INFLUENCE OF INORGANIC AND ORGANIC FERTILIZER ON GROWTH AND YIELD OF SOYBEAN

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ABSTRACT

Present research work was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2015 to March, 2016 to study the influence of different combinations of inorganic and organic fertilizer on soybean (var. BARI Soybean 6). The treatment combinations of inorganic and organic fertilizers *viz.*, T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD were tested in a 3 times replication with Randomized Complete Block Design (RCBD). Results indicated that, T_1 (Fertilizer at Recommended Dose, FRD-Urea: 50 kg ha^{-1}, TSP: 150 kg ha^{-1}, MP: 100 kg ha^{-1}, Gypsum: 80 kg ha^{-1} and Boron: 500 g ha^{-1}), T_7 (Vermicompost + 75% FRD) and T_9 (Poultry litter + 75% FRD) influenced significantly on most of the growth, yield parameters and yield of soybean. Application of fertilizers at recommended dose, vermicompost + 75% FRD and poultry litter + 75% FRD produced higher level of grain yield 2053, 2073 and 2166 kg ha^{-1} respectively. The treatments T_1, T_7 and T_9 also showed statistically similar results in respect of yield and yield contributing characters. Poultry litter + 75% FRD and vermicompost + 75% FRD produced 5.50 and 4.49% higher yield over FRD. The maximum yield might be attributed to higher number of pods $plant^{-1}$ and seeds pod^{-1} . Considering the sustainable yield and sound environment, poultry litter + 75% FRD (T_9) or vermicompost + 75% FRD (T_7) seems promising for soybean cultivation.

CHAPTER I

INTRODUCTION

Soybean (*Glycine max* L. Merrill) is one of the important oilseed pulse in the world. It became miracle crop of 20th century and designated as "Golden Bean". It is also considered as "Protein hope of future" for its nutritional value in Bangladesh. Soybean crop was introduced in sixties as supplementary oilseed crop to overcome the edible oil shortage in the country. Among grain legumes, soybean is an economically important crop that is grown in diverse environments throughout the world. Its adaptation to tropical and subtropical regions is still involving extensive breeding work (ITC, 1990). Nutritional point of view, soybean is an excellent source of vegetarian protein as well as vegetable oil. It contains high amount of protein 40-45 % protein, 18-20 % edible oil, 24-26 % carbohydrate and a rich source of vitamin A, B and D, 38-43% minerals and 2% phospholipids. (Kaul and Das, 1986); nutritional superiority on account of containing essential amino acids, unsaturated fatty acids and carbohydrates (Pawar *et al*., 2011).The soybean oil is cholesterol free and is an easily acceptable diet. Soybean accounts for approximately 50 % of the total production of oilseed crops in the world (FAO, 2007). As a grain legume, it is gaining important position in the agriculture of tropical countries including Bangladesh. In addition, being legume crop soybean is having considerable potentiality to fix atmospheric nitrogen. In Bangladesh, the area coverage of soybean is 60,893 ha and the annual production is 112,024 tons with an average yield of 1.83 t ha^{-1} (FAOSTAT, 2014).

After green revolution, the use of chemical fertilizer is tremendously increased all over the world. This injudicious heavy application of chemical fertilizers may cause depletion of certain nutrients in soil and certain others would generally accumulate in excess resulting in nutrient imbalance which affects the soil productivity as well as sometimes enter in food chain and are also injurious to human being. The average yield is deplorably low in Bangladesh because of injudicious use of plant nutrients. Hence, a balanced nutrients application and adoption of appropriate agronomic practices is must to harness the productivity of the crops. The long-term use of inorganic fertilizers without organic supplements damages the soil physical, chemical and biological properties and causes

environmental pollution. Organic manures act not only as a source of nutrients and organic matter, but also increase size, biodiversity and activity of the microbial population in soil, influence structure, nutrients get turnover and many other changes related to physical, chemical and biological parameters of the soil (Albiach *et al*., 2000). Environmental degradation is a major threat confronting the world, and the rampant use of chemical fertilizers contribute largely to the deterioration of the environment through depletion of fossil fuels, generation of carbon dioxide and contamination of water resources. It leads to loss of soil fertility due to abrupt use of fertilizers that has adversely impacted agricultural productivity and caused soil degradation. Now there is a growing realization that the adoption of ecological and sustainable farming practices can only reverse the declining trend in the global productivity and environment protection (Wani *et al*., 1995; Wani and Lee, 1992; Aveyard, 1988). Use of organic manures alone or in combination of chemical fertilizers will help to improve physic-chemical properties of the soils, Organic manures provide a good substrate for the growth of microorganisms and maintain a favorable nutritional balance and soil physical properties. One such strategy to maintain soil fertility for sustainable production of soybean is through judicious use of fertilizers (Bobde *et al*., 1998) coupled with organic resources that to achieve sustainability in production, the use of organic manures alone is not sufficient (Prasad, 1996). It has also been brought out that the use of organic manures in integration with fertilizers meets the need of micronutrients of soybean (Joshi *et al*., 2000). Lourduraj (2000) has also reported that the combined application of' inorganic and organic manures significantly enhanced the growth attributes and yield of' soybean as compared to the sole application of either of them.

The utilization of biological nitrogen fixation method can decrease the use of chemical nitrogen fertilizer (urea), prevent the depletion of soil organic matter and reduce environmental pollution to a considerable extent (Choudhury and Kennedy, 2004). Several bacteria that are associated with the roots of crop plants can induce beneficial effects on their hosts and often are collectively referred to as PGPR (Plant Growth Promoting *Rhizobacteria*) (Vermeiren *et al*., 1999). The biological fixation of nitrogen produced by these organisms can constitute a significant and ecologically favorable contribution to soil fertility (Vlassak *et al*., 1992). Nitroxin is a biologic nitrogen fertilizer

containing *Azospirillum* and *Azotobacter*. *Azospirillum* belongs to family *Spirilaceae*, heterotrophic and associative in nature. In addition to their nitrogen fixing ability of about 20 to 40 k ha^{-1}, they also produce growth regulating substances (Arun, 2007). Some symbiotic N_2 fixing *Rhizobium* strains not only fix atmospheric N_2 in the nodules but also show an antagonistic effect against soil-borne pathogens (Ganesan *et al*., 2007). Soybeanhas the ability to fix atmospheric nitrogen (N) through root nodule bacteria (*Bradyrhizobium japonicum)* and thus it enriches the soil fertility (Mahabal, 1986). Reports indicated that *B. japonicum* can fix about 300 kg N ha^{-1} $year^{-1}$ in symbiosis with soybean (Keser and Li, 1992). Saber *et al.* (2009) found dual inoculation of faba bean seeds with a mixture of *R. leguminosarum* and followed by foliar spraying led to significant enhancements in number and dry weight of nodules and nitrogenase activity during the growth period. Studies carried out by Wasule *et al.* (2007) clearly revealed that co-inoculation of *Bradyrhizobium* and phosphate microorganism significantly improved soybean growth and its yield components as compared with the sole application of *Bradyrhizobium* or phosphate microorganism. *Bradyrhizobium japonicum* is an important gram-negative bacterium that has the ability to form root nodules on soybeans and to fix atmospheric nitrogen and increase crop yield (Isawa *et al*.,1999). Combined application of' inorganic and organic manures enhanced the growth attributes and yield of soybean as compared to the sole application of either of them was reported by Lourduraj (2000).

Vermicompost are effective organic fertilizers and bio control agents that have organic nutrition role and increase plants growth (Simsek, 2011; Arancon *et al*., 2005). Vermicompost is the microbial composting of organic wastes through earthworm activity to form organic fertilizer which contains higher level of organic matter, organic carbon, total and available N, P, K and micronutrients, microbial and enzyme activities (Parthasarathi *et al*., 2007; Ranganathan, 2006; Edwards and Bohlen, 1996). Application of vermicompost is a sustainable technology capable that improve plants growth and yield of them (Castillo *et al*., 2010).Simsek (2011) concluded that vermicompost can improve food quality and safety. Applications of vermicompost singly or in combination with other organic fertilizer have been proved effective to enhance growth and yield of various plants like Soybean and other crops and yield of them increased (Javed and Panwar, 2013). Arancon *et al.* (2005) reported vermicompost contain most nutrients in

the available forms such as nitrates, phosphates, exchangeable calcium and soluble potassium that have vital role for plants. Vermicompost applications to field soils combined with 50% of the recommended inorganic fertilizers increased the yields of tomatoes (Kolte *et al*., 1999). Tuberlets from a true potato seed line produced the greatest marketable yields, after amending the soils with 75% of the recommended inorganic fertilizers and vermicompost at the rate 2.5 t ha^{-1} (Mrinal *et al*., 1998). Several workers (Banu *et al*., 2008; Zaller, 2007; Ranganathan, 2006) observed that integration of vermicompost with inorganic fertilization tended to increase the yield of crop viz. tomato, potato, rapeseed, groundnut, blackgram, paddy, mulberry and marigold.

The current emphases are on organic agriculture in order to mitigate climate change and increase carbon sequestration. Yields have increased with the application of organic matter (OM) in both cereal and horticultural crops (Aliyu, 2009; Abdullahi and Lombin, 1978). Trials with organic matter on the performance of legumes, particularly on soybean are few. Chiezey and Odunze (2009) found that the application of 1 t ha^{-1} of poultry manure significantly increased the grain yield of soybean. Most recommended rates of OM range between 3-15 t ha^{-1} which is quite high and may not be easily generated by small-scale farmers. Similarly, alternative uses of OM for fencing, thatching and livestock, feed and fuel may preclude their uses for soil amendment. Rather, the emphasis should be on the complementary roles of organic matter with inorganic fertilizers for crop use.

Presently, the chemical fertilizers are the major source of nutrients but escalating costs, coupled with increasing demand of chemical fertilizers and depleting soil health necessitates the safe and efficient use of organics in crop production. These practices were gaining much popularity to enhance and maintain soil organic carbon status for obtaining sustainable crop yields. However, under arable production systems, organic manures suffer from the drawback of slow release of nutrients at initial stages, may cause significant reduction in crop yield and results in lower farm income. Hence the present study was undertaken with following objectives:

- to find out the effects of different combinations of inorganic and organic fertilizers on growth performances of soybean,
- to find out the effects of different combinations of inorganic and organic fertilizers on yield attributes and yield of soybean.

CHAPTER II

REVIEW OF LITERATURE

Integration of organic and inorganic sources of fertilizers bears great significance for sustaining the soil productivity. Inorganic sources mainly include chemical fertilizers, while major organic sources are crop residues, FYM, compost, green manure, oil cakes, bio-fertilizers, vermicompost, bio-gas slurry etc. to improve soil health. From the different experiment, microbial fertilizers like *Rhizobium*, *Azotobacter*, *Bradirhizobium* Blue green algae, *Azolla* etc. have increased the yield and also played important role for minimizing the harmful effect of pesticides and herbicides. An attempt was made in this section to collect and study relevant information available regarding the influence of different combinations of inorganic and organic fertilizer in soybean to gather knowledge helpful in conducting the present research work.

2.1 Effect on growth parameters

2.1.1 Plant height

Patil and Udmale (2016) conducted an experiment on soybean during *kharif* 2007-08 at the Cropping Systems Research Project Farm, M.P.K.V., Rahuri with eight treatments, consisting of organic inputs *viz.* T_1 : Control, T_2 : Farm yard manure (FYM) at 5 t ha^{-1}, T_3 : Vermicompost (VC) at 2 t ha^{-1}, T_4 : FYM + VC (50+50) (2.5 t ha^{-1} + 1 t ha^{-1}), T_5 : FYM + Jeevamrut 2 times (30 and 45 DAS) (FYM 5 t ha^{-1}), T_6 : VC + Jeevamrut 2 times (30 and 45 DAS) (2 t ha^{-1} + 500 lit ha^{-1}), T_7 : FYM+VC (50+50)+Jeevamrut 2 times (30 and 45 DAS) (2.5 t ha^{-1}+1 t ha^{-1} +500 lit ha^{-1}) and T_8 : Jeevamrut 2 times (30 and 45 DAS) (500 lit ha^{-1}). *Rhizobium* and PSB biofertilizer is common to all treatments. They revealed that, the mean tallest plant (63.21 cm) was observed from T_7 treatments while the shortest one (45.80 cm) from control treatment (T_1).

A pot experiment under a rain shelter in Agro Technology Park, Eastern University, Sri Lanka was conducted by Sutharsan *et al.* (2016)to study the effects of different rates of nitrogen and phosphorous on the nodulation and growth of soybean. Fertilizer combinations viz. T_1-30N:150P: 75K: kg ha^{-1}, T_2-70N:150P:75K: kg ha^{-1}, T_3 (control)-

50N:150P:75K: kg ha^{-1}, T_4-50N:125P:75K: kg ha^{-1} and T_5-50N:175P:75K: kg ha^{-1} were used as treatments. They reported that, the highest plant height (70.05 cm) was recorded from T_4 and the lowest (65.00 cm) from T_1 (control treatment).

A field experiment was conducted by Begum *et al*. (2015) at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to study the effects of nitrogen and phosphorus on the performance of soybean. Three levels of nitrogen (0, 25 and 40 kg N ha^{-1}) and four levels of phosphorus (0, 18, 36 and 54 kg P ha^{-1}) were considered as treatment for the experiment. Crop grown with 40 kg N ha^{-1} produced the tallest plant (34.18 cm) and with 0 kg N ha^{-1} treatment produced the shortest plants (30.01cm). Application of 54 kg P ha^{-1} produced the tallest plant (34.26 cm) and 0 kg P ha^{-1} the shortest plants (30.95cm). The highest plant height (36.88 cm) was obtained from the highest level of N and P, whereas, the lowest plant height (27.77 cm) was obtained from the combination of 0 kg N with 36 kg P ha^{-1}.

A field study was conducted by Falodun *et al*. (2015)at the Department of Crop Science, University of Benin Teaching and Research Farm, Benin City, Edo State during the 2012/2013 cropping seasons with six treatments viz: 0, 200 kg ha^{-1} NPK 15:15:15, 10 t ha^{-1} poultry manure (PM), 7 t ha^{-1} poultry manure + 60 kg ha^{-1} NPK 15:15:15, 5 t ha^{-1} poultry manure + 100 kg ha^{-1} NPK 15:15:15, 2.5 t ha^{-1} poultry manure + 150 kg ha^{-1} NPK 15:15:15. They reported that, application of 2.5 t ha^{-1} PM and 150 kg ha^{-1} NPK gave the highest plant height (70.9 cm). The minimum plant height of (46.0 cm) was observed with the control (no fertilizers).

An on farmer's fields (twelve farmers)' study was carried out by Zoundji *et al.* (2015) in Northern and Centre Benin to determine the effectiveness of *Bradyrhizobium japonicum* strains introduced in Benin cropping systems with five inoculations treatments (control, FA3, STM3043, STM3045 and USDA110) and two phosphorus levels (0 and 50 kg of P_2O_5 ha^{-1}). Each farmer represented one replication. Results indicated that, in AEZ 3, STM3043 strain combined to 50 kg of P_20_5 ha^{-1} had the maximum height (93 cm $plant^{-1}$) with a gain of 52% compared to the control. In AEZ 5, the height of soybean plants varied from 36 cm (control + 0 kg of P_20_5 ha^{-1}) to 88 cm (STM3043 + 50 kg of P_20_5 ha^{-1}).

The effect of inorganic, biological and organic manures on nodulation and yield of soybean and soil properties was studied by Devi *et al.* (2013) during rainy seasons of 2008 and 2009 in India (Manipur). The experiment consists of nine treatments viz., T_1 - Absolute control, T_2 – FYM (Farmyard manure) at the rate of 5 t ha^{-1}, T_3 -Vermicompost at the rate of 1 t ha^{-1}, T_4 - 100% RDF (Recommended dose of fertilizer), T_5 - 100% RDF + PSB, T_6 - 75% RDF + vermicompost at the rate of 1 t ha^{-1}, T_7 - 75% RDF + vermicompost at the rate of 1 t ha^{-1} + PSB, T_8 - 50% RDF + vermicompost at the rate of 1 t ha^{-1} and T_9 - 50% RDF + vermicompost at the rate of 1 t ha^{-1} + PSB. They revealed that, tallest plant was produced by T_7 (41.49 cm), T_6 (38.88cm) and T_9 (38.48cm) which were significantly different from all other treatments. The lowest plant height (24.13cm) was recorded in control treatment.

A field experiment was conducted by Khaim*et al*. (2013) at Genetics and Plant Breeding farm, Bangladesh Agricultural University from July to November, 2011 to evaluate the effect of cowdung and poultry manure with chemical fertilizer on the yield and quality of soybean cv. BINA soybean-2. Nine treatments *viz*. control (CT), 100% recommended dose of chemical fertilizers ($RDCF_{100\%}$), 50% RDCF ($RDCF_{50\%}$), cowdung 10 t ha^{-1} (CD10 t ha^{-1}), 50% RDCF + CD 5 t ha^{-1} ($RDCF_{50\%}$ + CD5 t ha^{-1}), 75% RDCF + CD 3t ha^{-1} ($RDCF_{75\%}$ + CD 3 t ha^{-1}), poultry manure 3 t ha^{-1} (PM3 t ha^{-1}), 50% RDCF + PM 1.5 t ha^{-1} ($RDCF_{50\%}$ + PM 1.5 t ha^{-1}) and 75% RDCF + PM 1 t ha^{-1} ($RDCF_{75\%}$ + PM1 t ha^{-1}) were tested. The result revealed that at harvest, the tallest plant (47.77 cm) was recorded from $RDCF_{100\%}$, which was statistically different from other treatments but identical with $RDCF_{75\%}$ + PM1 t ha^{-1}. The shortest plant (25.47 cm) was found in control, which was statistically identical with CD10 t ha^{-1}.

