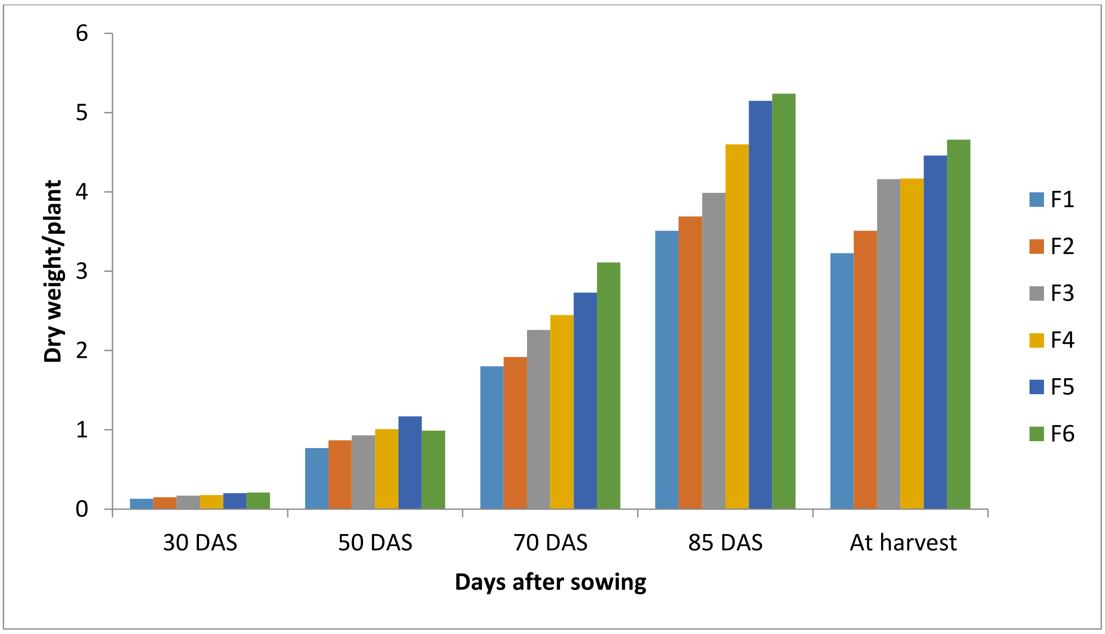

Fig. 7. Dry weight plant^{-1} of chickpea influenced by different combinations of bio fertilizer and inorganic fertilizer ($LSD_{0.05}$ = 0.044, 0.053, 0.102, 0.188 and 0.194 at 30, 50, 70, 85 DAS and at harvest respectively)

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination had significant influence on dry weight plant^{-1} (Table 2). Results indicated that the highest dry weight plant^{-1} (0.263, 1.360, 3.630, 5.959 and 5.192 g at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from the treatment combination of V_2F_6 which was closely followed by V_2F_5 at all growth stages. Treatment combination of V_2F_4 also showed statistically similar results with V_2F_6 at 85 DAS and at harvest. Similarly, the lowest dry weight plant^{-1} (0.125, 0.525, 1.269, 3.089 and 2.988 g at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from the treatment combination of V_1F_1 which was significantly different from all other treatment combinations followed by V_1F_2 and V_1F_2 at all growth stages.

Table 2. Dry weight plant^{-1} of chickpea influenced by combined effect of variety and combinations of bio fertilizer and inorganic fertilizer

Treatment	Dry weight plant^{-1} (g) at				
	30 DAS	**50 DAS**	**70 DAS**	**85 DAS**	**Harvest**
V_1F_1	0.125 f	0.525 f	1.269 i	3.089 h	2.988 h
V_1F_2	0.135 e	0.642 e	1.469 h	3.267 g	3.136 g
V_1F_3	0.138 e	0.708 de	1.653 gh	3.551 f	3.332 fg
V_1F_4	0.145 de	0.811 d	1.809 g	4.077 d	3.703 e
V_1F_5	0.149 d	0.973 cd	2.255 ef	4.426 c	4.026 d
V_1F_6	0.154 d	1.015 c	2.593 d	4.529 c	4.135 d
V_2F_1	0.133 e	1.011 c	2.335 e	3.924 de	3.464 f
V_2F_2	0.172 c	1.104 bc	2.368 e	4.109 d	3.887 de
V_2F_3	0.202 b	1.151 bc	2.857 cd	4.435 c	4.635 c
V_2F_4	0.213 b	0.973 bc	3.096 bc	5.131 ab	4.895 ab
V_2F_5	0.247 ab	1.211 ab	3.210 ab	5.882 ab	4.983 ab
V_2F_6	0.263 a	1.360 a	3.630 a	5.959 a	5.192 a
$LSD_{0.05}$	**0.017**	**0.047**	**0.102**	**0.116**	**0.204**
CV (%)	**4.526**	**4.714**	**5.366**	**5.218**	**6.074**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly

V_1= BARI Chola-5, V_2= BARI Chola- 9

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

4.1.4 Number of nodules plant^{-1}

Effect of variety

Significant influence was observed on number of nodules plant^{-1} of chickpea influenced by different variety (Fig. 8). It was found that the highest number of nodules plant^{-1} (21.22, 30.76 and 27.23 at 55, 70 and 85 DAS, respectively) was recorded from V_1 (BARI Chola-5) where the lowest number of nodules plant^{-1} (20.24, 27.24 and 24.42 at 55, 70 and 85 DAS, respectively) was obtained from V_2 (BARI Chola-9).