Field trials were conducted by Chiezey (2013) during the rainy seasons of 2009, 2010 and 2011 in Samaru in the northern Guinea Savanna zone of Nigeria to evaluate the response of soybean to separate and combined applications of farmyard manure (FYM) and mineral phosphorus fertilizers levels. Soybean varieties TGx 1448-2E and TGx 1019-2E were grown with three levels of FYM (0, 1 and 2 t ha^{-1}) and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}) in all possible factorial combinations laid out as a randomized complete block design, replicated four times. The result revealed that, the highest mean

plant height (68.10 cm) was found from farm yard manure (FYM) 2 t ha^{-1} and the lowest (56.60 cm) from no farm yard manure application plot. Application of 39.60 kg P ha^{-1} produced the highest mean plant height (63.60 cm) and the lowest (53.60 cm) no phosphorous application plot.

For studying the effects of vermicompost application, seeds inoculation with biological nitrogen fertilizer nitroxin and plant density management in soybean cultivar Williams, an experiment in factorial design with three factors based on randomized complete block design with 3 replication in the Astaneh Ashrafiyeh County (north of Iran) during 2010 was conducted by Azarpour *et al.* (2012). The factors of experiment consists of seed inoculation with biological nitrogen fertilizer nitroxin with two levels [N_1: control (without seed inoculation) and N_2: seed inoculation with nitroxin], application of vermicompost with three levels [V_1: control (without vermicompost application), V_2: 5 t ha^{-1} and V3: 10 t ha^{-1}] and plant density with three levels (D_1: 45 plants per m^2, D_2: 65 plants per m^2 and D_3: 85 plants per m^2). Results of data analysis showed that, the tallest plant (72.20 cm) was recorded from N_2 and the shortest one (66.30 cm) was from N_1. The tallest plant (73.93 cm) was recorded from V_3 and the shortest one (62.07 cm) was from V_1. The tallest plant (77.52 cm) was recorded from N_2V_3 and the shortest one (59.70 cm) was from N_1V_1.

A field experiment was conducted Yagoub *et al.* (2012) for two consecutive seasons (2009/2010 and 2010/2011) on the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, to study the effect of some fertilizers on growth and yield of soybean (*Glycine max L. merril*). The experiment was laid out in a randomized complete block design (RCBD) with four replicates. The fertilizers treatments consisted of three types of fertilizers: urea (180 kg ha^{-1}), NPK (361 kg ha^{-1}), compost (%) and the control. The results showed that the highest mean plant height in the first season was 32.65 cm given by urea treatment; in the second season was 31.38 cm given by control.

Field experiments were conducted by Chiezey and Odunze (2009) during the rainy seasons of 2003 and 2005 in Samaru in the Northern Guinea Savanna zone of Nigeria to

test the response of two soybean varieties to application of poultry manure and phosphorus fertilizer levels. Soybean varieties TGx 1448-2E and TGx 1019-2EB were grown without and with 1 t ha^{-1} of poultry manure and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}) in all possible factorial combinations using randomized complete block design with four replicates. The result of the experiment revealed that, the higher mean plant height (70.30 cm) was found from poultry manure 1 t ha^{-1} whereas the lower mean plant height (60.60 cm) was found from no poultry manure application plot. Among phosphorous levels, the highest mean plant height (69.00 cm) was found from 39.60 kg P ha^{-1} whereas the lowest mean plant height (62.50 cm) was found from no phosphorous application plot.

An experiment was conducted by Tomar and Khajanji (2009) at Raipur during 2001-02 and 2002-03 to study the effect of organic and inorganic sources of nutrients on the productivity, quality and economics of soybean. Four combinations of organic manuring *viz*. M_0: control, M_1: crop residues-rice straw @ 5 t ha^{-1}, M_2: FYM @ 5 t ha^{-1} and M_3: crop residue + FYM each @ 5 t ha^{-1} + Zinc @ 5 kg ha^{-1}) and three levels of mineral fertilizers *viz*. F_0: control, F_1: 100 % RDF and F_2: 50 % RDF) were used as treatment. They reported that, the tallest plant (54.77 cm) was recorded from organic manuring in soybean with crop residue + FYM each @ 5 t ha^{-1}+ zinc @ 5 kg ha^{-1} (M_3) and the shortest plant (42.68 cm) from control treatment (M_0).The tallest plant (58.41 cm) was recorded from 100% RDF (F_1) and the shortest plant (41.68 cm) from control treatment (F_0).

The field experiment was carried out by Myint *et al.* (2009) during the dry season to determine the effects of different organic amendments on soybean plant growth and grain yield. Treatments were a combination of chemical fertilizer (16-20-0) 60 kg ha^{-1} and extracts of jatropha 20 cc, chitosan 60 cc and fish waste 40 cc in 20 l of water; chicken manure 3 ton ha^{-1}; jatropha cake 3 and 6 ton ha^{-1}; chemical fertilizer (16-20-0) 180 kg ha^{-1} and control (no application). They reported that largest plant (35.77 cm) was found from treatment F_{180} (180 kg ha^{-1} of 16-20-0) in 2007 (DS) and (77.57 cm) in 2008 (WS) and the shortest plant (30.87 cm) and (62.17 cm) from control treatment (no fertilizers) irrespective of seasons.

The field experiment on soybean was conducted by Son *et al*. (2001) at Phuoc Thoi village, O Mon district, Cantho province with different fertilizer application doses to study the influence of organic and bio- fertilizer on the growth and grain yield of soybean and soil fertility. There were 11 treatment *viz.*T_1 = 100- 60 -30 (N - P_2O_5 - K_2O kg ha^{-1}), T_2= 60-60-30(N - P_2O_5 - K_2O kg ha^{-1}), T_3= 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_4 = 00-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_5= Inoculants + 60-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_6= Inoculants + 30-30-30(N - P_2O_5 - K_2O kg ha^{-1}), T_7= Compost + 60-60-30(N - P_2O_5 - K_2O kg ha^{-1}), T_8= Compost + 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_9= Inoculants + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}), T_{10}= Compost + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}) and T_{11}= Compost + inoculants +30-60-30(N - P_2O_5 - K_2O kg ha^{-1}). They reported that, the highest plant height (103.50 cm) obtained under T_7 (Compost + 60-60-30), then (102.50 cm) T_1 (100-60–30) at 56 DAS and the lowest plant height (83.30 cm) obtained under T_4.

2.1.2 Number of branches $plant^{-1}$

Patil and Udmale (2016) conducted an experiment at the Cropping Systems Research Project Farm, M.P.K.V., Rahuri during *kharif* 2007-08 to study the response of soybean to various organic inputs under irrigated condition. Eight treatments consisting of organic inputs *viz.* T_1 : Control, T_2 : Farm yard manure (FYM) at 5 t ha^{-1}, T_3 : Vermicompost (VC) at 2 t ha^{-1}, T_4 : FYM + VC (50+50) (2.5 t ha^{-1} + 1 t ha^{-1}), T_5 : FYM + Jeevamrut 2 times (30 and 45 DAS) (FYM 5 t ha^{-1}), T_6 : VC + Jeevamrut 2 times (30 and 45 DAS) (2 t ha^{-1} + 500 lit ha^{-1}), T_7 : FYM+VC (50+50)+Jeevamrut 2 times (30 and 45 DAS) (2.5 t ha^{-1}+1 t ha^{-1} +500 lit ha^{-1}) and T_8 : Jeevamrut 2 times (30 and 45 DAS) (500 lit ha^{-1}) were tested in the experiment. *Rhizobium* and PSB biofertilizer is common to all treatments. The result showed that, the maximum mean number of branches $plant^{-1}$ (8.70) was observed from T_7 treatments while the minimum mean number of branches $plant^{-1}$ (3.04) from control treatment (T_1).

A field experiment was conducted by Begum *et al*. (2015) at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to study the effects of nitrogen and phosphorus on the performance of soybean. Three levels of nitrogen (0, 25 and 40 kg N ha^{-1}) and four levels of phosphorus (0, 18, 36 and 54 kg P ha^{-1}) were

considered as treatment for the experiment. The highest number of branches plant^{-1} (3.71) was obtained from the combination of 25 kg N with 54 kg P ha^{-1} and lowest number of branches plant^{-1} (1.43) was obtained from the combination of 0 kg N with 18 kg P ha^{-1}.

A field study was conducted by Falodun *et al*. (2015) at the Department of Crop Science, University of Benin Teaching and Research Farm, Benin City, Edo State during the 2012/2013 cropping seasons, to investigate the effects of poultry manure and inorganic NPK 15:15:15 fertilizer on the growth and yield of soya bean. Six treatments viz: 0, 200 kg ha^{-1} NPK 15:15:15, 10 t ha^{-1} poultry manure (PM), 7 t ha^{-1} poultry manure + 60 kg ha^{-1} NPK 15:15:15, 5 t ha^{-1} poultry manure + 100 kg ha^{-1} NPK 15:15:15, 2.5 t ha^{-1} poultry manure + 150 kg ha^{-1} NPK 15:15:15 were tested in this experiment. Results showed that the effect of fertilizer application was not significant on the number of branches.

A field experiment was conducted by Khaim*et al*. (2013) at Genetics and Plant Breeding farm, Bangladesh Agricultural University from July to November, 2011 to evaluate the effect of cowdung and poultry manure with chemical fertilizer on the yield and quality of soybean cv. BINA soybean-2. The experiment was laid out in randomized complete block design having 9 treatments *viz*. control (CT), 100% recommended dose of chemical fertilizers (RDCF$_{100\%}$), 50% RDCF (RDCF$_{50\%}$), cowdung 10 t ha^{-1} (CD10 t ha^{-1}), 50% RDCF + CD 5 t ha^{-1} (RDCF$_{50\%}$ + CD5 t ha^{-1}), 75% RDCF + CD 3t ha^{-1} (RDCF$_{75\%}$ + CD 3 t ha^{-1}), poultry manure 3 t ha^{-1} (PM3 t ha^{-1}), 50% RDCF + PM 1.5 t ha^{-1} (RDCF$_{50\%}$ + PM 1.5 t ha^{-1}) and 75% RDCF + PM 1 t ha^{-1} (RDCF$_{75\%}$ + PM1 t ha^{-1}) with 3 replications. The result revealed that, the maximum number of branches plant^{-1} (4.67) was obtained in RDCF$_{100\%}$ that was statistically identical with the treatment RDCF$_{75\%}$+ PM 1 t ha^{-1} and minimum (1.96) was obtained in control.

Tomar and Khajanji (2009) conducted an experiment at Raipur during 2001-02 and 2002-03 to study the effect of organic and inorganic sources of nutrients on the productivity, quality and economics of soybean. Four combinations of organic manuring *viz*. M_0: control, M_1: crop residues-rice straw @ 5 t ha^{-1}, M_2: FYM @ 5 t ha^{-1} and M_3: crop residue + FYM each @ 5 t ha^{-1} + Zinc @ 5 kg ha^{-1}) and three levels of mineral fertilizers *viz*. F_0: control, F_1: 100 % RDF and F_2: 50 % RDF) were used as treatment. The result of

the experiment revealed that, the maximum number of branches plant^{-1} (6.10) was recorded from organic manuring in soybean with crop residue + FYM each @ 5 t ha^{-1}+ zinc @ 5 kg ha^{-1} (M_3) and the minimum number of branches plant^{-1} (3.87) was recorded from control treatment (M_0). In case of mineral fertilizer, the maximum number of branches plant^{-1} (8.88) was recorded from F_0 and the minimum number of branches plant^{-1} (5.29) was recorded from F_2.

2.1.3 Dry matter weight

Patil and Udmale (2016) conducted an experiment at the Cropping Systems Research Project Farm, M.P.K.V., Rahuri during *kharif* 2007-08 to study the response of soybean to various organic inputs under irrigated condition. Eight treatments consisting of organic inputs *viz.* T_1 : Control, T_2 : Farm yard manure (FYM) at 5 t ha^{-1}, T_3 : Vermicompost (VC) at 2 t ha^{-1}, T_4 : FYM + VC (50+50) (2.5 t ha^{-1} + 1 t ha^{-1}), T_5 : FYM + Jeevamrut 2 times (30 and 45 DAS) (FYM 5 t ha^{-1}), T_6 : VC + Jeevamrut 2 times (30 and 45 DAS) (2 t ha^{-1} + 500 lit ha^{-1}), T_7 : FYM+VC (50+50)+Jeevamrut 2 times (30 and 45 DAS) (2.5 t ha^{-1}+1 t ha^{-1} +500 lit ha^{-1}) and T_8 : Jeevamrut 2 times (30 and 45 DAS) (500 lit ha^{-1}) were tested in the experiment. *Rhizobium* and PSB biofertilizer is common to all treatments. The result showed that, the maximum mean dry matter accumulation plant^{-1} (36.71 g) was recorded from T_7 treatments the minimum (17.31 g) from control treatment (T_1).

A pot experiment under a rain shelter in Agro Technology Park, Eastern University, Sri Lanka was conducted by Sutharsan *et al.* (2016)to study the effects of different rates of nitrogen and phosphorous on the nodulation and growth of soybean. Fertilizer combinations viz. T_1-30N:150P: 75K: kg ha^{-1}, T_2-70N:150P:75K: kg ha^{-1}, T_3 (control)-50N:150P:75K: kg ha^{-1}, T_4-50N:125P:75K: kg ha^{-1} and T_5-50N:175P:75K: kg ha^{-1} were used as treatments. They reported that, the highest dry matter weight plant^{-1} (13.83 g) was recorded from T_4 and the lowest (10.55 g) from T_1 (control treatment).

A field experiment was conducted by Begum *et al*. (2015) at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to study the effects of nitrogen and phosphorus on the performance of soybean. Three levels of nitrogen (0, 25 and 40 kg N ha^{-1}) and four levels of phosphorus (0, 18, 36 and 54 kg P ha^{-1}) were

considered as treatment for the experiment. The highest dry matter weight plant^{-1} (17.89g) was observed with 25 kg N ha^{-1} and the lowest (17.89g) with control treatment (no fertilizers).They reported that, the highest dry weight of plant (20.81 g) was obtained from the combination of 25 kg N with 54 kg P ha^{-1} and the lowest (9.82 g) from the combination of 0 kg N with 0 kg P ha^{-1}.

An on farmer's fields' study was carried out by Zoundji *et al.* (2015) in Northern and Centre Benin to determine the effectiveness of *Bradyrhizobium japonicum* strains introduced in Benin cropping systems. Five inoculations treatments (control, FA3, STM3043, STM3045 and USDA110), two phosphorus levels (0 and 50 kg of P_2O_5 ha^{-1}) arranged in split plot design were established in twelve farmers' fields. Each farmer represented one replication. Results indicated that, in AEZ 3, for the variable shoot dry weight, the highest value was found with FA3 strain + 50 kg of P205 ha^{-1} (22.2 g per plant). In AEZ 5, the highest shoot dry weight was 23 g plant^{-1} (STM3045 + 50 kg of P_20_5 ha^{-1}). The lowest value was found with control without P (6 g plant^{-1}).

Tomar and Khajanji (2009) conducted an experiment at Raipur during 2001-02 and 2002-03 to study the effect of organic and inorganic sources of nutrients on the productivity, quality and economics of soybean. Four combinations of organic manuring *viz*. M_0: control, M_1: crop residues-rice straw @ 5 t ha^{-1}, M_2: FYM @ 5 t ha^{-1} and M_3: crop residue + FYM each @ 5 t ha^{-1} + Zinc @ 5 kg ha^{-1}) and three levels of mineral fertilizers *viz*. F_0: control, F_1: 100 % RDF and F_2: 50 % RDF) were used as treatment variables. They reported that, the maximum dry matter accumulation plant^{-1} (19.68 g) was recorded from organic manuring with crop residue + FYM each @ 5 t ha^{-1}+ zinc @ 5 kg ha^{-1} (M_3) and the minimum dry matter accumulation plant^{-1} (15.05 g) from control treatment (M_0). The maximum dry matter accumulation plant^{-1} (19.44 g) was recorded from F_1 treatment and the minimum (15.13 g) from F_0 treatment.

Field experiments were conducted by Chiezey and Odunze (2009) during the rainy seasons of 2003 and 2005 in Samaru in the Northern Guinea Savanna zone of Nigeria to test the response of two soybean varieties to application of poultry manure and phosphorus fertilizer levels. Soybean varieties TGx 1448-2E and TGx 1019-2EB were

grown without and with 1 t ha^{-1} of poultry manure and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}) .They reported that, the higher mean dry matter $plant^{-1}$ (27.90 g) was found from poultry manure 1 t ha^{-1} whereas the lower mean dry matter $plant^{-1}$ (21.30 g) was found from no poultry manure application plot. The highest mean dry matter $plant^{-1}$ (28.60 g) was found from 39.60 kg P ha^{-1} whereas the lowest mean dry matter $plant^{-1}$ (21.80 g) was found from no phosphorous application plot.

2.2 Effect on yield attributes

2.2.1 Number of pods $plant^{-1}$

A field experiment was conducted by Khanam *et al.* (2016)at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during December 2013 to April 2014 to evaluate the effect of phosphorus (P_0: 0 kg TSP ha^{-1}, P_1: 100 kg TSP ha^{-1}, P_2: 175 kg TSP ha^{-1}, P_3: 250 kg TSP ha^{-1}) and potassium (K_0: 0 kg MoP, K_1: 60 kg MoP ha^{-1}, K_2: 120 kg MoP ha^{-1}, K_3: 180 kg MoP ha^{-1}), and their combinations on growth and yield of soybean (*Glycine max*). The result revealed that, the highest number of pods (63.00) was recorded from 175 kg ha^{-1} of TSP along with 120 kg ha^{-1} of MoP and the lowest one (32.15) was recorded from P_0K_0 combination.

Patil and Udmale (2016) conducted an experiment at the Cropping Systems Research Project Farm, M.P.K.V., Rahuri during *kharif* 2007-08 to study the response of soybean to various organic inputs under irrigated condition. Eight treatments consisting of organic inputs *viz.* T_1 : Control, T_2 : Farm yard manure (FYM) at 5 t ha^{-1}, T_3 : Vermicompost (VC) at 2 t ha^{-1}, T_4 : FYM + VC (50+50) (2.5 t ha^{-1} + 1 t ha^{-1}), T_5 : FYM + Jeevamrut 2 times (30 and 45 DAS) (FYM 5 t ha^{-1}), T_6 : VC + Jeevamrut 2 times (30 and 45 DAS) (2 t ha^{-1} + 500 lit ha^{-1}), T_7 : FYM+VC (50+50)+Jeevamrut 2 times (30 and 45 DAS) (2.5 t ha^{-1}+1 t ha^{-1} +500 lit ha^{-1}) and T_8 : Jeevamrut 2 times (30 and 45 DAS) (500 lit ha^{-1}) were tested in the experiment. *Rhizobium* and PSB biofertilizer is common to all treatments. The result showed that, the maximum mean number of pods $plant^{-1}$ (58.53) was gained from T_7 treatments while the minimum mean number of pods $plant^{-1}$ (30.23) from control treatment (T_1).

A field experiment was conducted by Begum *et al*. (2015) at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to study the effects of nitrogen and phosphorus on the performance of soybean. Three levels of nitrogen (0, 25 and 40 kg N ha^{-1}) and four levels of phosphorus (0, 18, 36 and 54 kg P ha^{-1}) were considered as treatment for the experiment. The maximum number of filled pods $plant^{-1}$ (47.59) was observed with 25 kg N ha^{-1} and minimum (38.00) with control treatment (no fertilizers). They reported that, the highest number of filled pod $plant^{-1}$ (58.28) was obtained from the combination of 25 kg N with 54 kg P ha^{-1} and lowest (23.5) from the combination of 0 kg N with 0 kg P ha^{-1}.

A field study was conducted by Falodun *et al*. (2015)at the Department of Crop Science, University of Benin Teaching and Research Farm, Benin City, Edo State during the 2012/2013 cropping seasons, to investigate the effects of poultry manure and inorganic NPK 15:15:15 fertilizer on the growth and yield of soya bean (*Glycine max* (L.) Merr). Six treatments were 0, 200 kg ha^{-1} NPK 15:15:15, 10 t ha^{-1} poultry manure (PM), 7 t ha^{-1} poultry manure + 60 kg ha^{-1} NPK 15:15:15, 5 t ha^{-1} poultry manure + 100 kg ha^{-1} NPK 15:15:15, 2.5 t ha^{-1} poultry manure + 150 kg ha^{-1} NPK 15:15:15. Results showed that, application rate of 2.5 t ha^{-1} PM and 150 kg ha^{-1} NPK gave the highest number of pods $plant^{-1}$ (322). The minimum number of pods $plant^{-1}$ of (130) was observed with the control (no fertilizers).

Ahmed (2015) carried out a field experiment for two consecutive seasons (2009/10 and 2010/11) in the Demonstration Farm of the Faculty of Agriculture at Shambat-Sudan, to study the interactive effect of nitrogen fertilization and rhizobium inoculation on nodulation and yield of soybean. The treatments consist of increasing doses of nitrogen (0, 40 and 80 kg ha^{-1}urea) and one strain of rhizobium. The seeds of cultivar Giza 22 were either uninoculated or inoculated with *Rhizobium japonicum* strain TAL 110 before sowing. The results of the investigation showed that, maximum number of seeds pod^{-1} (3.00) was recorded from N_1R_1 treatment combination whereas the minimum one (2.80) was recorded from N_0R_0.

A study has been conducted by Kuntyastuti and Suryantini (2015) with the aim of evaluating the effect of P fertilizers and its residues on soybean growth and yield. Study was conducted in two planting seasons (PS). In the first planting season (PS-1) four doses of P fertilizer i.e. 0, 200, 400 and 600 kg ha^{-1} SP-36 was used. While in the second planting season (PS-2), fertilizer treatment was five doses of SP-36 i.e. 0, 50, 100, 200 and 400 kg ha^{-1}. The results revealed that, the maximum number of filled pods $plant^{-1}$ (74.50) was produced by 600 kg ha^{-1} P-fertilizer while the minimum value (62.00) was from 400 kg ha^{-1} P-fertilizer.

An on farmer's fields' study was carried out by Zoundji *et al.* (2015) in Northern and Centre Benin to determine the effectiveness of *Bradyrhizobium japonicum* strains introduced in Benin cropping systems. Five inoculations treatments (control, FA3, STM3043, STM3045 and USDA110), two phosphorus levels (0 and 50 kg of P_2O_5 ha^{-1}) arranged in split plot design were established in twelve farmers' fields. Each farmer represented one replication. Results indicated that, In AEZ 3, the best performances were observed with plots receiving FA3+ 50 kg of P_20_5 ha^{-1}. The highest mean values pods $plant^{-1}$ (91) was found in FA3+ 50 kg of P_20_5 ha^{-1} treatment compare to the control (38 pods $plant^{-1}$).

A field experiment was conducted by Khaim*et al*. (2013) at Genetics and Plant Breeding farm, Bangladesh Agricultural University from July to November, 2011 to evaluate the effect of cowdung and poultry manure with chemical fertilizer on the yield and quality of soybean cv. BINA soybean-2.Nine treatments *viz*. control (CT), 100% recommended dose of chemical fertilizers ($RDCF_{100\%)}$, 50% RDCF ($RDCF_{50\%}$), cowdung 10 t ha^{-1} (CD10 t ha^{-1}), 50% RDCF + CD 5 t ha^{-1} ($RDCF_{50\%}$ + CD5 t ha^{-1}), 75% RDCF + CD 3t ha^{-1} ($RDCF_{75\%}$ + CD 3 t ha^{-1}), poultry manure 3 t ha^{-1} (PM3 t ha^{-1}), 50% RDCF + PM 1.5 t ha^{-1} ($RDCF_{50\%}$ + PM 1.5 t ha^{-1}) and 75% RDCF + PM 1 t ha^{-1} ($RDCF_{75\%}$ + PM1 t ha^{-1}) were used as treatment variable . The result revealed that, the highest number of filled pod (21.00) was recorded in $RDCF_{100\%}$ that was statistically identical with the treatment $RDCF_{75\%}$ + PM1 t ha^{-1}, $RDCF_{50\%}$ + PM 1.5 t ha^{-1} and $RDCF_{75\%}$ + CD 3 t ha^{-1}. The lowest number of filled pods (12.80) was observed in control, which was identical with treatment RDCF50%, CD10 t ha^{-1}.

The effect of inorganic, biological and organic manures on nodulation and yield of soybean and soil properties was studied by Devi *et al.* (2013) during rainy seasons of 2008 and 2009 in India (Manipur). The experiment consists of nine treatments viz., T_1 - Absolute control, T_2 – FYM (Farmyard manure) at the rate of 5 t ha^{-1}, T_3 -Vermicompost at the rate of 1 t ha^{-1}, T_4 - 100% RDF (Recommended dose of fertilizer), T_5 - 100% RDF + PSB, T_6 - 75% RDF + vermicompost at the rate of 1 t ha^{-1}, T_7 - 75% RDF + vermicompost at the rate of 1 t ha^{-1} + PSB, T_8 - 50% RDF + vermicompost at the rate of 1 t ha^{-1} and T_9 - 50% RDF + vermicompost at the rate of 1 t ha^{-1} + PSB. The results of the integration revealed that, significantly the highest number of pod $plant^{-1}$ (65.68) was recorded at 75% RDF along with vermicompost at the rate of 1 t ha^{-1} and PSB as compared to other treatments and the lowest number of pod $plant^{-1}$ (24.19) were in the control.

Field trials were conducted by Chiezey (2013) during the rainy seasons of 2009, 2010 and 2011 in Samaru in the northern Guinea Savanna zone of Nigeria to evaluate the response of soybean to separate and combined applications of farmyard manure (FYM) and mineral phosphorus fertilizers levels. Soybean varieties TGx 1448-2E and TGx 1019-2E were grown with three levels of FYM (0, 1 and 2 t ha^{-1}) and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}). Result revealed that, the maximum mean pods $plant^{-1}$ (48.20) was found from FYM 2 t ha^{-1} whereas the minimum mean pods $plant^{-1}$ (35.20) was found from no FYM application plot.

A field experiment was conducted Yagoub *et al.* (2012) for two consecutive seasons (2009/2010 and 2010/2011) on the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, to study the effect of some fertilizers on growth and yield of soybean. Three types of fertilizers viz: urea (180 kg ha^{-1}), NPK (361 kg ha^{-1}), compost (%) and the control were tested in the experiment. The results showed that the highest mean number of pods per plant in the first season was 95.95 given by compost treatment, and in the second season was 80.2 given by NPK treatment.

Azarpour *et al.* (2012) conducted an experiment at Astaneh Ashrafiyeh County (north of Iran) during 2010.Seed inoculation with biological nitrogen fertilizer nitroxin with two levels [N_1: control (without seed inoculation) and N_2: seed inoculation with nitroxin], application of vermicompost with three levels [V_1: control (without vermicompost application), V_2: 5 t ha^{-1} and V3: 10 t ha^{-1}] and plant density with three levels (D_1: 45 plants per m^2, D_2: 65 plants per m^2 and D_3: 85 plants per m^2) were used as treatment variables. They reported that, the maximum number of pods $plant^{-1}$ (24.80) was recorded from N_2 and the minimum one (21.60) was from N_1. The maximum number of pods $plant^{-1}$ (26.43) was recorded from V_3 and the minimum one (18.42) was from V_1. Combination of N_2V_3 produced the maximum number of pods $plant^{-1}$ (28.57) and the minimum (17.39) from N_1V_1 combination.

The effect of packaged organic and inorganic fertilizers on the growth and yield of soyabean (*Glycine max* (L) merr.) was carried out by Falodun *et al.* (2010) in the rainforest zone of Nigeria. The treatments used were inorganic fertilizer NPK 15: 15: 15 and packaged organic fertilizer. The experiment was laid out in a randomized complete block designed (RCBD) in three replicates' with six treatments *viz.* 0, 100, 200 and 300 kg ha^{-1} NPK 15:15:15 fertilizer, and 100 and 300 Kg ha^{-1} organic fertilizer. Results showed that, maximum number of pods $plant^{-1}$ (511.31) was obtained by NPK 200 (kg ha^{-1}) and minimum number of pods $plant^{-1}$ (225.00) was obtained by control treatment.

Tomar and Khajanji (2009) conducted an experiment at Raipur during 2001-02 and 2002-03 to study the effect of organic and inorganic sources of nutrients on the productivity, quality and economics of soybean. Four combinations of organic manuring *viz*. M_0: control, M_1: crop residues-rice straw @ 5 t ha^{-1}, M_2: FYM @ 5 t ha^{-1} and M_3: crop residue + FYM each @ 5 t ha^{-1} + Zinc @ 5 kg ha^{-1}) and three levels of mineral fertilizers *viz*. F_0: control, F_1: 100 % RDF and F_2: 50 % RDF) were used as treatment variable. They reported that, the maximum number of pods $plant^{-1}$ (28.68) was recorded from organic manuring in soybean with crop residue + FYM each @ 5 t ha^{-1}+ zinc @ 5 kg ha^{-1} (M_3) and the minimum number of pods $plant^{-1}$ (20.32) was recorded from control treatment (M_0).The maximum number of pods $plant^{-1}$ (29.22) was recorded from F_1 treatment and the minimum number of pods $plant^{-1}$ (20.98) was recorded from F_0 treatment.

Field experiments were conducted by Chiezey and Odunze (2009) during the rainy seasons of 2003 and 2005 in Samaru in the Northern Guinea Savanna zone of Nigeria to test the response of two soybean varieties to application of poultry manure and phosphorus fertilizer levels. Soybean varieties TGx 1448-2E and TGx 1019-2EB were grown without and with 1 t ha^{-1} of poultry manure and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}) . Result revealed that, the maximum mean pods $plant^{-1}$ (90.70) was found from poultry manure 1 t ha^{-1} whereas the minimum mean pods $plant^{-1}$ (77.00) was found from no poultry manure application plot. The maximum mean pods $plant^{-1}$ (100.80) was found from 39.60 kg P ha^{-1} whereas the minimum mean pods $plant^{-1}$ (66.20) was found from 0 kg P ha^{-1}.

The field experiment was carried out by Myint *et al.* (2009)at the National Corn and Sorghum Research Center, on a site with Pakchong series soils during the dry season in 2007 (DS) and the wet season in 2008 (WS).This study aimed to determine the effects of different organic amendments on soybean plant growth and grain yield. Treatments were a combination of chemical fertilizer (16-20-0) 60 kg ha^{-1} and extracts of jatropha 20 cc, chitosan 60 cc and fish waste 40 cc in 20 l of water; chicken manure 3 ton ha^{-1}; jatropha cake 3 and 6 ton ha^{-1}; chemical fertilizer (16-20-0) 180 kg ha^{-1} and control (no application). In DS, the soybean crop applied with chemical fertilizer produced a higher pod number (37.63). In WS, however, crops applied with 6 ton of jatropha cake significantly increased pods per plant (97.23) over other treatments. The plot applied with chicken manure obtained significantly lower pod numbers (30.03) in DS and also minimum pods (57.53) in WS.

The field experiment on soybean was conducted by Son *et al*. (2001) at Phuoc Thoi village, O Mon district, Cantho province with different fertilizer application doses to study the influence of organic and bio- fertilizer on the growth and grain yield of soybean and soil fertility. There were 11 treatment *viz.*T_1 = 100- 60 -30 (N - P_2O_5 - K_2O kg ha^{-1}), T_2= 60-60-30(N - P_2O_5 - K_2O kg ha^{-1}), T_3= 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_4 = 00-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_5= Inoculants + 60-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_6= Inoculants + 30-30-30(N - P_2O_5 - K_2O kg ha^{-1}), T_7= Compost + 60-60-30(N - P_2O_5 - K_2O kg ha^{-1}), T_8= Compost + 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_9= Inoculants + 00-00-00

(N - P_2O_5 - K_2O kg ha^{-1}), T_{10}= Compost + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}) and T_{11}= Compost + inoculants +30-60-30(N - P_2O_5 - K_2O kg ha^{-1}). They concluded that, the highest number of pods $plant^{-1}$ (25.07) obtained under T_1 (100- 60 -30) (N - P_2O_5 - K_2O kg ha^{-1}) at 56 DAS and the lowest pods $plant^{-1}$ (19.30) obtained under T_4 (N - P_2O_5 - K_2O kg ha^{-1}).

2.2.2 Number of seeds pod^{-1}/ $plant^{-1}$

Patil and Udmale (2016) conducted an experiment at the Cropping Systems Research Project Farm, M.P.K.V., Rahuri during *kharif* 2007-08 to study the response of soybean to various organic inputs under irrigated condition. Eight treatments consisting of organic inputs *viz.* T_1 : Control, T_2 : Farm yard manure (FYM) at 5 t ha^{-1}, T_3 : Vermicompost (VC) at 2 t ha^{-1}, T_4 : FYM + VC (50+50) (2.5 t ha^{-1} + 1 t ha^{-1}), T_5 : FYM + Jeevamrut 2 times (30 and 45 DAS) (FYM 5 t ha^{-1}), T_6 : VC + Jeevamrut 2 times (30 and 45 DAS) (2 t ha^{-1} + 500 lit ha^{-1}), T_7 : FYM+VC (50+50)+Jeevamrut 2 times (30 and 45 DAS) (2.5 t ha^{-1}+1 t ha^{-1} +500 lit ha^{-1}) and T_8 : Jeevamrut 2 times (30 and 45 DAS) (500 lit ha^{-1}) were tested in the experiment. *Rhizobium* and PSB biofertilizer is common to all treatments. The result showed that, the maximum mean number of seeds $plant^{-1}$ (163.20) was secured from T_7 treatments while the minimum mean number of seeds $plant^{-1}$ (86.61) from control treatment (T_1).

A field experiment was conducted by Khanam *et al.* (2016)at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during December 2013 to April 2014 to evaluate the effect of phosphorus (P_0: 0 kg TSP ha^{-1}, P_1: 100 kg TSP ha^{-1}, P_2: 175 kg TSP ha^{-1}, P_3: 250 kg TSP ha^{-1}) and potassium (K_0: 0 kg MoP, K_1: 60 kg MoP ha^{-1}, K_2: 120 kg MoP ha^{-1}, K_3: 180 kg MoP ha^{-1}), and their combinations on growth and yield of soybean (*Glycine max*). The result of the investigation revealed that, the highest numbers of seeds pod^{-1} (2.98) was recorded with 175 kg ha^{-1} of TSP. The maximum numbers of seeds pod^{-1} of soybean (2.50) was recorded from 120 kg $ha^{-1}$of MoP. The maximum seeds pod^{-1} of soybean (3.11) was recorded with combined application of TSP and MoP at 175 kg ha^{-1} and 120 kg ha^{-1}. The lowest value for number of seeds pod^{-1} (1.71, 2.26 and 1.62) was recorded from P_0, K_0 and P_0K_0 combination, respectively.