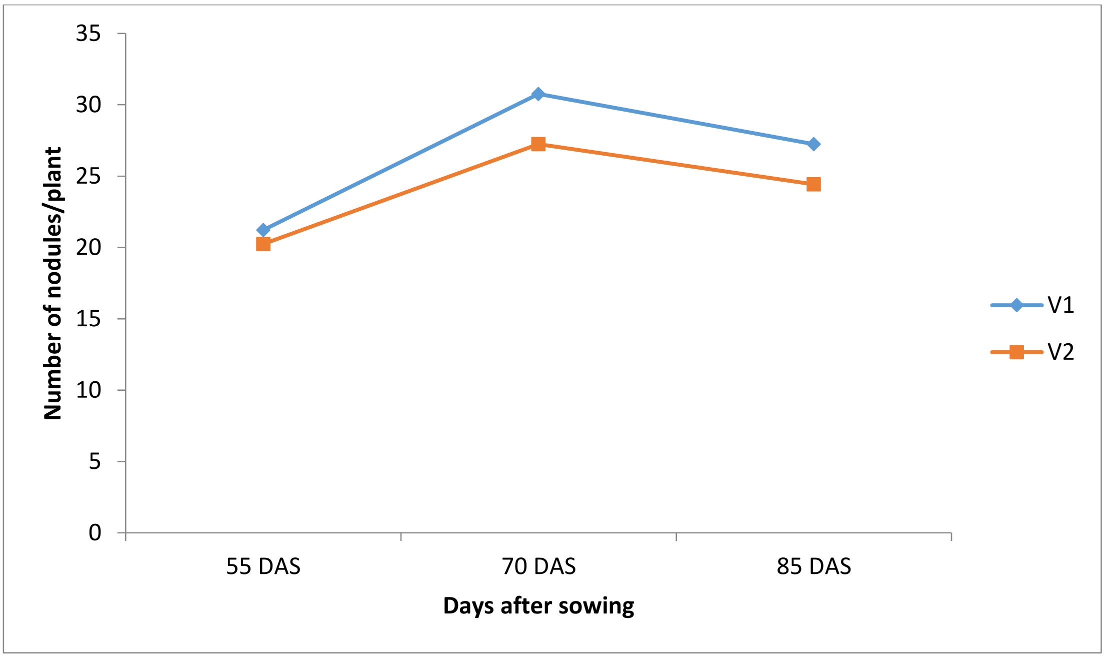

Fig. 8. Number of nodules plant^{-1} of chickpea influenced by different variety ($LSD_{0.05}$ = 0.104, 1.033, 1.107 at 55, 70 and 85 DAS respectively)

V_1= BARI Chola-5, V_2= BARI Chola- 9

Effect bio-fertilizer and inorganic fertilizer combination

Considerable variation was found on number of nodules plant^{-1} affected by bio-fertilizer and inorganic fertilizer combination (Fig. 9). Results signified that the highest number of nodules plant^{-1} (26.06, 36.42 and 32.95 at 55, 70 and 85 DAS, respectively) was achieved from F_4 (Recommended dose of inorganic fertilizer + bio fertilizer) which was significantly different from all other treatments followed by F_3 (25% less recommended dose of inorganic fertilizer + bio fertilizer) at all growth stages. The lowest number of nodules plant^{-1} (13.89, 19.39 and 17.14 at 55, 70 and 85 DAS, respectively) was found from the treatment, F_1 (75% less recommended dose of inorganic fertilizer + bio fertilizer) followed by F_2 (50% less recommended dose of inorganic fertilizer + bio fertilizer) at all growth stages. The results obtained from the present study was in agreement the findings of Hamaoui and Sheikh (2001) and Rokhzadi and Toashih (2011).

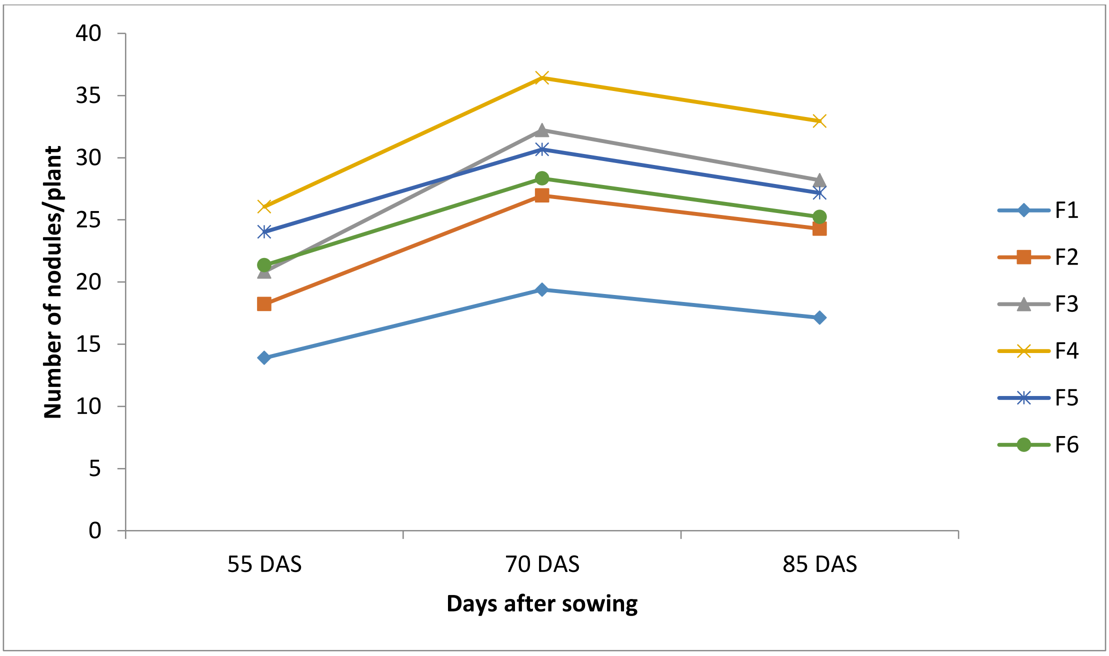

Fig. 9. Number of nodules plant^{-1} of chickpea influenced by different combinations of bio fertilizer and inorganic fertilizer ($LSD_{0.05}$ = 0.685, 1.012 and 1.156 at 55, 70 and 85 DAS)

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

Combined effect of variety and bio-fertilizer inorganic fertilizer combination

Combined effect of variety and bio-fertilizer inorganic fertilizer combination had significant influence on number of nodules plant^{-1} (Table 3). Results indicated that the highest number of nodules plant^{-1} (27.11, 38.67 and 34.11 at 55, 70 and 85 DAS, respectively) was recorded from the treatment combination of V_1F_4 which was significantly different from all other treatment combinations followed by V_2F_4 and V_1F_5 at all growth stages. Similarly, the lowest number of nodules plant^{-1} (13.67, 18.11 and 26.11 at 55, 70 and 85 DAS, respectively) was recorded from the treatment combination of V_2F_1 which was closely followed by V_1F_1 at all growth stages.

Table 3. Number of nodules plant^{-1} of chickpea influenced by combined effect of variety and combinations of bio fertilizer and inorganic fertilizer

Treatment	**Number of nodules plant^{-1} at**		
	55 DAS	**70 DAS**	**85 DAS**
V_1F_1	14.11 i	20.67 g	18.17 g
V_1F_2	19.44 g	28.89 e	25.67 de
V_1F_3	20.33 ef	34.65 b	30.22 b
V_1F_4	27.11 a	38.67 a	34.11 a
V_1F_5	24.17 bc	32.56 c	28.67 c
V_1F_6	22.13 d	29.11 de	26.56 d
V_2F_1	13.67 i	18.11 h	16.11 d
V_2F_2	17.00 h	25.03 f	22.89 f
V_2F_3	21.33 de	29.78 d	26.17 d
V_2F_4	25.00 b	34.17 b	31.78 b
V_2F_5	23.89 bc	28.78 e	25.67 de
V_2F_6	20.56 e	27.55 f	23.89
$LSD_{0.05}$	**0.674**	**1.288**	**1.074**
CV (%)	**5.867**	**8.312**	**8.544**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly

V_1= BARI Chola-5, V_2= BARI Chola- 9

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

4.1.5 Nodule dry weight plant^{-1}

Effect of variety

Significant influence was observed on nodule dry weight plant^{-1} of chickpea influenced by different variety (Fig. 10 and). It was found that the highest nodule dry weight plant^{-1} (87.07, 144.33, 141.31 g at 55, 70 and 85 DAS, respectively) was recorded from V_1 (BARI Chola-5) where the lowest nodule dry weight plant^{-1} (83.94, 139.07 and 133.58 g at 55, 70 and 85 DAS, respectively) was obtained from V_2 (BARI Chola-9).

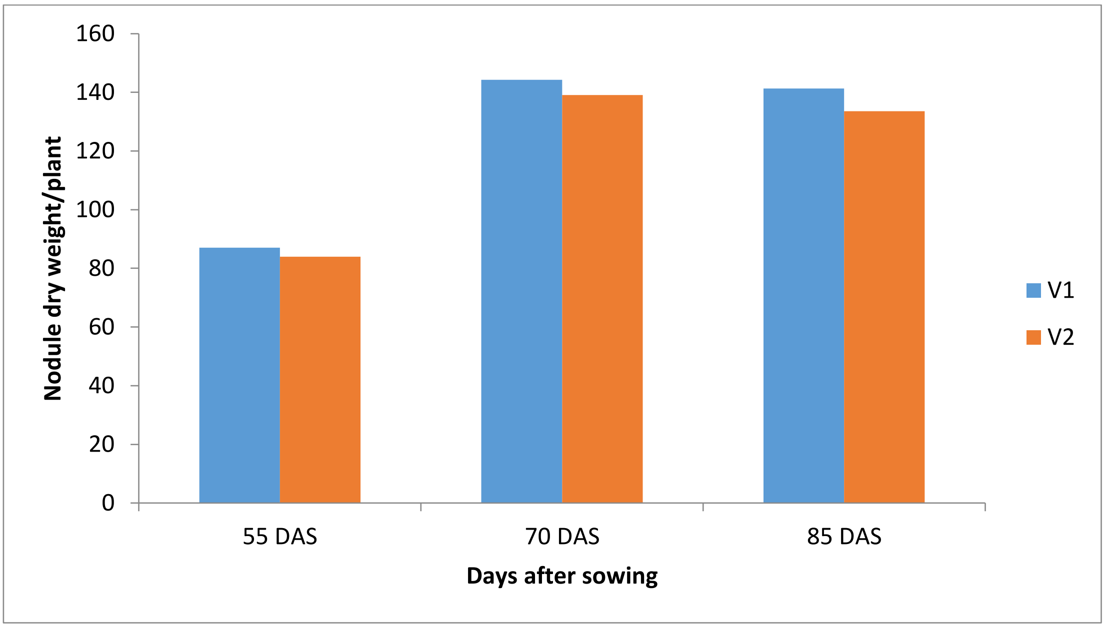

Fig. 10. Nodule dry weight plant^{-1} of chickpea influenced by different variety ($LSD_{0.05}$ = 1.052, 1.107 and 1.115 at 55, 70 and 85 DAS)

V_1= BARI Chola-5, V_2= BARI Chola- 9

Effect bio-fertilizer and inorganic fertilizer combination

Considerable variation was found on nodule dry weight plant^{-1} affected by bio-fertilizer and inorganic fertilizer combination (Fig. 11).. Results signified that the highest nodule dry weight plant^{-1} (95.92, 161.40 and 152.12 g at 55, 70 and 85

DAS, respectively) was achieved from F_4 (Recommended dose of inorganic fertilizer + bio fertilizer) which was significantly different from all other treatments followed by F_5 (25% higher recommended dose of inorganic fertilizer + bio fertilizer) and F_3 (25% less recommended dose of inorganic fertilizer + bio fertilizer). The lowest nodule dry weight plant^{-1} (71.37, 119.63 and 117.00 g at 55, 70 and 85 DAS, respectively) was found from the treatment, F_1 (75% less recommended dose of inorganic fertilizer + bio fertilizer) followed by F_2 (50% less recommended dose of inorganic fertilizer + bio fertilizer) at all growth stages.