A field experiment was conducted by Begum *et al*. (2015) at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to study the effects of nitrogen and phosphorus on the performance of soybean. Three levels of nitrogen (0, 25 and 40 kg N ha^{-1}) and four levels of phosphorus (0, 18, 36 and 54 kg P ha^{-1}) were considered as treatment for the experiment. The highest number of seeds pod^{-1} (1.94) was recorded with 25 kg N ha^{-1} whereas lowest number of seeds pod^{-1} (1.64) was observed with control treatment (no fertilizers). The highest number of seeds pod^{-1} (2.07) was recorded with 54 kg P ha^{-1} whereas lowest number of seeds pod^{-1} (1.07) was observed with control treatment (no fertilizers).

Ahmed (2015) carried out a field experiment for two consecutive seasons (2009/10 and 2010/11) in the Demonstration Farm of the Faculty of Agriculture at Shambat-Sudan, to study the interactive effect of nitrogen fertilization and rhizobium inoculation on nodulation and yield of soybean. The treatments consist of increasing doses of nitrogen (0, 40 and 80 kg ha^{-1}urea) and one strain of rhizobium. The seeds of cultivar Giza 22 were either uninoculated or inoculated with *Rhizobium japonicum* strain TAL 110 before sowing. The results of the investigation showed that, maximum number of seeds pod^{-1} (3.00) was recorded from N_1R_1 treatment combination whereas the minimum one (2.80) was recorded from N_0R_0.

A field experiment was conducted by Khaim*et al*. (2013) at Genetics and Plant Breeding farm, Bangladesh Agricultural University from July to November, 2011 to evaluate the effect of cowdung and poultry manure with chemical fertilizer on the yield and quality of soybean cv. BINA soybean-2. Nine treatments were control (CT), 100% recommended dose of chemical fertilizers ($RDCF_{100\%}$), 50% RDCF ($RDCF_{50\%}$), cowdung 10 t ha^{-1} (CD10 t ha^{-1}), 50% RDCF + CD 5 t ha^{-1} ($RDCF_{50\%}$ + CD5 t ha^{-1}), 75% RDCF + CD 3t ha^{-1} ($RDCF_{75\%}$ + CD 3 t ha^{-1}), poultry manure 3 t ha^{-1} (PM3 t ha^{-1}), 50% RDCF + PM 1.5 t ha^{-1} ($RDCF_{50\%}$ + PM 1.5 t ha^{-1}) and 75% RDCF + PM 1 t ha^{-1} ($RDCF_{75\%}$ + PM1 t ha^{-1}) . The result revealed that, application of $RDCF_{100\%}$ produced the highest number of grains $plant^{-1}$ (52.25), which was statistically identical to $RDCF_{75\%}$ + PM1 t ha^{-1}. The lowest number of seeds $plant^{-1}$ (25.65) was found in control.

The effect of inorganic, biological and organic manures on nodulation and yield of soybean and soil properties was studied by Devi *et al.* (2013) during rainy seasons of 2008 and 2009 in India (Manipur). Nine treatments viz., T_1 - Absolute control, T_2 – FYM (Farmyard manure) at the rate of 5 t ha^{-1}, T_3 -Vermicompost at the rate of 1 t ha^{-1}, T_4 - 100% RDF (Recommended dose of fertilizer), T_5 - 100% RDF + PSB, T_6 - 75% RDF + vermicompost at the rate of 1 t ha^{-1}, T_7 - 75% RDF + vermicompost at the rate of 1 t ha^{-1} + PSB, T_8 - 50% RDF + vermicompost at the rate of 1 t ha^{-1} and T_9 - 50% RDF + vermicompost at the rate of 1 t ha^{-1} + PSB were used as treatment variables. The experiment was replicated thrice in randomized block design. The results of the integration revealed that, significantly the highest number of seeds per pod (2.96) was recorded at 75% RDF along with vermicompost at the rate of 1 t ha^{-1} and PSB as compared to other treatments and the lowest number of seeds pod^{-1} (1.90) were in the control.

A field experiment was conducted Yagoub *et al.* (2012) for two consecutive seasons (2009/2010 and 2010/2011) on the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, to study the effect of some fertilizers on growth and yield of soybean (*Glycine max L. merril*). The fertilizers treatments consisted of three types of fertilizers: urea (180 kg ha^{-1}), NPK (361 kg ha^{-1}), compost (%) and the control. The results showed that the highest mean number of seeds per plant in the first season was 156.8 given by control, and in the second season it was 138.5 given by NPK treatment.

A field experiment was carried out by Xiang *et al.* (2012) to determine the effect of Phosphorus (P) application (0, 8.5, 17.0 and 25.5 kg ha^{-1}) and Potassium (K) application (0, 37.5, 75.0 and 112.5 kg ha^{-1}) on growth and yield of soybean (*Glycine max* (L.) Merr.) in relay strip intercropping system.The highest seeds per pod (1.28) were produced by relay strip intercropping soybean at the rate of 112.5 kg K ha^{-1} and the control treatment gave the lowest seeds per pod (1.20).

Azarpour *et al.* (2012) conducted an experiment at Astaneh Ashrafiyeh County (north of Iran) during 2010.Seed inoculation with biological nitrogen fertilizer nitroxin with two

levels [N_1: control (without seed inoculation) and N_2: seed inoculation with nitroxin], application of vermicompost with three levels [V_1: control (without vermicompost application), V_2: 5 t ha^{-1} and V3: 10 t ha^{-1}] and plant density with three levels (D_1: 45 plants per m^2, D_2: 65 plants per m^2 and D_3: 85 plants per m^2) were used as treatment variables. They reported that, the maximum number of seeds $plant^{-1}$ (56.50) was recorded from N_2 and the minimum one (48.90) was from N_1. The maximum number of seeds $plant^{-1}$ (60.29) was recorded from V_3 and the minimum one (42.96) was from V_1. The maximum number of seeds $plant^{-1}$ (65.28) was recorded from N_2V_3 and the minimum one (40.29) was from N_1V_1.

Tomar and Khajanji (2009) conducted an experiment at Raipur during 2001-02 and 2002-03 to study the effect of organic and inorganic sources of nutrients on the productivity, quality and economics of soybean. Four combinations of organic manuring *viz*. M_0: control, M_1: crop residues-rice straw @ 5 t ha^{-1}, M_2: FYM @ 5 t ha^{-1} and M_3: crop residue + FYM each @ 5 t ha^{-1} + Zinc @ 5 kg ha^{-1}) and three levels of mineral fertilizers *viz*. F_0: control, F_1: 100 % RDF and F_2: 50 % RDF) were tested as treatment in the experiment. They found that, the maximum number of seeds pod^{-1} (2.95) was recorded from organic manuring in soybean with crop residue + FYM each @ 5 t ha^{-1}+ zinc @ 5 kg ha^{-1} (M_3) and the minimum number of seeds pod^{-1} (1.95) was recorded from control treatment (M_0).The maximum number of seeds pod^{-1} (2.68) was recorded from F_1 and the minimum number of seeds pod^{-1} (1.90) was recorded from F_0.

The field experiment was carried out by Myint *et al.* (2009)at the National Corn and Sorghum Research Center, on a site with Pakchong series soils during the dry season in 2007 (DS) and the wet season in 2008 (WS).This study aimed to determine the effects of different organic amendments on soybean plant growth and grain yield. Treatments were a combination of chemical fertilizer (16-20-0) 60 kg ha^{-1} and extracts of jatropha 20 cc, chitosan 60 cc and fish waste 40 cc in 20 l of water; chicken manure 3 ton ha^{-1}; jatropha cake 3 and 6 ton ha^{-1}; chemical fertilizer (16-20-0) 180 kg ha^{-1} and control (no application). In DS, applying chemical fertilizer resulted in a greater seed number per plant (64.60). In WS, amendment with 6 and 3 ton of jatropha cake showed increased

seed numbers (180.26 and 163.80) over the other treatments. The chitosan extract-treated plot produced the lowest seed number (92.77).

The field experiment on soybean was conducted by Son *et al*. (2001) at Phuoc Thoi village, O Mon district, Cantho province with different fertilizer application doses to study the influence of organic and bio- fertilizer on the growth and grain yield of soybean and soil fertility. There were 11 treatment *viz.*T_1 = 100- 60 -30 (N - P_2O_5 - K_2O kg ha^{-1}), T_2= 60-60-30(N - P_2O_5 - K_2O kg ha^{-1}), T_3= 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_4 = 00-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_5= Inoculants + 60-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_6= Inoculants + 30-30-30(N - P_2O_5 - K_2O kg ha^{-1}), T_7= Compost + 60-60-30(N - P_2O_5 - K_2O kg ha^{-1}), T_8= Compost + 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_9= Inoculants + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}), T_{10}= Compost + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}) and T_{11}= Compost + inoculants +30-60-30(N - P_2O_5 - K_2O kg ha^{-1}). They concluded that, the highest number of seeds pod^{-1} (2.23) obtained under T_1 (100- 60 -30) (N - P_2O_5 - K_2O kg ha^{-1}), T_2 and T_8 at 56 DAS and the lowest number of seeds pod^{-1} (2.03) obtained under T_4 (00-60-30, N - P_2O_5 - K_2O kg ha^{-1}) and T_{10} (Compost + 00-00-00, N - P_2O_5 - K_2O kg ha^{-1}).

2.2.3 100 seed weight

Patil and Udmale (2016) conducted an experiment at the Cropping Systems Research Project Farm, M.P.K.V., Rahuri during *kharif* 2007-08 to study the response of soybean to various organic inputs under irrigated condition. Eight treatments consisting of organic inputs *viz.* T_1 : Control, T_2 : Farm yard manure (FYM) at 5 t ha^{-1}, T_3 : Vermicompost (VC) at 2 t ha^{-1}, T_4 : FYM + VC (50+50) (2.5 t ha^{-1} + 1 t ha^{-1}), T_5 : FYM + Jeevamrut 2 times (30 and 45 DAS) (FYM 5 t ha^{-1}), T_6 : VC + Jeevamrut 2 times (30 and 45 DAS) (2 t ha^{-1} + 500 lit ha^{-1}), T_7 : FYM+VC (50+50)+Jeevamrut 2 times (30 and 45 DAS) (2.5 t ha^{-1}+1 t ha^{-1} +500 lit ha^{-1}) and T_8 : Jeevamrut 2 times (30 and 45 DAS) (500 lit ha^{-1}) were tested in the experiment. *Rhizobium* and PSB biofertilizer is common to all treatments. The result showed that, the maximum mean 100 grain weight (14.20 g) was observed from T_7 treatments while the minimum mean 100 grain weight (12.10 g) from control treatment (T_1).

A field experiment was conducted by Khanam *et al.* (2016)at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during December 2013 to April 2014 to evaluate the effect of phosphorus (P_0: 0 kg TSP ha^{-1}, P_1: 100 kg TSP ha^{-1}, P_2: 175 kg TSP ha^{-1}, P_3: 250 kg TSP ha^{-1}) and potassium (K_0: 0 kg MoP, K_1: 60 kg MoP ha^{-1}, K_2: 120 kg MoP ha^{-1}, K_3: 180 kg MoP ha^{-1}), and their combinations on growth and yield of soybean (*Glycine max*). The result revealed that, the heaviest 1000-seed weight (106.2 g) was obtained with 175 kg $ha^{-1}$of TSP and the lightest one (101.50 g) from 0 kg $ha^{-1}$of TSP. The application of 120 kg MoP ha^{-1} resulted in maximum 1000-seed weight (106.4 g) and the minimum one (101.2 g) from 0 kg MoP ha^{-1}.The maximum 1000-seed weight (109.1 g) was harvested with the combined application of TSP and MoP@175 and 120 kg ha^{-1}, respectively and the minimum 1000-seed weight (96.56 g) was harvested with the combined application of TSP and MoP@ 0 and 0 kg ha^{-1}, respectively.

A field experiment was conducted by Begum *et al*. (2015) at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to study the effects of nitrogen and phosphorus on the performance of soybean. Three levels of nitrogen (0, 25 and 40 kg N ha^{-1}) and four levels of phosphorus (0, 18, 36 and 54 kg P ha^{-1}) were considered as treatment for the experiment. The maximum 1000 seed weight (120.24 g) was recorded with 25 kg N ha^{-1} whereas minimum 1000 seed weight (111.26 g) was observed with control treatment (no fertilizers). The maximum 1000 seed weight (122.20 g) was recorded with 54 kg P ha^{-1} whereas minimum 1000 seed weight (109.15 g) was observed with control treatment (no fertilizers). The maximum 1000 seed weight (127.98 g) was obtained from the combination of 25 kg N with 54 kg P ha^{-1} and minimum 1000 seed weight (105.13 g) was obtained from the combination of 0 kg N with 0 kg P ha^{-1}.

Field trials were conducted by Chiezey (2013) during the rainy seasons of 2009, 2010 and 2011 in Samaru in the northern Guinea Savanna zone of Nigeria to evaluate the response of soybean to separate and combined applications of farmyard manure (FYM) and mineral phosphorus fertilizers levels. Soybean varieties TGx 1448-2E and TGx 1019-2E were grown with three levels of FYM (0, 1 and 2 t ha^{-1}) and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}). Result revealed that, the maximum mean 100 seed weight (13.00 g) was found from FYM 2 t ha^{-1} and minimum (12.30 g) from FYM 1 t ha^{-1}

application plot. The maximum mean 100 seed weight (12.70 g) was found from 0 and 26.40 kg P ha^{-1} and the minimum mean 100 seed weight (11.80 g) was found from 0 kg P ha^{-1}.

A field experiment was conducted by Khaim*et al*. (2013) at Genetics and Plant Breeding farm, Bangladesh Agricultural University from July to November, 2011 to evaluate the effect of cowdung and poultry manure with chemical fertilizer on the yield and quality of soybean cv. BINA soybean-2.Nine treatments *viz*. control (CT), 100% recommended dose of chemical fertilizers ($RDCF_{100\%)}$, 50% RDCF ($RDCF_{50\%}$), cowdung 10 t ha^{-1} (CD10 t ha^{-1}), 50% RDCF + CD 5 t ha^{-1} ($RDCF_{50\%}$ + CD5 t ha^{-1}), 75% RDCF + CD 3t ha^{-1} ($RDCF_{75\%}$ + CD 3 t ha^{-1}), poultry manure 3 t ha^{-1} (PM3 t ha^{-1}), 50% RDCF + PM 1.5 t ha^{-1} ($RDCF_{50\%}$ + PM 1.5 t ha^{-1}) and 75% RDCF + PM 1 t ha^{-1} ($RDCF_{75\%}$ + PM1 t ha^{-1}) were considered as treatment for the experiment. The result revealed that, the highest value of the 100-grain weight was found in $RDCF_{100\%}$ (12.64 g) which was identical with $RDCF_{75\%}$ +PM1 t ha^{-1} (12.62 g) and the lowest weight was observed in control (10.20 g) treatment.

A field experiment was conducted Yagoub *et al.* (2012) for two consecutive seasons (2009/2010 and 2010/2011) on the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, to study the effect of some fertilizers on growth and yield of soybean. The fertilizers treatments consisted of three types of fertilizers: urea (180 kg ha^{-1}), NPK (361 kg ha^{-1}), compost (%) and the control. The results showed that the highest mean of 100 seeds weight in the first season was 9.83 (g) given by control; in the second season was 6.47 (g) given by NPK treatment.

Azarpour *et al.* (2012) conducted an experiment at Astaneh Ashrafiyeh County (north of Iran) during 2010.Seed inoculation with biological nitrogen fertilizer nitroxin with two levels [N_1: control (without seed inoculation) and N_2: seed inoculation with nitroxin], application of vermicompost with three levels [V_1: control (without vermicompost application), V_2: 5 t ha^{-1} and V3: 10 t ha^{-1}] and plant density with three levels (D_1: 45 plants per m^2, D_2: 65 plants per m^2 and D_3: 85 plants per m^2) were used as treatment variables. They reported that, the maximum 100 seed weight (15.70 g) was recorded from

N_2 and the minimum (14.90 g) from N_1. The maximum 100 seed weight (16.25 g) was recorded from V_3 and the one (13.98 g) from V_1. The highest 100 seed weight (16.76 g) was recorded from N_2V_3 and the shortest (13.79g) from N_1V_1 treatment combination.

An experiment was conducted by Tomar and Khajanji (2009) at Raipur during 2001-02 and 2002-03 to study the effect of organic and inorganic sources of nutrients on the productivity, quality and economics of soybean. Treatments consisted of four combinations of organic manuring *viz*. M_0: control, M_1: crop residues-rice straw @ 5 t ha^{-1}, M_2: FYM @ 5 t ha^{-1} and M_3: crop residue + FYM each @ 5 t ha^{-1} + Zinc @ 5 kg ha^{-1}) and three levels of mineral fertilizers *viz*. F_0: control, F_1: 100 % RDF and F_2: 50 % RDF) laid out in split plot design with three replications. They found that, organic manure did not significantly influenced 100 seed weight. The maximum 1000 seed weight (12.51 g) was recorded from F_2 and the minimum 100 seed weight (12.32 g) was recorded from F_0 treatment.

The field experiment was carried out by Myint *et al.* (2009)at the National Corn and Sorghum Research Center, on a site with Pakchong series soils during the dry season in 2007 (DS) and the wet season in 2008 (WS) to determine the effects of different organic amendments on soybean plant growth and grain yield. Treatments were a combination of chemical fertilizer (16-20-0) 60 kg ha^{-1} and extracts of jatropha 20 cc, chitosan 60 cc and fish waste 40 cc in 20 l of water; chicken manure 3 ton ha^{-1}; jatropha cake 3 and 6 ton ha^{-1}; chemical fertilizer (16-20-0) 180 kg ha^{-1} and control (no application). The maximum 100 seed weight (19.27 g) was counted from chemical fertilizer (16-20-0) 180 kg ha^{-1} and the minimum 100 seed weight (17.77 g) was counted from Ce + F_{60} treatment.