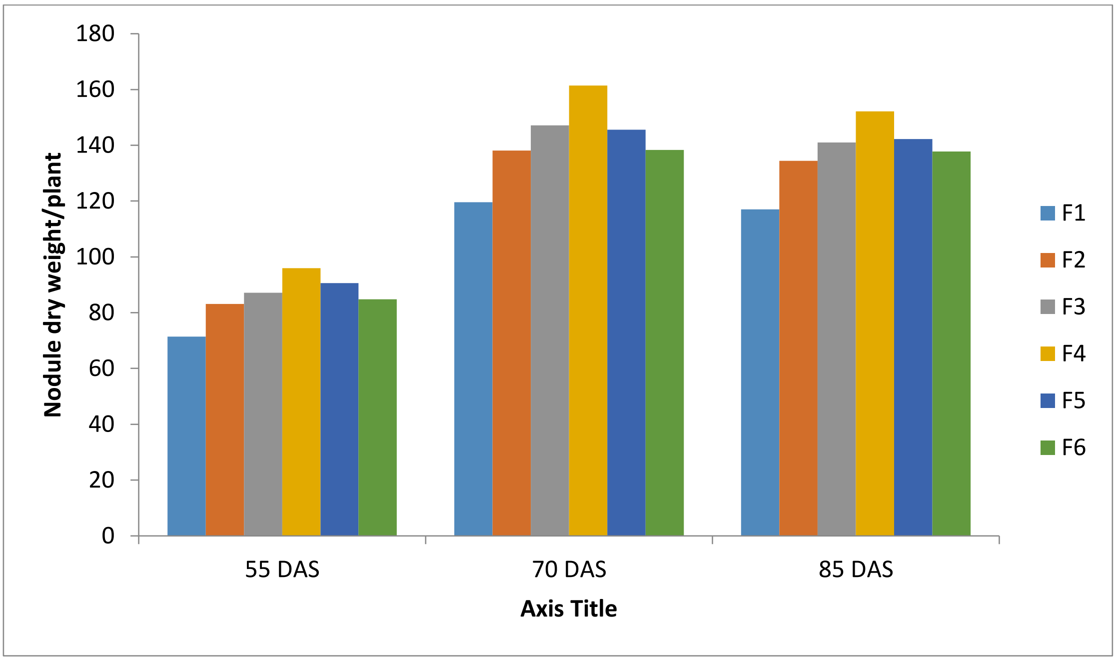

Fig. 11. Nodule dry weight plant^{-1} of chickpea influenced by different combinations of bio fertilizer and inorganic fertilizer ($LSD_{0.05}$ = 0.671, 1.144 and 1.352 at 55, 70 and 85 DAS respectively)

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination had significant influence on nodule dry weight plant^{-1} (Table 4). Results indicated that the highest nodule dry weight plant^{-1} (98.11, 162.42 and 156.18 g at 55, 70 and 85 DAS, respectively) was recorded from the treatment combination of V_1F_4 which was significantly different from all other treatment combinations followed by V_2F_4 and V_1F_5 at all growth stages. Similarly, the lowest nodule dry weight plant^{-1} (70.16, 118.24 and 116.43 at 55, 70 and 85 DAS, respectively) was recorded from the treatment combination of V_2F_1 which was statistically identical with V_1F_1 at 85 DAS.

Table 4. Nodule dry weight plant^{-1} of chickpea influenced by combined effect of variety and combinations of bio fertilizer and inorganic fertilizer

Treatment	Nodule dry weight plant^{-1} (g) at		
	55 DAS	**70 DAS**	**85 DAS**
V_1F_1	72.57 ef	121.02 ef	117.57 e
V_1F_2	85.16 d	142.04 c	137.67 d
V_1F_3	86.27 d	150.47 b	143.35 c
V_1F_4	98.11 a	162.42 a	156.18 a
V_1F_5	91.13 bc	148.47 b	148.17 b
V_1F_6	89.17 c	141.53 c	144.93 c
V_2F_1	70.16 f	118.24 f	116.43 e
V_2F_2	81.09 e	134.16 d	131.23 e
V_2F_3	88.12 cd	143.76 c	138.76 d
V_2F_4	93.73 b	160.37 a	148.06 b
V_2F_5	90.01 c	142.73 c	136.29 d
V_2F_6	80.53	135.13 d	130.73 e
$LSD_{0.05}$	**1.417**	**2.512**	**1.314**
CV (%)	**9.524**	**11.316**	**10.341**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly

V_1= BARI Chola-5, V_2= BARI Chola- 9

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

4.2 Yield and yield contributing parameters

4.2.1 Number of pods plant^{-1}

Effect of variety

Significant variation was observed on number of pods plant^{-1} of chickpea influenced by different variety (Table 5). It was noted that the highest number of pods plant^{-1} (45.52) was recorded from V_2 (BARI Chola-9) where the lowest number of pods plant^{-1} (44.37) was obtained from V_1 (BARI Chola-5).

Effect of bio-fertilizer + inorganic fertilizer combination

Significant variation was observed on number of pods plant^{-1}as influenced by bio-fertilizer and inorganic fertilizer combination (Table 5). It was noted that the highest number of pods plant^{-1} (52.33) achieved from F_4 (Recommended dose of inorganic fertilizer + bio fertilizer) followed by F_6 (50% higher recommended dose of inorganic fertilizer + bio fertilizer). The lowest number of pods plant^{-1} (38.37) was found from the treatment, F_1 (75% less recommended dose of inorganic fertilizer + bio fertilizer) which was nearest to F_3 (25% less recommended dose of inorganic fertilizer + bio fertilizer) but significantly different. Kader *et al.* (2002) and Shehata and El-Khawas (2003) also found similar results with the present study.

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination had significant influence on number of pods plant^{-1} (Table 5). Results indicated that the highest number of pods plant^{-1} (54.33) was recorded from the treatment combination of V_2F_4 which was significantly different from all other treatments followed by V_1F_4 and V_2F_6. Similarly, the lowest number of pods plant^{-1} (54.33) was recorded from the treatment combination of V_2F_1 which was significantly different from all other treatment combinations followed by V_1F_1.

4.2.2 Weight 1000 seeds

Effect of variety

Significant variation was observed on 1000 seed weight of chickpea influenced by different variety (Table 5 IX). It was noted that the highest 1000 seed weight (210.61 g) was recorded from V_2 (BARI Chola-9) where the lowest 1000 seed weight (130.85 g) was obtained from V_1 (BARI Chola-5).