Field experiments were conducted by Chiezey and Odunze (2009) during the rainy seasons of 2003 and 2005 in Samaru in the Northern Guinea Savanna zone of Nigeria to test the response of two soybean varieties to application of poultry manure and phosphorus fertilizer levels. Soybean varieties TGx 1448-2E and TGx 1019-2EB were grown without and with 1 t ha^{-1} of poultry manure and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}) in all possible factorial combinations using randomized complete block design with four replicates. Result revealed that, the maximum mean 100 seed weight

(12.80 g) was found from poultry manure 1 t ha^{-1} whereas the minimum mean 100 seed weight (12.60 g) was found from no poultry manure application plot. Among phosphorous levels, the maximum mean 100 seed weight (13.00 g) was found from 0 and 26.40 kg P ha^{-1} whereas the minimum mean 100 seed weight (12.10 g) was found from 13.20 kg P ha^{-1}.

The field experiment on soybean was conducted by Son *et al*. (2001) at Phuoc Thoi village, O Mon district, Cantho province with different fertilizer application doses to study the influence of organic and bio- fertilizer on the growth and grain yield of soybean and soil fertility. There were 11 treatment *viz.*T_1 = 100- 60 -30 (N - P_2O_5 - K_2O kg ha^{-1}), T_2= 60-60-30(N - P_2O_5 - K_2O kg ha^{-1}), T_3= 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_4 = 00-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_5= Inoculants + 60-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_6= Inoculants + 30-30-30(N - P_2O_5 - K_2O kg ha^{-1}), T_7= Compost + 60-60-30(N - P_2O_5 - K_2O kg ha^{-1}), T_8= Compost + 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_9= Inoculants + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}), T_{10}= Compost + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}) and T_{11}= Compost + inoculants +30-60-30(N - P_2O_5 - K_2O kg ha^{-1}). They reported that, the highest 100 seed weight (16.83 g) obtained under T_7 (Compost + 60-60-30) at 56 DAS and the 100 seed weight (15.67 g) obtained under T_9 (Inoculants + 00-00-00, N - P_2O_5 - K_2O kg ha^{-1}).

2.2.4 Shelling percentages

The effect of packaged organic and inorganic fertilizers on the growth and yield of soybean .was carried out by Falodun *et al.* (2010) in the rainforest zone of Nigeria. The treatments used were inorganic fertilizer NPK 15: 15: 15 and packaged organic fertilizer. Six treatments *viz.* 0, 100, 200 and 300 kg ha^{-1} NPK 15:15:15 fertilizer, and 100 and 300 Kg ha^{-1} organic fertilizer were considered as treatment for the experiment. Results showed that, maximum shelling percentage (80.70%) was obtained by NPK 100 (kg ha^{-1}) and minimum shelling percentage (65.60%) was obtained by NPK 200(kg ha^{-1}).

2.3 Effect on yield

2.3.1 Seed yield

A field experiment was conducted by Khanam *et al.* (2016)at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during December 2013 to April 2014 to evaluate the effect of phosphorus (P_0: 0 kg TSP ha^{-1}, P_1: 100 kg TSP ha^{-1}, P_2: 175 kg TSP ha^{-1}, P_3: 250 kg TSP ha^{-1}) and potassium (K_0: 0 kg MoP, K_1: 60 kg MoP ha^{-1}, K_2: 120 kg MoP ha^{-1}, K_3: 180 kg MoP ha^{-1}), and their combinations on growth and yield of soybean. The result revealed that,the maximum seed yield (3.67 t ha^{-1}) was harvested with the combined application of TSP and MoP@175 and 120 kg ha^{-1}, respectively and the minimum seed yield (1.78 t ha^{-1}) was harvested with the combined application of TSP and MoP@ 0 and 0 kg ha^{-1}, respectively.

Patil and Udmale (2016) conducted an experiment at the Cropping Systems Research Project Farm, M.P.K.V., Rahuri during *kharif* 2007-08 to study the response of soybean to various organic inputs under irrigated condition. Eight treatments consisting of organic inputs *viz.* T_1 : Control, T_2 : Farm yard manure (FYM) at 5 t ha^{-1}, T_3 : Vermicompost (VC) at 2 t ha^{-1}, T_4 : FYM + VC (50+50) (2.5 t ha^{-1} + 1 t ha^{-1}), T_5 : FYM + Jeevamrut 2 times (30 and 45 DAS) (FYM 5 t ha^{-1}), T_6 : VC + Jeevamrut 2 times (30 and 45 DAS) (2 t ha^{-1} + 500 lit ha^{-1}), T_7 : FYM+VC (50+50)+Jeevamrut 2 times (30 and 45 DAS) (2.5 t ha^{-1}+1 t ha^{-1} +500 lit ha^{-1}) and T_8 : Jeevamrut 2 times (30 and 45 DAS) (500 lit ha^{-1}) were tested in the experiment. *Rhizobium* and PSB biofertilizer is common to all treatments. The result showed that, the maximum mean grain yield (24.72 q ha^{-1}) was observed from T_7 treatments while the minimum mean grain yield (18.90 q ha^{-1}) from control treatment (T_1).

A field experiment was conducted by Begum *et al*. (2015) at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to study the effects of nitrogen and phosphorus on the performance of soybean. Three levels of nitrogen (0, 25 and 40 kg N ha^{-1}) and four levels of phosphorus (0, 18, 36 and 54 kg P ha^{-1}) were considered as treatment for the experiment. The maximum seed yield (1.95 t ha^{-1}) was recorded with 25 kg N ha^{-1} whereas minimum seed yield (1.41 t ha^{-1}) was observed with

control treatment (no fertilizers). The maximum seed yield (2.09 t ha^{-1}) was recorded with 54 kg P ha^{-1} whereas minimum seed yield (1.30 t ha^{-1}) was observed with control treatment (no fertilizers). The maximum seed yield (2.30 t ha^{-1}) was obtained from the combination of 25 kg N with 54 kg P ha^{-1} and minimum seed yield (1.08 t ha^{-1}) was obtained from the combination of 0 kg N with 0 kg P ha^{-1}.

A field study was therefore conducted by Falodun *et al*. (2015)at the Department of Crop Science, University of Benin Teaching and Research Farm, Benin City, Edo State during the 2012/2013 cropping seasons, to investigate the effects of poultry manure and inorganic NPK 15:15:15 fertilizer on the growth and yield of soya bean (*Glycine max* (L.) Merr). Six treatments viz: 0, 200 kg ha^{-1} NPK 15:15:15, 10 t ha^{-1} poultry manure (PM), 7 t ha^{-1} poultry manure + 60 kg ha^{-1} NPK 15:15:15, 5 t ha^{-1} poultry manure + 100 kg ha^{-1} NPK 15:15:15, 2.5 t ha^{-1} poultry manure + 150 kg ha^{-1} NPK 15:15:15 were tested as treatment in the experiment. Results showed that, application of 2.5 t ha^{-1} PM and 150 kg ha^{-1} NPK gave the maximum grain yield (7.37 t ha^{-1}). The minimum grain yield (3.24 t ha^{-1}) was observed with the control (no fertilizers) treatment.

Usman *et al.* (2015) carried out a field experiments at the Teaching and Research Farm, University of Agriculture, Makurdi to determine the effect of three levels of NPK fertilizer on growth parameters and yield of maize-soybean intercrop. Cropping system at two levels (sole and intercrops) and NPK fertilizer at three levels (0, 150 and 300 kg ha^{-1} of NPK 20:10:10) were tested as treatment in the experiment. They reported that, the maximum grain yield (2000 kg ha^{-1}) was observed with 300 kg ha^{-1} of NPK application and the minimum value for grain yield (500 kg ha^{-1}) was observed in control treatment (no NPK).

A study has been conducted by Kuntyastuti and Suryantini (2015) with the aim of evaluating the effect of P fertilizers and its residues on soybean growth and yield. Study was conducted in two planting seasons (PS). In the first planting season (PS-1) four doses of P fertilizer i.e. 0, 200, 400 and 600 kg ha^{-1} SP-36 was used. While in the second planting season (PS-2), fertilizer treatment was five doses of SP-36 i.e. 0, 50, 100, 200 and 400 kg ha^{-1}. The results revealed that, the results revealed that, the maximum grain

yield pot^{-1} (271.90 g) was produced by 200 kg ha^{-1} P-fertilizer while the minimum value (240.89 g) was from 0 kg ha^{-1} P-fertilizer.

An on farmer's fields' study was carried out by Zoundji *et al.* (2015) in Northern and Centre Benin to determine the effectiveness of *Bradyrhizobium japonicum* strains introduced in Benin cropping systems. Five inoculations treatments (control, FA3, STM3043, STM3045 and USDA110), two phosphorus levels (0 and 50 kg of P_2O_5 ha^{-1}) arranged in split plot design were established in twelve farmers' fields. Each farmer represented one replication. Results indicated that, the highest mean values grain yield (2739 kg ha^{-1}) was found in FA3+ 50 kg of P_20_5 ha^{-1} treatment compare to the control (770 kg ha^{-1}) in AEZ 3.

Ahmed (2015) Carried out a field experiment for two consecutive seasons (2009/10 and 2010/11) in the Demonstration Farm of the Faculty of Agriculture at Shambat-Sudan, to study the interactive effect of nitrogen fertilization and rhizobium inoculation on nodulation and yield of soybean .The treatments consist of increasing doses of nitrogen (0, 40 and 80 kg ha^{-1}urea) and one strain of rhizobium. The seeds of cultivar Giza 22 were either uninoculated or inoculated with *Rhizobium japonicum* strain TAL 110 before sowing. The results of the investigation showed that, maximum number of seeds yield (2.22 t ha^{-1}) was recorded from N_1R_1 treatment combination whereas the minimum one (1.35 t ha^{-1}) was recorded from N_0R_0.

Field trials were conducted by Chiezey (2013) during the rainy seasons of 2009, 2010 and 2011 in Samaru in the northern Guinea Savanna zone of Nigeria to evaluate the response of soybean to separate and combined applications of farmyard manure (FYM) and mineral phosphorus fertilizers levels. Soybean varieties TGx 1448-2E and TGx 1019-2E were grown with three levels of FYM (0, 1 and 2 t ha^{-1}) and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}). Result revealed that, the maximum mean seed yield (2322.5 kg ha^{-1}) was found from FYM 2 t ha^{-1} whereas the minimum mean seed yield (1814.10 kg ha^{-1}) was found from no FYM application plot. Among phosphorous levels, the maximum mean seed yield (2388.40 kg ha^{-1}) was found from 39.60 kg P ha^{-1} whereas the

minimum mean seed yield (1598.40 kg ha^{-1}) was found from no phosphorous application plot.

The effect of inorganic, biological and organic manures on nodulation and yield of soybean and soil properties was studied by Devi *et al.* (2013) during rainy seasons of 2008 and 2009 in India (Manipur). The experiment consists of nine treatments viz., T_1 - Absolute control, T_2 – FYM (Farmyard manure) at the rate of 5 t ha^{-1}, T_3 -Vermicompost at the rate of 1 t ha^{-1}, T_4 - 100% RDF (Recommended dose of fertilizer), T_5 - 100% RDF + PSB, T_6 - 75% RDF + vermicompost at the rate of 1 t ha^{-1}, T_7 - 75% RDF + vermicompost at the rate of 1 t ha^{-1} + PSB, T_8 - 50% RDF + vermicompost at the rate of 1 t ha^{-1} and T_9 - 50% RDF + vermicompost at the rate of 1 t ha^{-1} + PSB. They reported that, integration of inorganic fertilizer with vermicompost and PSB was superior in grain yield than the application of chemical fertilizer or organic manure alone. Combination of 75% RDF with vermicompost at the rate of 1 t ha^{-1} and PSB produced significantly highest grain yield (1.92 t ha^{-1}) of soybean and the lowest (.70 t ha^{-1}) from control treatment.

A field experiment was conducted by Khaim *et al*. (2013) at Genetics and Plant Breeding farm, Bangladesh Agricultural University from July to November, 2011 to evaluate the effect of cowdung and poultry manure with chemical fertilizer on the yield and quality of soybean cv. BINA soybean-2. Nine treatments *viz*. control (CT), 100% recommended dose of chemical fertilizers ($RDCF_{100\%}$), 50% RDCF ($RDCF_{50\%}$), cowdung 10 t ha^{-1} (CD10 t ha^{-1}), 50% RDCF + CD 5 t ha^{-1} ($RDCF_{50\%}$ + CD5 t ha^{-1}), 75% RDCF + CD 3t ha^{-1} ($RDCF_{75\%}$ + CD 3 t ha^{-1}), poultry manure 3 t ha^{-1} (PM3 t ha^{-1}), 50% RDCF + PM 1.5 t ha^{-1} ($RDCF_{50\%}$ + PM 1.5 t ha^{-1}) and 75% RDCF + PM 1 t ha^{-1} ($RDCF_{75\%}$ + PM1 t ha^{-1}) were tested in the experiment. The result revealed that, the highest grain yield (2699 kg ha^{-1}) was obtained in RDCF, which was statistically identical to $RDCF_{75\%}$ + PM1 t ha^{-1} and the lowest grain yield (1570.27 kg ha^{-1}) was recorded from control treatment.

An experiment was conducted by Janagrad *et al*. (2013) to investigate the effects of biological and chemical fertilizers on soybean performance, at the Research Farm of the University of Tabriz, Iran. Treatments were non-inoculated (NI) and inoculated seeds

with phosphate solubilizing bacteria (PSB), *bradyrhizobium japonicum* (BJ) and B. *japonicum* + PSB (BJ + PSB) and also Chemical fertilizers were 16.5 Kg ha^{-1} urea + 49.5 Kg ha^{-1} triple superphosphate (33%), 33.3 Kg ha^{-1} urea + 99 Kg ha^{-1} triple superphosphate (66%), 50 Kg ha^{-1} urea + 150 Kg ha^{-1} triple superphosphate (100%) with control (0%). They reported that, 66 and 100% fertilizer application produced significantly more yield than control in non-inoculated seed but 33% × BJ + PSB produced highest grain yield in inoculated seed.

A field experiment was conducted by Yagoub *et al.* (2012) for two consecutive seasons (2009/2010 and 2010/2011) on the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, to study the effect of some fertilizers on growth and yield of soybean (*Glycine max L. merril*). The experiment was laid out in a randomized complete block design (RCBD) with four replicates. The fertilizers treatments consisted of three types of fertilizers: urea (180 kg ha^{-1}), NPK (361 kg ha^{-1}), compost (%) and the control. The results showed that the highest mean green yield in the first season it was 15618.17 (kg ha^{-1}) given by control, and in the second season it was 13964.57 (kg ha^{-1}) given by NPK.

Azarpour *et al.* (2012) conducted an experiment at Astaneh Ashrafiyeh County (north of Iran) during 2010.Seed inoculation with biological nitrogen fertilizer nitroxin with two levels [N_1: control (without seed inoculation) and N_2: seed inoculation with nitroxin], application of vermicompost with three levels [V_1: control (without vermicompost application), V_2: 5 t ha^{-1} and V3: 10 t ha^{-1}] and plant density with three levels (D_1: 45 plants per m^2, D_2: 65 plants per m^2 and D_3: 85 plants per m^2) were used as treatment variables. They reported that, the maximum seed yield (2392 t ha^{-1}) was recorded from N_2 and the minimum (2163.2 t ha^{-1}) from N_1. The maximum seed yield (2868 t ha^{-1}) was recorded from V_3 and the minimum one (1661 t ha^{-1}) was from V_1. The maximum seed yield (2920 t ha^{-1}) was recorded from N_2V_3 and the minimum(1486 t ha^{-1}) from N_1V_1 treatment combination.

The effect of packaged organic and inorganic fertilizers on the growth and yield of soyabean (*Glycine max* (L) merr.) was carried out by Falodun *et al.* (2010) in the rainforest zone of Nigeria. The treatments used were inorganic fertilizer NPK 15: 15: 15 and packaged organic fertilizer.Six treatments were 0, 100, 200 and 300 kg ha^{-1} NPK 15:15:15 fertilizer, and 100 and 300 Kg ha^{-1} organic fertilizer.Results showed that, highest grain yield (3213.33 kg ha^{-1}) was obtained by NPK 200 (kg ha^{-1}) and lowest grain yield (1141.60 kg ha^{-1}) was obtained by control treatment.

An experiment was conducted by Tomar and Khajanji (2009) at Raipur during 2001-02 and 2002-03 to study the effect of organic and inorganic sources of nutrients on the productivity, quality and economics of soybean. Four combinations of organic manuring *viz*. M_0: control, M_1: crop residues-rice straw @ 5 t ha^{-1}, M_2: FYM @ 5 t ha^{-1} and M_3: crop residue + FYM each @ 5 t ha^{-1} + Zinc @ 5 kg ha^{-1}) and three levels of mineral fertilizers *viz*. F_0: control, F_1: 100 % RDF and F_2: 50 % RDF) were tested in the experiment as treatment variable. The result of the experiment revealed that, the maximum seed yield (13.58 q ha^{-1}) was recorded from organic manuring in soybean with crop residue + FYM each @ 5 t ha^{-1}+ zinc @ 5 kg ha^{-1} (M_3) and the minimum (9.95 q ha^{-1}) from control treatment (M_0). In case of mineral fertilizer, the maximum seed yield (12.88 q ha^{-1}) was recorded from F_1 and the minimum seed yield (10.32 q ha^{-1}) was recorded from F_0.

A field experiments were conducted by Chiezey and Odunze (2009) during the rainy seasons of 2003 and 2005 in Samaru in the Northern Guinea Savanna zone of Nigeria to test the response of two soybean varieties to application of poultry manure and phosphorus fertilizer levels. Soybean varieties TGx 1448-2E and TGx 1019-2EB were grown without and with 1 t ha^{-1} of poultry manure and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}). Result revealed that, the maximum mean seed yield (1967.30 kg ha^{-1}) was found from poultry manure 1 t ha^{-1} and the minimum mean (1471.0 kg ha^{-1}) from no poultry manure application plot. The maximum mean seed yield (2015.70 kg ha^{-1}) was found from application of 39.60 kg P ha^{-1} and the minimum (1518.80 kg ha^{-1}) from no phosphorous application plot.

The field experiment was carried out by Myint *et al.* (2009) at the National Corn and Sorghum Research Center, on a site with Pakchong series soils during the dry season in 2007 (DS) and the wet season in 2008 (WS) to determine the effects of different organic amendments on soybean plant growth and grain yield. Eight treatments were a combination of chemical fertilizer (16-20-0) 60 kg ha^{-1} and extracts of jatropha 20 cc, chitosan 60 cc and fish waste 40 cc in 20 l of water; chicken manure 3 ton ha^{-1}; jatropha cake 3 and 6 ton ha^{-1}; chemical fertilizer (16-20-0) 180 kg ha^{-1} and control (no application).In DS, crops applied with chemical fertilizer gave significantly greater yield (1755.00 kg ha^{-1}) than any other treatment. Application of chitosan and fish waste extracts (1533.33 and 1436.67 kg ha^{-1}) tended to be higher than those of the other treatments of the control, jatropha extracts, chicken manure and 3 and 6 ton of jatropha cake (1133.33, 1251.67, 1356.67, 1313.33 and 1245 kg ha^{-1}, respectively). In WS, soybean grain yield amended with 3 ton of jatropha cake gave the highest yield (5410.83 kg ha^{-1}). The seed yield of soybean applied with 6 ton of jatropha cake (4331.67 kg ha^{-1}) and chemical fertilizer (4190.83 kg ha^{-1}) seemed to be higher than the yields of the control (3280 kg ha^{-1}), jatropha, chitosan and fish waste extracts (3600, 3444.17 and 3850.83 kg ha^{-1}) and chicken manure (3757.50 kg ha^{-1}) plots.

The field experiment on soybean was conducted by Son *et al*. (2001) at Phuoc Thoi village, O Mon district, Cantho province to study the influence of organic and bio-fertilizer on the growth and grain yield of soybean and soil fertility. Eleven treatments *viz.*T_1 = 100- 60 -30 (N - P_2O_5 - K_2O kg ha^{-1}), T_2= 60-60-30(N - P_2O_5 - K_2O kg ha^{-1}), T_3= 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_4 = 00-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_5= Inoculants + 60-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_6= Inoculants + 30-30-30(N - P_2O_5 - K_2O kg ha^{-1}), T_7= Compost + 60-60-30(N - P_2O_5 - K_2O kg ha^{-1}), T_8= Compost + 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_9= Inoculants + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}), T_{10}= Compost + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}) and T_{11}= Compost + inoculants +30-60-30(N - P_2O_5 - K_2O kg ha^{-1}) were tested. They found that, the gain yield (2.50 t ha^{-1}) obtained under T_1 (100- 60 -30) (N - P_2O_5 - K_2O kg ha^{-1}) at 56 DAS and the lowest pods $plant^{-1}$ (1.86 t ha^{-1}) obtained under T_4 (00-60-30, N - P_2O_5 - K_2O kg ha^{-1}).

2.3.2 Stover yield

A field experiment was conducted by Khanam *et al.* (2016)at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during December 2013 to April 2014 to evaluate the effect of phosphorus (P_0: 0 kg TSP ha^{-1}, P_1: 100 kg TSP ha^{-1}, P_2: 175 kg TSP ha^{-1}, P_3: 250 kg TSP ha^{-1}) and potassium (K_0: 0 kg MoP, K_1: 60 kg MoP ha^{-1}, K_2: 120 kg MoP ha^{-1}, K_3: 180 kg MoP ha^{-1}), and their combinations on growth and yield of soybean. They reported that, the highest soybean stover yield (3.21 t ha^{-1} and 3.72 t ha^{-1}) were produced when the crop was fertilized with 175 kg $ha^{-1}$of TSP and 120 kg $ha^{-1}$of MoP and the lowest (2.94 t ha^{-1} 2.58 t ha^{-1}). The maximum stover yield (4.01 t ha^{-1}) was harvested with the combined application of TSP and MoP@175 and 120 kg ha^{-1}, respectively and the minimum stover yield (2.41 t ha^{-1}) was harvested with the combined application of TSP and MoP@ 100 and 180 kg ha^{-1} respectively.

Patil and Udmale (2016) conducted an experiment at the Cropping Systems Research Project Farm, M.P.K.V., Rahuri during *kharif* 2007-08 to study the response of soybean to various organic inputs under irrigated condition. Eight treatments consisting of organic inputs *viz.* T_1 : Control, T_2 : Farm yard manure (FYM) at 5 t ha^{-1}, T_3 : Vermicompost (VC) at 2 t ha^{-1}, T_4 : FYM + VC (50+50) (2.5 t ha^{-1} + 1 t ha^{-1}), T_5 : FYM + Jeevamrut 2 times (30 and 45 DAS) (FYM 5 t ha^{-1}), T_6 : VC + Jeevamrut 2 times (30 and 45 DAS) (2 t ha^{-1} + 500 lit ha^{-1}), T_7 : FYM+VC (50+50)+Jeevamrut 2 times (30 and 45 DAS) (2.5 t ha^{-1}+1 t ha^{-1} +500 lit ha^{-1}) and T_8 : Jeevamrut 2 times (30 and 45 DAS) (500 lit ha^{-1}) were tested in the experiment. *Rhizobium* and PSB biofertilizer is common to all treatments. They reported that, the maximum mean stover yield (31.24 q ha^{-1}) was observed from T_7 treatments while the minimum mean stover yield (25.19 q ha^{-1}) from control treatment (T_1).

A field experiment was conducted by Begum *et al*. (2015) at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to study the effects of nitrogen and phosphorus on the performance of soybean. Three levels of nitrogen (0, 25 and 40 kg N ha^{-1}) and four levels of phosphorus (0, 18, 36 and 54 kg P ha^{-1}) were considered as treatment for the experiment. The maximum stover yield (2.35 t ha^{-1}) was recorded with 25 kg N ha^{-1} whereas minimum stover yield (1.69 t ha^{-1}) was observed with

control treatment (no fertilizers). The maximum stover yield (2.46 t ha^{-1}) was recorded with 54 kg P ha^{-1} whereas minimum stover yield (1.61t ha^{-1}) was observed with control treatment (no fertilizers). The maximum stover yield (2.63 t ha^{-1}) was obtained from the combination of 25 kg N with 54 kg P ha^{-1} and minimum stover yield (1.28 t ha^{-1}) was obtained from the combination of 0 kg N with 0 kg P ha^{-1}.

An on farmer's fields' study was carried out by Zoundji *et al.* (2015) in Northern and Centre Benin to determine the effectiveness of *Bradyrhizobium japonicum* strains introduced in Benin cropping systems. Five inoculations treatments (control, FA3, STM3043, STM3045 and USDA110), two phosphorus levels (0 and 50 kg of P_2O_5 ha^{-1}) arranged in split plot design were established in twelve farmers' fields. Each farmer represented one replication. Results indicated that, the highest mean values straw yield (5274 kg ha^{-1}) was found in FA3+ 50 kg of P_20_5 ha^{-1} treatment compare to the control (1810 kg ha^{-1}) in AEZ 3.

The effect of inorganic, biological and organic manures on nodulation and yield of soybean and soil properties was studied by Devi *et al.* (2013) during rainy seasons of 2008 and 2009 in India (Manipur). The experiment consists of nine treatments viz., T_1 - Absolute control, T_2 – FYM (Farmyard manure) at the rate of 5 t ha^{-1}, T_3 -Vermicompost at the rate of 1 t ha^{-1}, T_4 - 100% RDF (Recommended dose of fertilizer), T_5 - 100% RDF + PSB, T_6 - 75% RDF + vermicompost at the rate of 1 t ha^{-1}, T_7 - 75% RDF + vermicompost at the rate of 1 t ha^{-1} + PSB, T_8 - 50% RDF + vermicompost at the rate of 1 t ha^{-1} and T_9 - 50% RDF + vermicompost at the rate of 1 t ha^{-1} + PSB. The experiment was replicated thrice in randomized block design. The results of the integration revealed that, significantly higher stover yield (2.04 t ha^{-1}) was produced by the integration of 75% RDF with vermicompost at the rate of 1 t ha^{-1} and PSB and the lowest (0.97 t ha^{-1}) from control.

Field trials were conducted by Chiezey (2013) during the rainy seasons of 2009, 2010 and 2011 in Samaru in the northern Guinea Savanna zone of Nigeria to evaluate the response of soybean to separate and combined applications of farmyard manure (FYM) and mineral phosphorus fertilizers levels. Soybean varieties TGx 1448-2E and TGx 1019-

2E were grown with three levels of FYM (0, 1 and 2 t ha^{-1}) and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}). They found that, the maximum mean stover yield (6529.0 kg ha^{-1}) was found from FYM 2 t ha^{-1} whereas the minimum mean stover yield (2944.20 kg ha^{-1}) was found from no FYM application plot. Among phosphorous levels, the maximum mean stover yield (6575.70 kg ha^{-1}) was found from 39.60 kg P ha^{-1} whereas the minimum mean stover yield (4817.90 kg ha^{-1}) was found from no phosphorous application plot.

A field experiment was conducted by Khaim*et al*. (2013) at Genetics and Plant Breeding farm, Bangladesh Agricultural University from July to November, 2011 to evaluate the effect of cowdung and poultry manure with chemical fertilizer on the yield and quality of soybean cv. BINA soybean-2.Nine treatments *viz*. control (CT), 100% recommended dose of chemical fertilizers ($RDCF_{100\%}$), 50% RDCF ($RDCF_{50\%}$), cowdung 10 t ha^{-1} (CD10 t ha^{-1}), 50% RDCF + CD 5 t ha^{-1} ($RDCF_{50\%}$ + CD5 t ha^{-1}), 75% RDCF + CD 3t ha^{-1} ($RDCF_{75\%}$ + CD 3 t ha^{-1}), poultry manure 3 t ha^{-1} (PM3 t ha^{-1}), 50% RDCF + PM 1.5 t ha^{-1} ($RDCF_{50\%}$ + PM 1.5 t ha^{-1}) and 75% RDCF + PM 1 t ha^{-1} ($RDCF_{75\%}$ + PM 1 t ha^{-1}) were tested in the experiment. The result revealed that, the highest stover yield (4660 kg ha^{-1}) was obtained in the treatment $RDCF_{75\%}$ +PM1 t ha^{-1} which was statistically identical to $RDCF_{100\%}$ but dissimilar to other treatments. The lowest stover yield (3010 kg ha^{-1}) was recorded in the control treatment.

Field experiments were conducted by Chiezey and Odunze (2009) during the rainy seasons of 2003 and 2005 in Samaru in the Northern Guinea Savanna zone of Nigeria to test the response of two soybean varieties (TGx 1448-2E and TGx 1019-2EB) to application of poultry manure (0 and 1 t ha^{-1}) and phosphorus fertilizer levels.They found that, the maximum mean stover yield (4070.40 kg ha^{-1}) was found from poultry manure 1 t ha^{-1} and the minimum mean stover yield (3086.20 kg ha^{-1}) was found from no poultry manure application plot.The maximum mean stover yield (3887.70 kg ha^{-1}) was found from application of 39.60 kg P $ha^{-1}$and the minimum mean stover yield (3293.70 kg ha^{-1}) from no phosphorous application plot.

An experiment was conducted by Tomar and Khajanji (2009)at Raipur during 2001-02 and 2002-03 to study the effect of organic and inorganic sources of nutrients on the productivity, quality and economics of soybean [*Glycine max* (L.) Merr.]. Treatments consisted of four combinations of organic manuring *viz*. M_0: control, M_1: crop residues-rice straw @ 5 t ha^{-1}, M_2: FYM @ 5 t ha^{-1} and M_3: crop residue + FYM each @ 5 t ha^{-1} + Zinc @ 5 kg ha^{-1}) and three levels of mineral fertilizers *viz*. F_0: control, F_1: 100 % RDF and F_2: 50 % RDF) were used as treatments. They reported that, the maximum stover yield (24.90 q ha^{-1}) was recorded from organic manuring in soybean with crop residue + FYM each @ 5 t ha^{-1}+ zinc @ 5 kg ha^{-1} (M_3) and the minimum stover yield (22.85 q ha^{-1}) was recorded from control treatment (M_0).The maximum stover yield (24.88 q ha^{-1}) was recorded from F_1 and the minimum (21.90 q ha^{-1}) from F_0 treatment.

The field experiment was carried out by Myint *et al.* (2009)at the National Corn and Sorghum Research Center, on a site with Pakchong series soils during the dry season in 2007 (DS) and the wet season in 2008 (WS).This study aimed to determine the effects of different organic amendments on soybean plant growth and grain yield. Treatments were a combination of chemical fertilizer (16-20-0) 60 kg ha^{-1} and extracts of jatropha 20 cc, chitosan 60 cc and fish waste 40 cc in 20 l of water; chicken manure 3 ton ha^{-1}; jatropha cake 3 and 6 ton ha^{-1}; chemical fertilizer (16-20-0) 180 kg ha^{-1} and control (no application).In DS, the application of chemical fertilizer and 6 ton of jatropha cake showed substantially greater weight (3086.67 and 3055.00 kg ha^{-1}) than any other treatment. In WS, soybean plants amended with 3 ton of jatropha cake gave higher plant dry weight (7214.17 kg ha^{-1}) than other treatments. The treatments of fish waste extacts, jatropha cake 6 ton and chemical fertilizer (4740.83, 6617.5 and 5173.33 kg ha^{-1}) seemed to produce greater weight than that of the control.

2.3.3 Biological yield

A field experiment was conducted by Khanam *et al.* (2016)at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during December 2013 to April 2014 to evaluate the effect of phosphorus (P_0: 0 kg TSP ha^{-1}, P_1: 100 kg TSP ha^{-1}, P_2: 175 kg TSP ha^{-1}, P_3: 250 kg TSP ha^{-1}) and potassium (K_0: 0 kg MoP, K_1: 60 kg MoP ha^{-1}, K_2:

120 kg MoP ha^{-1}, K_3: 180 kg MoP ha^{-1}), and their combinations on growth and yield of soybean. The result revealed that the maximum soybean biological yield (6.22 t ha^{-1}) was produced when the crop was fertilized with 175 kg $ha^{-1}$of TSP and the minimum soybean biological yield (5.00 t ha^{-1}) was produced when the crop was fertilized with 0 kg $ha^{-1}$of TSP. The highest soybean biological yield (6.88 t ha^{-1}) was produced when the crop was fertilized with 120 kg $ha^{-1}$of MoP and the lowest soybean biological yield (4.68 t ha^{-1}) was produced when the crop was fertilized with 0 kg $ha^{-1}$of TSP. The maximum biological yield (7.69 t ha^{-1}) was harvested with the combined application of TSP and MoP@175 and 120 kg ha^{-1}, respectively and the minimum biological yield (4.41 t ha^{-1}) was harvested with the combined application of TSP and MoP@ 0 and 0 kg ha^{-1}, respectively.

Patil and Udmale (2016) conducted an experiment at the Cropping Systems Research Project Farm, M.P.K.V., Rahuri during *kharif* 2007-08 to study the response of soybean to various organic inputs under irrigated condition. Eight treatments consisting of organic inputs *viz.* T_1 : Control, T_2 : Farm yard manure (FYM) at 5 t ha^{-1}, T_3 : Vermicompost (VC) at 2 t ha^{-1}, T_4 : FYM + VC (50+50) (2.5 t ha^{-1} + 1 t ha^{-1}), T_5 : FYM + Jeevamrut 2 times (30 and 45 DAS) (FYM 5 t ha^{-1}), T_6 : VC + Jeevamrut 2 times (30 and 45 DAS) (2 t ha^{-1} + 500 lit ha^{-1}), T_7 : FYM+VC (50+50)+Jeevamrut 2 times (30 and 45 DAS) (2.5 t ha^{-1}+1 t ha^{-1} +500 lit ha^{-1}) and T_8 : Jeevamrut 2 times (30 and 45 DAS) (500 lit ha^{-1}) were tested in the experiment. *Rhizobium* and PSB biofertilizer is common to all treatments. The result showed that, the maximum mean biological yield (55.96 q ha^{-1}) was found from T_7 treatments while the minimum mean biological yield (44.09 q ha^{-1}) from control treatment (T_1).

A field experiment was conducted by Khaim*et al*. (2013) at Genetics and Plant Breeding farm, Bangladesh Agricultural University from July to November, 2011 to evaluate the effect of cowdung and poultry manure with chemical fertilizer on the yield and quality of soybean cv. BINA soybean-2.Nine treatments *viz*. control (CT), 100% recommended dose of chemical fertilizers ($RDCF_{100\%}$), 50% RDCF ($RDCF_{50\%}$), cowdung 10 t ha^{-1} (CD10 t ha^{-1}), 50% RDCF + CD 5 t ha^{-1} ($RDCF_{50\%}$ + CD5 t ha^{-1}), 75% RDCF + CD 3t ha^{-1} ($RDCF_{75\%}$ + CD 3 t ha^{-1}), poultry manure 3 t ha^{-1} (PM3 t ha^{-1}), 50% RDCF + PM 1.5 t ha^{-1} ($RDCF_{50\%}$ + PM 1.5 t ha^{-1}) and 75% RDCF + PM 1 t ha^{-1} ($RDCF_{75\%}$ + PM1 t ha^{-1})

were tested in the experiment. The highest biological yield was recorded from $RDCF_{100\%}$ (7373 kg ha^{-1}) treatment and the lowest from control (4581 kg ha^{-1}) treatment.