Effect of bio-fertilizer + inorganic fertilizer combination

There observed significant variation on 1000 seed weight of Chickpea as influenced by bio-fertilizer and inorganic fertilizer combination (Table 5). The results verified that the highest 1000 seed weight (183.52 g) achieved from F_5 (25% higher recommended dose of inorganic fertilizer + bio fertilizer) which was statistically identical with F_3 (25% less recommended dose of inorganic fertilizer + bio fertilizer), F_4 (Recommended dose of inorganic fertilizer + bio fertilizer) and F_6 (50% higher recommended dose of inorganic fertilizer + bio fertilizer). The lowest 1000 seed weight (117.45 g) was found from the treatment, F_1 (75% less recommended dose of inorganic fertilizer + bio fertilizer) which was significantly different from all other treatments followed by F_2 (50% less recommended dose of inorganic fertilizer + bio fertilizer).

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination had significant influence on 1000 seed weight (Table 5 and Appendix IX). Results indicated that the highest 1000 seed weight (234.02 g) was recorded from the treatment combination of V_2F_5 which was statistically identical with V_2F_3, V_2F_4 and V_2F_6. Similarly, the lowest 1000 seed weight (110.38 g) was recorded from the treatment combination of V_2F_1 which was significantly different from all other treatment combinations followed by V_1F_1.

4.2.3 Grain yield

Effect of variety

Significant variation was observed on grain yield of chickpea influenced by different variety (Table 5). It was noted that the highest grain yield (2.46 t ha^{-1}) was recorded from V_2 (BARI Chola-9) where the lowest grain yield (2.04 t ha^{-1}) was obtained from V_1 (BARI Chola-5). It can be inferred form the result that V_2 (BARI Chola-9) out yielded over V_1 (BARI Chola-5) by producing 20.58% higher yield.

Effect bio-fertilizer and inorganic fertilizer combination

Grain yield influenced significantly due to bio-fertilizer and inorganic fertilizer combination in Chola (Table 5). The results revealed that the highest grain yield (2.59 t ha^{-1}) achieved from F_5 (25% higher recommended dose of inorganic fertilizer + bio fertilizer) which was significantly different from all other treatments followed by F_4 (Recommended dose of inorganic fertilizer + bio fertilizer). The lowest grain yield (1.77 t ha^{-1}) was found from the treatment, F_1 (75% less recommended dose of inorganic fertilizer + bio fertilizer) which was significantly different from all other treatments followed by F_2 (50% less recommended dose of inorganic fertilizer + bio fertilizer).

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination

Combined effect of variety and bio-fertilizer + inorganic fertilizer combination had significant influence on grain yield (Table 5). Results indicated that the highest grain yield (2.83) was recorded from the treatment combination of V_2F_5

which was statistically identical with V_2F_4 followed by V_2F_3 and V_2F_6. Similarly, the lowest grain yield (1.57 t ha^{-1}) was recorded from the treatment combination of V_2F_1 which was significantly different from all other treatment combinations followed by V_1F_2.

Table 5. Yield and yield contributing parameters of chickpea influenced by different combinations of bio fertilizer and inorganic fertilizer

Treatment	Yield and yield contributing parameters		
	Number of pods plant^{-1}	**1000 seed weight (g)**	**Grain yield (t ha^{-1})**
Effect of variety			
V_1	44.37 b	130.85 b	2.04 b
V_2	45.52 a	210.61 a	2.46 a
$LSD_{0.05}$	**0.544**	**2.254**	**0.102**
CV (%)	**5.288**	**7.389**	**4.386**
Effect of bio-fertilizer and inorganic fertilizer combination			
F_1	38.37 e	117.45 c	1.77 e
F_2	44.27 c	175.53 b	2.08 d
F_3	43.90 d	182.10 a	2.31 c
F_4	52.33 a	183.08 a	2.49 b
F_5	44.07 c	183.52 a	2.59 a
F_6	46.74 b	182.70 a	2.27 c
$LSD_{0.05}$	**0.457**	**2.884**	**0.112**
CV (%)	**7.866**	**9.214**	**5.289**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly

V_1= BARI Chola-5, V_2= BARI Chola- 9

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

Table 6. Yield and yield contributing parameters of chickpea influenced by combined effect of variety and different combinations of bio fertilizer and inorganic fertilizer

Treatment	Yield and yield contributing parameters		
	Number of pods plant^{-1}	1000 seed weight (g)	Grain yield (t ha^{-1})
V_1F_1	38.93 i	124.51 d	1.57 g
V_1F_2	42.40 g	130.29 c	1.90 f
V_1F_3	47.33 d	131.81 c	2.09 e
V_1F_4	50.33 b	132.89 c	2.21 d
V_1F_5	42.13 g	133.02 c	2.35 cd
V_1F_6	45.07 f	132.57 c	2.12 e
V_2F_1	37.80 j	110.38 e	1.96 ef
V_2F_2	46.13 e	220.77 b	2.26 d
V_2F_3	40.47 h	232.39 a	2.53 b
V_2F_4	54.33 a	233.26 a	2.77 a
V_2F_5	46.00 e	234.02 a	2.83 a
V_2F_6	48.40 c	232.83 a	2.42 b
$LSD_{0.05}$	**0.586**	**1.235**	**0.142**
CV (%)	**7.866**	**9.214**	**5.289**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly

V_1= BARI Chola-5, V_2= BARI Chola- 9

F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer
F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer
F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer
F_4= Recommended dose of inorganic fertilizer + bio fertilizer
F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer
F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was carried out at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka from November, 2016 to March 2017 to study the to study the impact of different combinations of bio fertilizer and inorganic fertilizer on growth and yield of chickpea. Two varieties of chickpea (V_1: BARI Chola-5 and V_2: BARI Chola-9) and six bio fertilizer and inorganic fertilizer combination treatments (F_1= 75% less recommended dose of inorganic fertilizer + bio fertilizer, F_2= 50% less recommended dose of inorganic fertilizer + bio fertilizer, F_3= 25% less recommended dose of inorganic fertilizer + bio fertilizer, F_4= Recommended dose of inorganic fertilizer + bio fertilizer, F_5= 25% higher recommended dose of inorganic fertilizer + bio fertilizer and F_6= 50% higher recommended dose of inorganic fertilizer + bio fertilizer) were used in the experiment where *Trichoderma* was considered as biofertilizer. The data on crop growth and yield parameters were collected. Collected data were statistically analyzed for the evaluation of best treatment effects for cheickpea variety and the best combination.