A field experiment was conducted Yagoub *et al.* (2012) for two consecutive seasons (2009/2010 and 2010/2011) on the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, to study the effect of some fertilizers on growth and yield of soybean. Three types of fertilizers: urea (180 kg ha^{-1}), NPK (361 kg ha^{-1}), compost (%) and the control were used as treatment variables. The results showed that the highest mean biological yield in first season was 8953.75 (kg ha^{-1}) given by control, in second season was 6464.42 (kg ha^{-1}) given by NPK treatment.

2.3.4 Harvest index

A field experiment was conducted by Khanam *et al.* (2016)at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during December 2013 to April 2014 to evaluate the effect of phosphorus (P_0: 0 kg TSP ha^{-1}, P_1: 100 kg TSP ha^{-1}, P_2: 175 kg TSP ha^{-1}, P_3: 250 kg TSP ha^{-1}) and potassium (K_0: 0 kg MoP, K_1: 60 kg MoP ha^{-1}, K_2: 120 kg MoP ha^{-1}, K_3: 180 kg MoP ha^{-1}), and their combinations on growth and yield of soybean (*Glycine max*). The result revealed that, the maximum HI of soybean (48.54%) was recorded from 175 kg ha^{-1} of TSP whereas the minimum HI (40.94%) was recorded from control treatment. The harvest index did not significantly differed by different K level.The highest HI (49.38%) was recorded from the combination of 175 and 120 kg $ha^{-1}$of TSP and MoP, respectively and the lowest value of HI (38.09%) was counted for treatment combination P_0K_3.

Patil and Udmale (2016) conducted an experiment at the Cropping Systems Research Project Farm, M.P.K.V., Rahuri during *kharif* 2007-08 to study the response of soybean to various organic inputs under irrigated condition. Eight treatments consisting of organic inputs *viz.* T_1 : Control, T_2 : Farm yard manure (FYM) at 5 t ha^{-1}, T_3 : Vermicompost (VC) at 2 t ha^{-1}, T_4 : FYM + VC (50+50) (2.5 t ha^{-1} + 1 t ha^{-1}), T_5 : FYM + Jeevamrut 2 times (30 and 45 DAS) (FYM 5 t ha^{-1}), T_6 : VC + Jeevamrut 2 times (30 and 45 DAS) (2 t ha^{-1} + 500 lit ha^{-1}), T_7 : FYM+VC (50+50)+Jeevamrut 2 times (30 and 45 DAS) (2.5 t ha^{-1}+1 t ha^{-1} +500 lit ha^{-1}) and T_8 : Jeevamrut 2 times (30 and 45 DAS) (500 lit ha^{-1}) were

tested in the experiment. *Rhizobium* and PSB biofertilizer is common to all treatments. The result showed that, the maximum mean harvest index (45.60%) was observed from T_6 treatments while the minimum mean biological yield (42.86%) from control treatment (T_1).

A field experiment was conducted by Khaim*et al*. (2013) at Genetics and Plant Breeding farm, Bangladesh Agricultural University from July to November, 2011 to evaluate the effect of cowdung and poultry manure with chemical fertilizer on the yield and quality of soybean cv. BINA soybean-2.Nine treatments *viz*. control (CT), 100% recommended dose of chemical fertilizers ($RDCF_{100\%}$), 50% RDCF ($RDCF_{50\%}$), cowdung 10 t ha^{-1} (CD10 t ha^{-1}), 50% RDCF + CD 5 t ha^{-1} ($RDCF_{50\%}$ + CD5 t ha^{-1}), 75% RDCF + CD 3t ha^{-1} ($RDCF_{75\%}$ + CD 3 t ha^{-1}), poultry manure 3 t ha^{-1} (PM3 t ha^{-1}), 50% RDCF + PM 1.5 t ha^{-1} ($RDCF_{50\%}$ + PM 1.5 t ha^{-1}) and 75% RDCF + PM 1 t ha^{-1} ($RDCF_{75\%}$ + PM1 t ha^{-1}) were tested in the experiment. They reported that the highest harvest index was observed in $RDCF_{100\%}$ (37.09%) treatment and the lowest value (34.24%) was observed in control treatment. The treatments CD10 t ha^{-1}, $RDCF_{75\%}$ +CD 3 t ha^{-1}, PM3 t ha^{-1}, RDCF50%+PM 1.5 t ha^{-1} and $RDCF_{75\%}$ + PM1 t ha^{-1} showed the statistically identical harvest index.

An experiment was conducted by Tomar and Khajanji (2009)at Raipur during 2001-02 and 2002-03 to study the effect of organic and inorganic sources of nutrients on the productivity, quality and economics of soybean.Four combinations of organic manuring *viz*. M_0: control, M_1: crop residues-rice straw @ 5 t ha^{-1}, M_2: FYM @ 5 t ha^{-1} and M_3: crop residue + FYM each @ 5 t ha^{-1} + Zinc @ 5 kg ha^{-1}) and three levels of mineral fertilizers *viz*. F_0: control, F_1: 100 % RDF and F_2: 50 % RDF) were considered as treatment variables. The result of the experiment revealed that, the maximum harvest index (35.29%) was recorded from organic manuring in soybean with crop residue + FYM each @ 5 t ha^{-1}+ zinc @ 5 kg ha^{-1} (M_3) and the minimum harvest index (30.33%) was recorded from control treatment (M_0). In case of mineral fertilizer, the maximum harvest index (34.11%) was recorded from F_1 and the minimum harvest index (32.02%) was recorded from F_0 treatment.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out during November, 2015 to March, 2016 to come across the optimum combination of inorganic fertilizer, vermicompost, poultry manure, biofertilizer and mixed fertilizer aiming reduction of usage of chemical fertilizer in soybean variety-BARI Soybean–6 with 10 combinations of fertilizers. The materials and methods of this experiment are presented in this chapter under the following headings-

3.1 Experimental Site

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU). It is situated at 23°74/ North latitude and 90°35/ East longitude (Anon., 1989). The land was 8.6 m above the sea level. It belongs to Madhupur Tract (AEZ 28). For better understanding about experimental site it is shown in the Map of AEZ of Bangladesh in Appendix- I. The land topography was medium high and soil texture was silty clay with pH 6.1. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-II.

3.2 Climate

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

3.3 Soil

The field belongs to the general soil type which was characterized by shallow red brown terrace soil. The land of the selected experimental plot was medium high under the Tejgaon series. There was available sunshine during the experimental period.

3.4 Materials

(a) Seeds- BARI Soybean-6 was collected from Bangladesh Agricultural Research Institute (BARI).

(b) Fertilizers- Biofertilizerwas collected from Bangladesh Institute of Nuclear Agriculture (BINA), Vermicompost was collected from NUSRA, NGO, Mirpur, Dhaka, and mixed fertilizerwas collected from Bangladesh Agricultural Development Corporation (BADC).Poultry litter, Urea, TSP, Gypsum and Boron were collected from the farm of SAU.

3.5 Description of the variety

BARI Soybean-6

Development Year: 2002

Developed By: Oilseed Research Centre (BARI)

Identifying Character

Plant height: 50-55 cm

Seed color: cream color

Number of seeds pod^{-1}: 2-3 seed

Seed size: medium

Specific character: medium tolerant to mosaic

Crop Duration: 100-110 days

Average yield: 1.80-2.10 t ha^{-1}

Sowing time: Mid December-mid January

Harvesting time: March-April

Major Diseases

Yellow mosaic

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

Major Pest

Hairy caterpillar

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

3.6 Layout of the experiment

The experiment was laid out according to the experimental design (RCBD). The field was divided into 3 blocks to represent 3 replications. There were 30 unit plots altogether in the experiment. The size of each unit plot was 3m × 2m. Distance maintained between replication and plots were 1.0m and .75mrespectively. The treatments were assigned in plot at random.

3.7 Experimental treatments

The experiment comprised with the following ten treatments including control

T_0: Control (without fertilizer)

T_1: Fertilizer at Recommended Dose (FRD)

T_2: Biofertilizer + 50% FRD

T_3: Biofertilizer + 75% FRD

T_4: Mixed fertilizer + 50% FRD

T_5: Mixed fertilizer + 75% FRD

T_6: Vermicompost + 50% FRD

T_7: Vermicompost + 75% FRD

T_8: Poultry litter + 50% FRD

T_9: Poultry litter + 75% FRD

Recommended dose:

Biofertilizer: 3.3kg ha^{-1},Poultry litter: 10 t ha^{-1}, Vermicompost: 2 t ha^{-1}, Mixed fertilizer: 254 kg ha^{-1},Urea: 50 kg ha^{-1}, TSP: 150 kg ha^{-1}, MP: 100 kg ha^{-1}, Gypsum: 80 kg ha^{-1} and Boron: 500 g ha^{-1}.The rate of chemical fertilizers as N,P,K,S and B were 23,30,50,14 and 0.085kg ha^{-1} respectively.

3.8 Detail of experimental preparation

3.8.1 Land preparation

The plot selected for the experiment was opened on 17 November, 2015 with a power tiller and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross- ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed.

3.8.2 Fertilization

Well rotten poultry litter and vermicompost were applied @ 10 and 2 t ha^{-1}, respectively before final land preparation according to treatment. The recommended inorganic fertilizer dose used for soybean was 254-50-150-100-80-0.5 kg ha^{-1} of mixed fertilizer, Urea, TSP, MP, Gypsum and Boric acid, respectively. Fertilization (basal dose) was completed on 24 November, 2015. Full amount of all fertilizers as per treatment applied during final land preparation as basal dose.

3.8.3 Seed sowing:

Seeds of the variety BARI Soybean-6 was sown on 25 November, 2015 in lines maintaining a line to line distance of 30 cm and plant to plant distance of 5-6 cm in the well prepared plot.

3.9 Intercultural operations

3.9.1 Irrigation

A light irrigation was given on 25 November, 2015 before sowing seed. First irrigation was given on 15 December, 2015 which was 20 days after sowing. Second irrigation was given on 30 December, 2015 which was 35 days after sowing and third irrigation was given on 20 January, 2016 which was 56 days after sowing.

3.9.2 Gap filling, thinning, and weeding

Gap filling was done on 4 December, 2015 which was 10 days after sowing. During plant growth period one thinning and one weeding was done, thinning was done on 10 December, 2015 which was 16 days after sowing and the weeding was done on 29 December, 2015 which was 34 after sowing.

3.9.3 Plant protection measures

Insecticides Bavistin 250WP was applied through the seed sowing line to control ant on 28 November, 2015.

3.10 Harvesting

The crops were harvested on 15 March, 2016 i.e.110 DAS when the leaves turn yellow and fall off, the pods turn to brown color and dry. Samples were collected from different places of each plot one m^2 in the center avoiding border plant. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated, cleaned and dried in the sun for 3 to 5 consecutive days for achieving safe moisture of seed.

3. 11 Data collection

The data were recorded on the following parameters

a. Plant height (cm)
b. Number of branches $plant^{-1}$
c. Dry matter weight $plant^{-1}$ (g)
d. Number of pods $plant^{-1}$
e. Number of seeds pod^{-1}
f. Pod length (cm)
g.100 seed weight (g)
h. Shelling percentage (%)
i. Seed yield (t ha^{-1})
j. Stover yield (t ha^{-1})

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

l. Harvest index (%)

3.12 Procedure of recording data

It was done on the basis of following parameter-

3.12.1 Plant height

At different stages of crop growth (30, 45, 60, 75 DAS and at harvest), the height of five randomly selected plants from the inner rows avoiding border plant per plot was measured from ground level to the tip of the plant and the mean value of plant height was recorded in cm.

3.12.2 Number of branches $plant^{-1}$

At different stages of crop growth (45, 60, 75 DAS and at harvest) **t**he number of branches $plant^{-1}$ was counted from five randomly sampled plants. It was done by counting total number of branches of the 5 sampled plants then the average data were recorded.

3.12.3 Dry matter weight $pant^{-1}$

Five plants were collected randomly from each plot at 45, 60, 75 DAS and at harvest. The sample plants were oven dried for 72hours at 70°C and then dry weight $plant^{-1}$ was determined.

3.12.4 Number of pods $plant^{-1}$

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

3.12.5 Number of grains pod^{-1}

Number of grains pod^{-1} was counted from twenty selected pods of plants and then the average seed number was calculated.

3.12.6 Pod length (cm)

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

3.12.7 Weight of 100 grain

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

3.12.8 Shelling percentage

100 g dry pod was measured in each plot and shelling percentage was calculated by using the following formula -

$$\text{Shelling percentage} = \frac{\text{Grain weight}}{\text{Pod weight}} \times 100$$

3.12.9 Grain yield (kg ha^{-1})

Grain yield was calculated from cleaned and well dried grains collected from the central 1 m^2 area the each plot (leaving two boarder rows) and expressed as kg ha^{-1} on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

3.12.10 Stover yield (kg ha^{-1})

Stover yield was determined with crop plants collected from the central 1 m^2 area of the each plot. After threshing, the sub sample was oven dried to a constant weight and finally converted to kg ha^{-1}.

3. 12. 11 Biological yield (kg ha^{-1})

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

3.12.12 Harvest index (HI) (%)

Harvest index is the ratio of economic (grain) yield and biological yield. It was calculated by dividing the economic yield (grain) from the harvested area by the biological yield of the same area (Donald, 1963) and multiplying by 100.

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (kg/ ha)}}{\text{Biological yield (kg/ ha)}} \times 100$$

Here, Biological yield (kg ha^{-1}) = Grain yield (kg ha^{-1}) + Stover yield (kg ha^{-1})

3.13 Statistical analysis

The obtained data for different characters were statistically analyzed with the computer based software MSTAT-C to find out the influence of different combinations of inorganic and organic fertilizer in soybean and the mean values of all characters were evaluated and analysis of variances were performed by the F-test. The significance of the difference among treatment means were estimated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the influence of different combinations of inorganic and organic fertilizers in soybean. Data on different growth, yield contributing characters and yield of soybean were recorded. The results have been presented and discussed with the help of tables and graphs and possible interpretations given under the following headings:

4.1 Plant height (cm)

Plant height is an important morphological character that acts as a potent indicator of availability of growth resources in its vicinity. Plant height of soybean varied significantly at 30, 45, 60, 75 DAS and at harvest for different inorganic and organic fertilizer and their combinations under the present trial (Figure 1). At 30 DAS, the tallest plant (23.23cm) was recorded from T_9 (Poultry litter + 75% FRD), which was statistically similar with T_8 (Poultry litter + 50% FRD), T_6 (Vermicompost + 50% FRD), T_5 (Mixed fertilizer + 75% FRD), T_3 (Biofertilizer + 75% FRD), T_2 (Biofertilizer + 50% FRD)and T_1(Fertilizer at Recommended Dose, FRD). The shortest plant (20.35 cm) was obtained from T_7 (Vermicompost + 75% FRD) which was statistically similar with T_4 (Mixed fertilizer + 50% FRD), T_0 (Control), T_1 (Fertilizer at Recommended Dose, FRD), T_2 (Biofertilizer + 50% FRD), T_3 (Biofertilizer + 75% FRD), T_5(Mixed fertilizer + 75% FRD), T_6 (Vermicompost + 50% FRD)and T_8(Poultry litter + 50% FRD). At 45 DAS, the tallest plant (4083 cm) was recorded from T_1 treatment which was statistically similar with all the treatment combinations except T_0, whereas the shortest plant (33.07 cm) was obtained from T_0. At 60 DAS, the tallest plant (52.55 cm) was recorded from T_1, which was statistically similar with all the treatment combinations except T_0 and the shortest plant (40.21 cm) was found from T_0. At 75 DAS, the longest plant (55.53 cm) was recorded from T_7, which was statistically similar with T_1, T_5, T_6 and T_9 (54.80cm, 54.13 cm, 52.27 cm and 52.27 cm, respectively) and, whereas the shortest plant was recorded from T_0 (48.13 cm) which was statistically similar with T_8, T_2, T_3, T_4, T_6 and T_9 (49.93 cm, 50.73 cm, 51.07, 51.27 cm, 52.27 cm and 52.27 cm, respectively). At harvest, the

tallest plant was attained from T_1 (52.72 cm), which was statistically similar with all the treatments except $T_0$and the shortest plant (45.80 cm) was recorded from T_0 and it was statistically similar with all the treatments except T_1, T_7 and T_9. The significant increase in plant height observed by plants treated with fertilizer may be attributed to internodes elongation and other nutrients received by the plant from both organic and inorganic sources. This observation confirms the findings of Falodun *et al.* (2015), Khaim *et al.* (2013), Espinoza (2001) and Navin *et al*. (1996). Falodun and Osaigbovo (2010) reported that nutrients in inorganic are readily available for plant up take upon application while the organic forms of nutrients are slowly available. So there is a continuous supply of nutrient to the plant up to maturity. Babalad (1999) had observed increased plant height in soybean due to the application of organic manure and inorganic fertilizers. Patil and Udmale (2016) and Bacchav (1996) also reported that, the increase in plant height due to organic inputs might be attributed to increase in the availability of cytokinine to shoot which in turn play a role in cell elongation process either through cell division or cell elongation. Arslan*et al.* (1993) reported that different doses of potassium and sulphur fertilizers from organic and inorganic sources had significant effect on the plant height of soybean. Nitrogen fertilization increased the plant height (Akbari *et al*., 2001).Myint *et al.* (2009) added that chemical fertilizer application provided better plant growth due to its higher nutrient availability and rapid nitrogen mineralization power. Other organic amendments also tended to accumulate the nutrient availability to support the plant growth. This result was supported by Suppadit (2004) who considered that organic sewage sludge could be used as a replacement for fertilizer. Moreover, effective soil microorganisms provided higher nitrogen fixation and stimulation of plant growth in succeeding crops. This was supported by Vangnai *et al*. (1982), who revealed that higher nitrogen fixation activity occurred under sufficient soil moisture content.