Evaluation of growth parameters, in terms varietal performance, results revealed that the highest plant height (14.26, 25.42, 36.57, 41.02 and 34.87 cm at 30, 50, 70, 85 DAS and at harvest, respectively), number of branches plant^{-1} (2.13, 3.58, 5.55, 4.30 and 4.03 at 30, 50, 70, 85 DAS and at harvest, respectively) and dry weight plant^{-1} (0.21, 1.14, 2.92, 4.91 and 4.51 g at 30, 50, 70, 85 DAS and at harvest, respectively) were recorded from V_2 (BARI Chola-9) but the highest number of nodules plant^{-1} (21.22, 30.76 and 27.23 at 55, 70 and 85 DAS, respectively) and nodule dry weight plant^{-1} (87.07, 144.33, 141.31 g at 55, 70 and 85 DAS, respectively) were achieved from V_1 (BARI Chola-5). Again, the lowest pant height (10.94, 18.93, 30.24, 34.51 and 30.12 at 30, 50, 70, 85 DAS and at harvest, respectively), number of branches plant^{-1} (11.78, 3.47, 5.47, 4.11 and 3.60 at 30, 50, 70, 85 DAS and at harvest, respectively) and dry weight plant^{-1} (0.14, 0.78, 1.84, 3.82 and 3.55 g at 30, 50, 70, 85 DAS and at harvest, respectively) was obtained from V_1 (BARI Chola-5) where the lowest number of nodules plant^{-1} (20.24, 27.24 and 24.42 at 55, 70 and 85 DAS, respectively) and nodule dry weight plant^{-1} (83.94, 139.07 and 133.58 g at 55, 70 and 85 DAS, respectively) was obtained from V_2 (BARI Chola-9).

Considering the effect of bio-fertilizer and inorganic fertilizer combination, the highest plant height (14.45, 25.05, 37.69, 42.29 and 36.22 cm at 30, 50, 70, 85 DAS and at harvest, respectively), number of branches plant^{-1} (2.03, 4.29, 6.73, 4.98 and 4.57 at 30, 50, 70, 85 DAS and at harvest, respectively) and dry weight plant^{-1} (0.21, 0.99, 3.11, 5.24 and 4.66 g at 30, 50, 70, 85 DAS and at harvest, respectively) were obtained from F_6 (50% higher recommended dose of inorganic fertilizer + bio fertilizer) where the highest number of nodules plant^{-1} (26.06, 36.42 and 32.95 at 55, 70 and 85 DAS, respectively) and nodule dry weight plant^{-1} (95.92, 161.40 and 152.12 g at 55, 70 and 85 DAS, respectively) were achieved from F_4 (Recommended dose of inorganic fertilizer + bio fertilizer). Again, the lowest pant height (10.66, 20.06, 28.84, 34.69 and 28.84 cm at 30, 50, 70, 85 DAS and at harvest, respectively), number of branches plant^{-1} (1.95, 2.60, 4.25, 3.63 and 3.15 cm at 30, 50, 70, 85 DAS and at harvest, respectively), dry weight plant^{-1} (0.13, 0.77, 1.80, 3.51 and 3.23 g at 30, 50, 70, 85 DAS and at harvest, respectively), number of nodules plant^{-1} (13.89, 19.39 and 17.14 at 55, 70 and 85 DAS, respectively) and nodule dry weight plant^{-1} (71.37, 119.63 and 117.00 g at 55, 70 and 85 DAS, respectively) were found from the treatment, F_1 (75% less recommended dose of inorganic fertilizer + bio fertilizer).

In terms of combined effect of variety and bio-fertilizer inorganic fertilizer combination, the highest plant height(15.83, 28.07, 40.27, 44.63 and 37.45 cm at 30, 50, 70, 85 DAS and at harvest, respectively), number of branches plant^{-1} (2.46, 4.40, 6.80, 5.20 and 4.73 at 30, 50, 70, 85 DAS and at harvest, respectively) and dry weight plant^{-1} (0.263, 1.360, 3.630, 5.959 and 5.192 g at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from the treatment combination of V_2F_6 where the highest number of nodules plant^{-1} (27.11, 38.67 and 34.11 at 55, 70 and 85 DAS, respectively) and nodule dry weight plant^{-1} (98.11, 162.42 and 156.18 g at 55, 70 and 85 DAS, respectively) was recorded from the treatment combination of V_1F_4. Again, the lowest plant height (9.02, 16.45, 24.58, 30.67 and 25.67 cm at 30, 50, 70, 85 DAS and at harvest, respectively), number of branches plant^{-1} (1.60, 2.53, 4.17, 3.53 and 2.86 at 30, 50, 70, 85 DAS and at harvest, respectively) and dry weight plant^{-1} (0.125, 0.525, 1.269, 3.089 and 2.988 g at 30, 50, 70, 85 DAS and at harvest, respectively) was recorded from the treatment combination of V_1F_1 but the lowest number of nodules plant^{-1} (13.67, 18.11 and 26.11 at 55, 70 and 85 DAS, respectively) and nodule dry weight plant^{-1} (70.16, 118.24 and 116.43 at 55, 70 and 85 DAS, respectively) was recorded from the treatment combination of V_2F_1.

Evaluation of yield and yield contributing parameters, the variety, V_2 (BARI Chola-9 gave the highest number of pods plant^{-1} (45.52), 1000 seed weight (210.61 g) and grain yield (2.46 t ha^{-1}) where the lowest number of pods plant^{-1} (44.37), 1000 seed weight (130.85 g) and grain yield (2.04 t ha^{-1}) was obtained from V_1 (BARI Chola-5).

Again, in terms of effect of bio-fertilizer and inorganic fertilizer combination, the highest 1000 seed weight (183.52 g) and grain weight (2.59 t ha^{-1}) achieved from F_5 (25% higher recommended dose of inorganic fertilizer + bio fertilizer) but the highest number of pods plant^{-1} (52.33) was achieved from F_4 (Recommended dose of inorganic fertilizer + bio fertilizer). On the other hand, the lowest number of pods plant^{-1} (38.37), lowest 1000 seed weight (117.45 g) and lowest grain yield (1.77 t ha^{-1}) was found from the treatment, F_1 (75% less recommended dose of inorganic fertilizer + bio fertilizer).

Considering the Combined effect of variety and bio-fertilizer inorganic fertilizer combination, the highest number of pods plant^{-1} (54.33) was recorded from the treatment combination of V_2F_4 but the highest 1000 seed weight (234.02 g) and grain yield (2.83) was recorded from the treatment combination of V_2F_5 where the lowest number of pods plant^{-1} (54.33), lowest 1000 seed weight (110.38 g) and lowest grain yield (1.57 t ha^{-1}) was recorded from the treatment combination of V_2F_1.

From the above findings, it can be concluded that the variety V_2 (BARI Chola-9) gave the best performance with the treatment of 25% higher recommended dose of inorganic fertilizer + bio fertilizer (V_2F_5) on growth and yield performance of chickpea. So, this treatment combination can be treated as the best under the present study.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

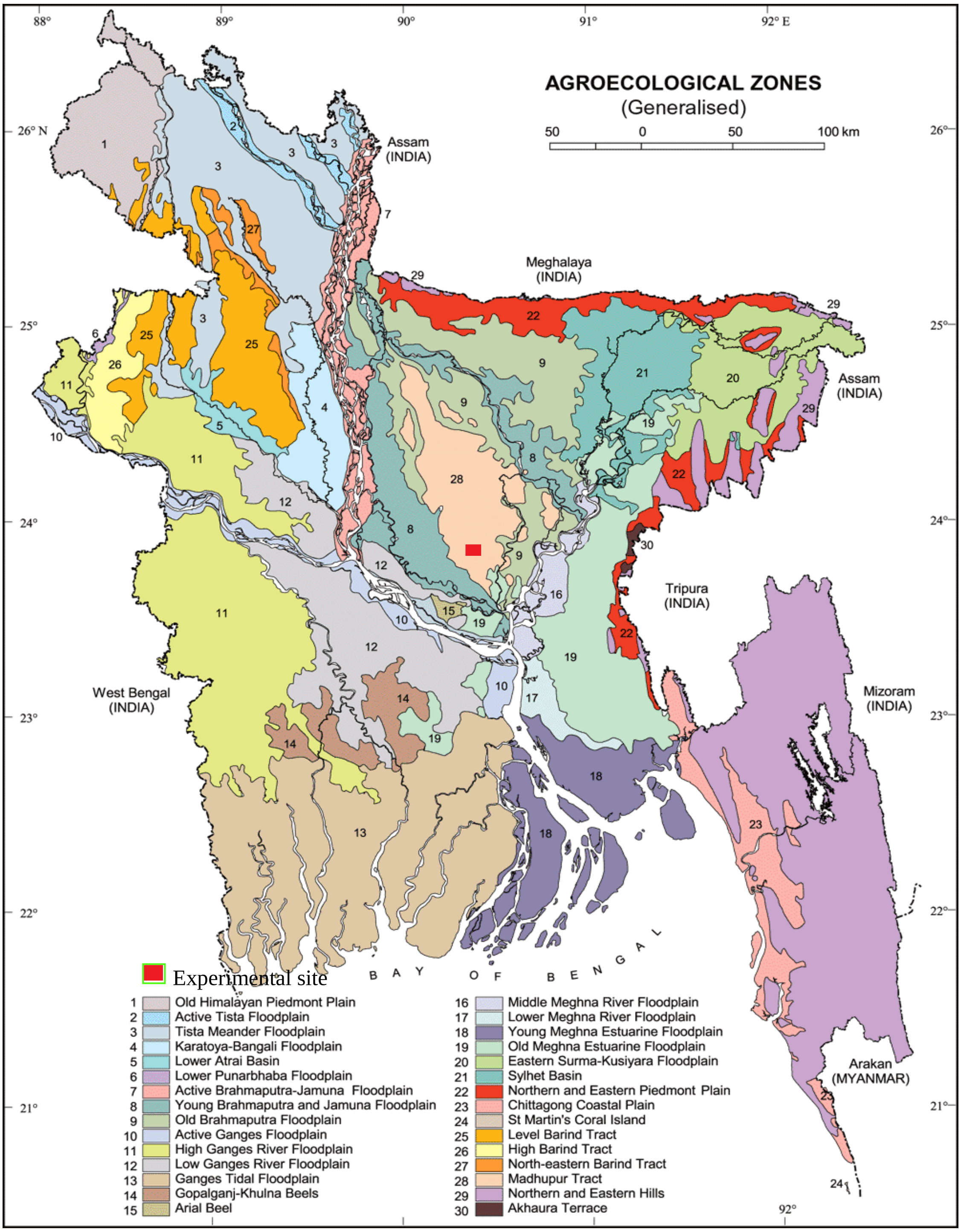

Fig. 12. Experimental site

Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from November 2016 to March, 2017

Month	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	*Min.*	*Mean*	
November 2016	56.75	28.60	8.52	18.56	14.40
December 2016	54.80	25.50	6.70	16.10	0.0
January 2017	46.20	23.80	11.70	17.75	0.0
February 2017	37.90	22.75	14.26	18.51	0.0
March 2017	52.44	35.20	21.00	28.10	20.4

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

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Plant height of chickpea influenced by combined effect of variety and combinations of bio fertilizer and inorganic fertilizer

Sources of variation	Degrees of freedom	Mean square of plant height				
		30 DAS	50 DAS	70 DAS	85 DAS	At harvest
Replication	2	0.224	1.304	0.428	1.218	1.352
Factor A	1	16.283*	12.624*	18.347*	16.386*	15.839**
Factor B	5	22.884*	19.689*	26.389*	24.597*	32.514*
AB	5	7.389*	10.633**	12.546*	18.671**	16.642*
Error	22	1.126	1.544	1.835	2.314	2.746

* = 5% level of significanct ** = 1% level of significanct

Appendix V. Number of branches plant^{-1} of chickpea influenced by combined effect of variety and combinations of bio fertilizer and inorganic fertilizer

Sources of variation	Degrees of freedom	Mean square of number of branches plant^{-1}				
		30 DAS	50 DAS	70 DAS	85 DAS	At harvest
Replication	2	0.020	0.091	0.051	0.022	0.064
Factor A	1	0.770*	1.40**	2.300*	2.684*	2.808**
Factor B	5	1.162*	3.561*	5.039**	5.507*	7.165*
AB	5	1.282**	1.033*	1.151*	2.613*	3.114*
Error	22	0.017	0.041	0.067	0.172	0.167

* = 5% level of significanct ** = 1% level of significanct

Appendix VI. Dry weight plant^{-1} of chickpea influenced by combined effect of variety and combinations of bio fertilizer and inorganic fertilizer

Sources of variation	Degrees of freedom	Mean square of dry weight plant^{-1}				
		30 DAS	50 DAS	70 DAS	85 DAS	At harvest
Replication	2	0.004	0.113	0.099	0.102	0.087
Factor A	1	0.104**	3.588*	3.524*	3.887*	6.714 *
Factor B	5	1.766**	6.146**	7.114*	7.62**	8.577*
AB	5	0.644**	2.311*	2.211*	4.713*	5.281*
Error	22	0.012	0.022	0.174	0.294	0.536

* = 5% level of significanct ** = 1% level of significanct

Appendix VII. Number of nodules plant^{-1} of chickpea influenced by combined effect of variety and combinations of bio fertilizer and inorganic fertilizer

Sources of variation	Degrees of freedom	Mean square of number of nodules plant^{-1}		
		55 DAS	70 DAS	85 DAS
Replication	2	0.442	0.852	0.817
Factor A	1	16.57*	15.258*	12.03*
Factor B	5	26.08**	29.762*	28.79*
AB	5	10.64*	12.235*	9.68**
Error	22	1.139	2.258	1.012

* = 5% level of significanct ** = 1% level of significanct

Appendix VIII. Nodule dry weight plant^{-1} of chickpea influenced by combined effect of variety and combinations of bio fertilizer and inorganic fertilizer

Sources of variation	**Degrees of freedom**	**Mean square of nodule dry weight plant^{-1}**		
		55 DAS	**70 DAS**	**85 DAS**
Replication	2	1.966	2.042	2.018
Factor A	1	21.697**	29.684*	33.58*
Factor B	5	36.644*	54.517*	59.02**
AB	5	11.251*	14.663*	14.671*
Error	22	2.117	3.372	3.139

* = 5% level of significanct ** = 1% level of significanct

Appendix IX. Yield and yield contributing parameters of chickpea influenced by variety and also different bio fertilizer and inorganic fertilizer combinations

Sources of variation	**Degrees of freedom**	**Mean square of yield and yield contributing parameters**		
		Number of pods plant^{-1}	**1000 seed weight**	**Grain weight**
Replication	2	2.881	2.901	0.022
Factor A	1	13.03*	41.691*	4.263*
Factor B	5	31.70*	118.67*	8.295*
AB	5	27.61**	64.271*	12.03*
Error	22	2.012	1.107	0.471

* = 5% level of significanct ** = 1% level of significanct

Appendix X. Some pictorial presentation

Fig. 13. Young Seedlings

Fig. 14. Field View

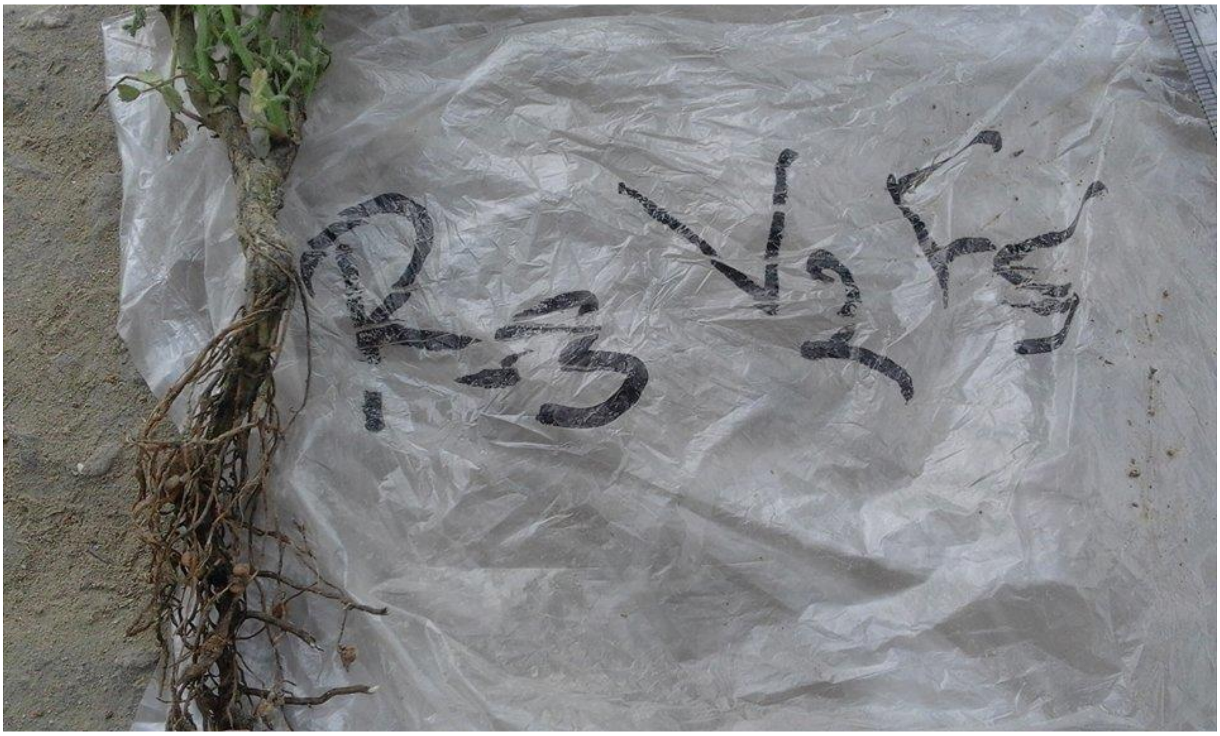

Fig. 15. Plant Nodule

Fig. 16. Matured Plants

Fig. 17. Data Collection

Fig. 18. Drying Plants