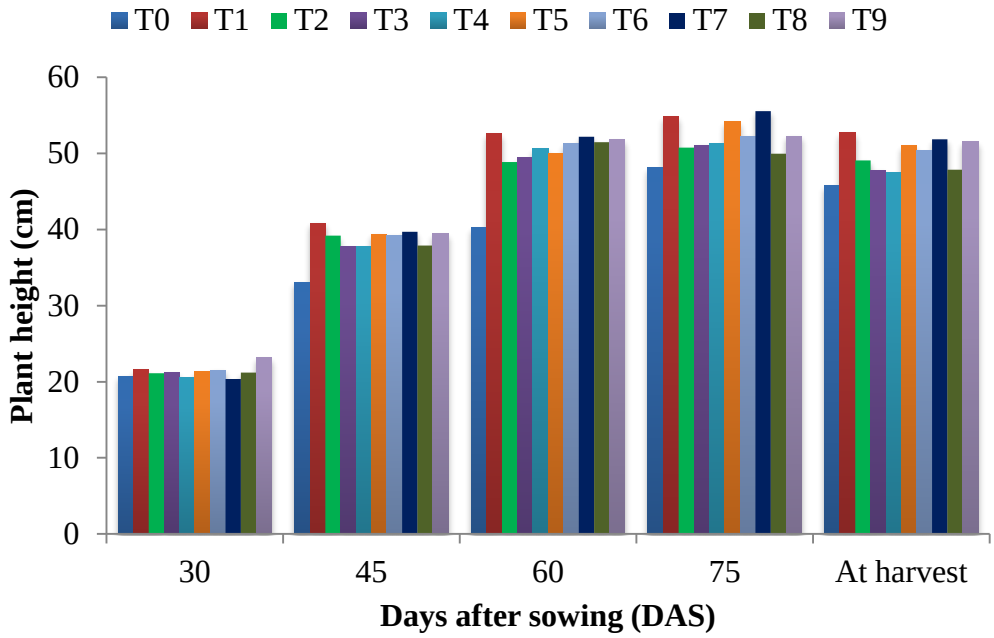

Figure 1. Effect of organic and inorganic fertilizers on plant height of soybean at different days after sowing (LSD $_{(0.05)}$ = 2.33, 4.43, 3.87, 4.21 and 5.43at 30, 45, 60, 75 DAS and at harvest, respectively)

T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD

4.2 Number of branches plant^{-1}

Statistically significant variation was recorded for number of branches plant^{-1} of soybean at 45, 60, 75 DAS and at harvest for the application of different combinations of inorganic and organic fertilizers (Figure 2). At 45 DAS, the maximum number of branches plant^{-1} was recorded from T_1 (1.67) which was statistically similar with T_7 (1.60), whereas the minimum number of branches plant^{-1} was found from T_0 (0.90) which was statistically similar with T_8 (0.93) and T_6 (1.00). At 60 DAS, the maximum number of branches plant^{-1} was recorded from T_1 (1.73), and it was statistically similar with T_7 (1.67), T_9 (1.60), while the minimum values was recorded from T_0 (0.452). At 75 DAS, the maximum values of number of branches plant^{-1} was recorded from T_1 (1.87) which

was statistically similar with T_7 (1.83), T_9 (1.73), T_6 (1.67) and T_3 (1.67), and the minimum from T_0 (1.37) which was statistically identical with T_8 (1.47), T_5 (1.47) andT_4 (1.50). At harvest, the maximum values of number of branches plant^{-1} was obtained from T_1 (1.87), which was closely followed by T_7 (1.83) and T_9 (1.70) and the minimum number of branches plant^{-1} was recorded from T_0 (1.37) which was closely followed by T_8 (1.47), T_5 (1.47) and T_4 (1.50). Recommended doses of fertilizer gave the highest value for number of branches plant^{-1} which showed similarity with combination of organic and inorganic fertilizer. The integration of biological and organic manure with chemical fertilizers had a significant impact on number of branches plant^{-1}. This clearly indicated the need for adding organic manures to the soil conjunctive with inorganic fertilizers, which increased the availability of nutrients considerably resulting in a positive effect on growth parameters. These findings are in accordance with the results of Babalad (1999) who had observed increased plant height in soybean due to the application of organic manure and inorganic fertilizers. Patil and Udmale (2016) explained that, an early stage crop accumulates more amounts of constituents and nutrients from organic and chemical sources which results to stimulate the cell division in the meristimatic tissue and increase in vegetative growth of plant which favors the maximizing growth of branches. Muthuvel *et al*. (1985) reported that number of branches per plant was significantly influenced due to FYM application (10 t ha^{-1}) in redgram crop. Khaim *et al.* (2013) and Falodun and Osaigbovo (2010) stated that total number of branches plant^{-1} was enhanced by organic and inorganic fertilizers.

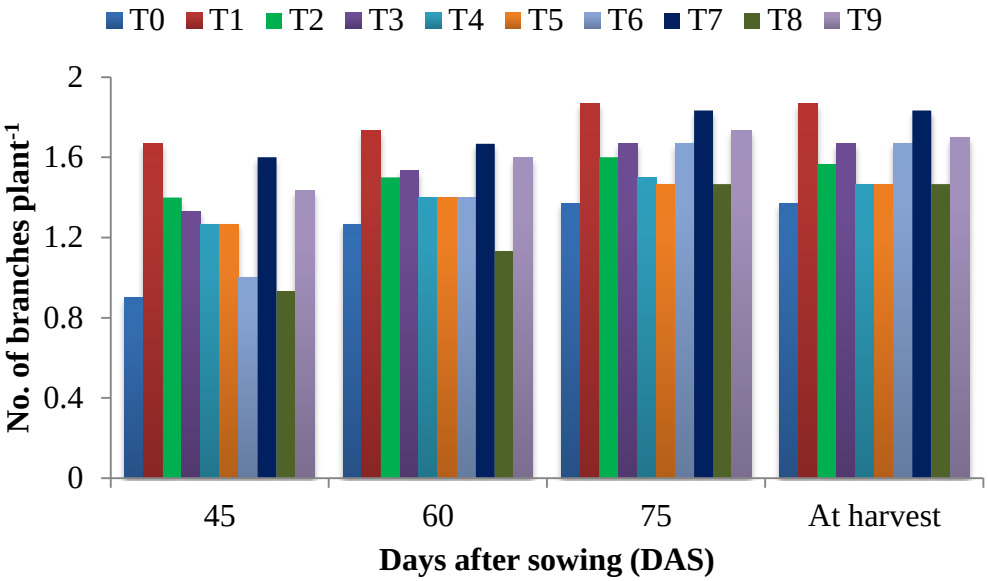

Figure 2. Effect of organic and inorganic fertilizers on number of branches plant^{-1} of soybean at different days after sowing (LSD $_{(0.05)}$ = 0.18, 0.20, 0.20 and 0.22 at 45, 60, 75 DAS and at harvest, respectively)

T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD

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

Different combinations of inorganic and organic fertilizers showed significant variation for dry weight plant^{-1} at 30, 45, 60, 75 DAS and at harvest (Table 1). At 30 DAS, the highest dry weight plant^{-1} was recorded from T_6 (0.50 g) which was statistically similar with T_4 (0.46 g), and the lowest from T_0 (0.27 g) which was statistically similar with T_8 (0.30 g). At 45 DAS, the highest dry weight plant^{-1} was observed from T_1 (2.22 g), which was statistically similar with T_7 (2.06 g) and T_9 (2.01 g) The lowest weight was obtained from T_0 (1.33 g) which was statistically similar with T_2 (1.44 g), T_6 (1.57 g) and T_8 (1.57 g). At 60 DAS, the highest dry weight plant^{-1} was obtained from T_1 (5.33 g), which was statistically similar with T_9 (5.15 f), T_7 (5.00 g) and T_5 (4.67 g), while the lowest was obtained from T_0 (3.20 g) which was closely followed by T_3 and T_2 (3.33 g and 3.77g,

respectively). At 75 DAS, the highest dry weight plant^{-1} was recorded from T_9 (7.53 g) which was closely followed by T_1 (7.17 g) and that of lowest from T_0 (4.67 g) which was closely followed by T_2 and T_3 (4.87g and 5.50 g, respectively). At harvest, the highest dry weight plant^{-1} was attained in T_1 (9.21 g), which was statistically similar with T_9 and T_7 (8.93 g and 8.83 g, respectively) again the lowest was obtained from T_0 (5.33 g) which was statistically similar with T_2 (5.67 g). Application of all inorganic fertilizer in recommended doses gave the highest dry matter accumulation followed by the combination of vermicompost and poultry litter with 75% inorganic fertilizers in recommended doses. This might be due to optimum supply and availability of nutrients continuously through organic source which help in better uptake of nutrient resulted into more synthesis of nucleic acid and amino acid, amide substances in growing region and meristimatic tissue ultimately enhancing cell division and thereby increased all the growth attributes in these treatments. These findings are in accordance with the results of Patil and Udmale (2016); Sharma and Mishra (1997); Gopalkrishna and Palaniappan (1992).

Table 1. Combined effect of organic and inorganic fertilizers on dry weight plant^{-1} of soybean at different days after sowing

Treatments	Dry weight plant^{-1} (g)				
	30 DAS	45 DAS	60DAS	75 DAS	At harvest
T_0	0.27 c	1.33 f	3.20 e	4.67 f	5.33 f
T_1	0.43 b	2.22 a	5.33 a	7.17 ab	9.21 a
T_2	0.43 b	1.45 f	3.77 c-e	4.87 ef	5.67 f
T_3	0.42 b	1.78 c-e	3.33 de	5.50 d-f	6.83 de
T_4	0.46 ab	1.69 de	4.16 bc	6.53 bc	6.67 e
T_5	0.42 b	1.86 b-d	4.67 ab	6.53 bc	8.17 bc
T_6	0.50 a	1.56 ef	4.00 b-d	5.62 c-e	7.15 de
T_7	0.41 b	2.06 ab	5.00 a	6.17 cd	8.83 ab
T_8	0.30 c	1.56 ef	4.22 bc	6.07 cd	7.53 cd
T_9	0.42 b	2.01 a-c	5.15 a	7.53 a	8.93 ab
LSD $_{(0.05)}$	**0.05**	**0.24**	**0.69**	**0.95**	**0.80**
CV (%)	**7.99**	**8.13**	**9.46**	**9.11**	**6.27**

T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD

4.4 Number of pods plant^{-1}

Number of pods plant^{-1} of soybean showed statistically significant variation for the application of different inorganic and organic fertilizers, and their combinations (Figure 3). The maximum number of pods plant^{-1} was found in T_9 (26.47), which was statistically similar with T_1 and T_7 (26.20 and 23.13, respectively), while the minimum number from T_0 (19.00) which was statistically similar with rest of the treatments except T_1, T_7 and T_8.This might be due to the fact that T_1, T_7 and T_8 provided same quantities of nutrient for pod formation under sufficient soil moisture conditions and organic manure had low nitrogen-releasing ability. In a similar manner as for the number of pods, the application of organic amendments and chemical fertilizer possibly accumulated more nutrients

during the critical plant growth period and higher available P contributed to the developing seed numbers. There seemed to be less nutrient ability in the control plots resulting in low pod numbers. Begum *et al.* (2015) and Singh and Bajpai (1990) observed that increasing phosphorus rate increased the number of pods plant^{-1}.Chaubey *et al.* (2000) obtained significantly the highest number of pods plant^{-1} by applying S @ 45 kg ha^{-1} through gypsum in groundnut.Soybean seed inoculation by *rhizobial* bacteria (Kazemi *et al*., 2005) and *B. japonicum* bacteria (Zhang *et al*., 2003) was also increased pods per plant. This result was supported by Moghadam *et al.* (2014), Myint *et al*. (2009) and Manalo *et al*. (1998) who considered that biofertilizer significantly increased the number of pods plant^{-1}.

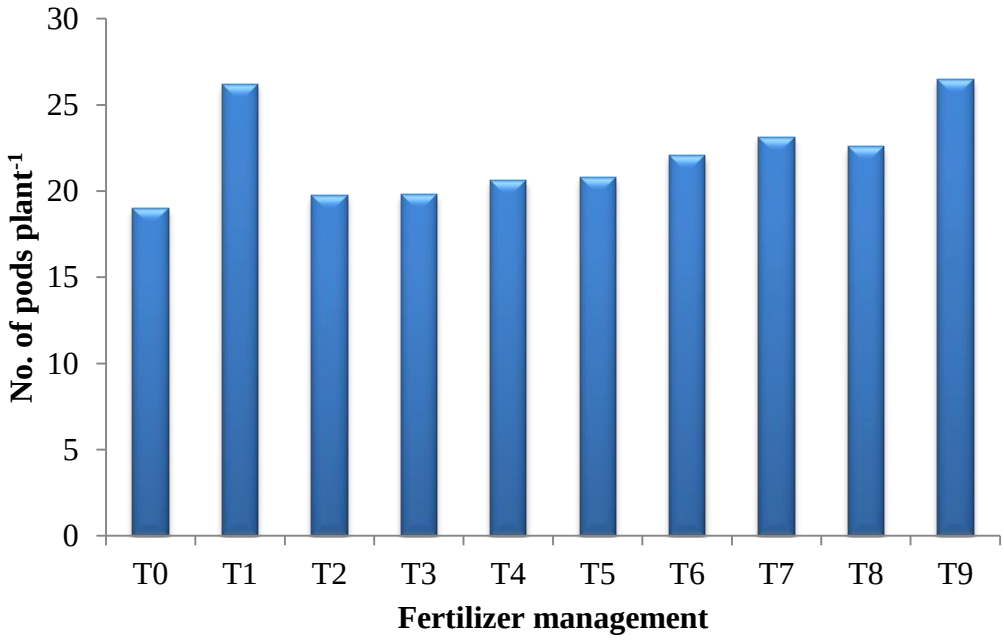

Figure 3. Effect of organic and inorganic fertilizers on no. of pods plant^{-1} of soybean (LSD $_{(0.05)}$ = 3.35)

T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD

4.5 Number of grains pod^{-1}

Statistically significant variation was observed for grains pod^{-1}due to use of different inorganic and organic fertilizers and their combinations (Figure 4). The highest total grains pod^{-1} was obtained from T_9 (2.67) which was statistically similar with rest of the treatment except T_7 and T_0 (2.08 and 2.17, respectively), while the lowest total grains pod^{-1} was recorded from T_7 (2.08) which was statistically similar with T_0, T_2 and T_3 (2.17, 2.43 and 2.40, respectively). This was perhaps due to a continuous supply of nitrogen, phosphorus, potassium to the crop at the early stages and through organic manure (as slow release nutrient) also at later stages of crop growth. This finding is consistence with the finding of Patil and Udmale (2016).Khaim *et al.* (2013) and Pathwary (2003) found highest seed plant^{-1} of soybean in S and P treated plant. Begum *et al*. (2015), Tomar *et al.* (2004) and Islam *et al.* (2004) observed that number of seeds pod^{-1} increased with the increase of phosphorus application.

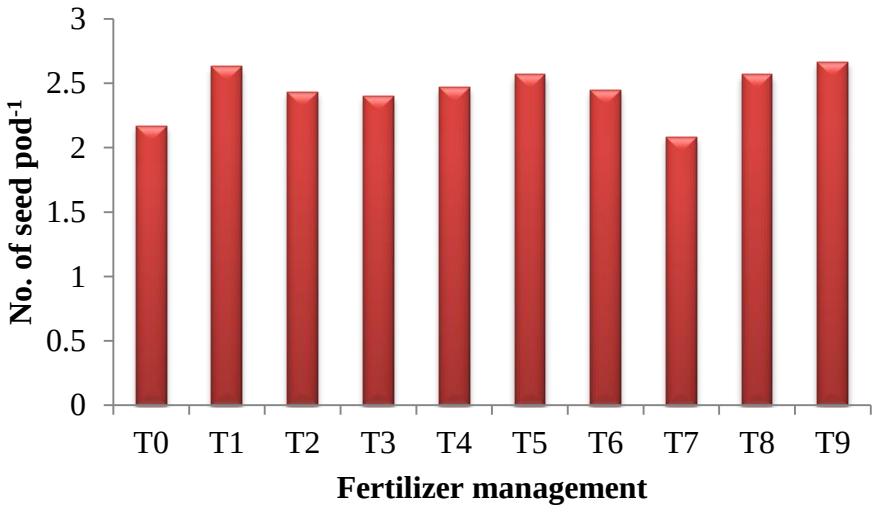

Figure 4. Effect of organic and inorganic fertilizers on number of seeds pod^{-1} of soybean (LSD $_{(0.05)}$ =0.36)

T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD

4.6 Pod length (cm)

Significant variation was recorded in case of pod length of soybean due to application of different inorganic and organic fertilizers, and their combinations (Figure 5). The longest pod was observed in T_1 (3.85 cm), which was statistically similar with rest of the treatments except T_0, again the shortest pod was recorded from T_0 (3.29 cm) which was statistically similar with rest of the treatment except T_1, T_5, T_8 and T_9. Better pod length depends on optimum dry matter partitioning during reproductive stage of plant. Nutrient elements from organic and inorganic sources ensure long term and optimum nutrient supply to the plant which ensure maximize accumulation of photosynthates to the pod; consequently increase the length of pod. These findings are in accordance with the results of Khaim *et al.* (2013). Pathwary (2003) also found highest seed plant^{-1} of soybean in S and P treated plant.

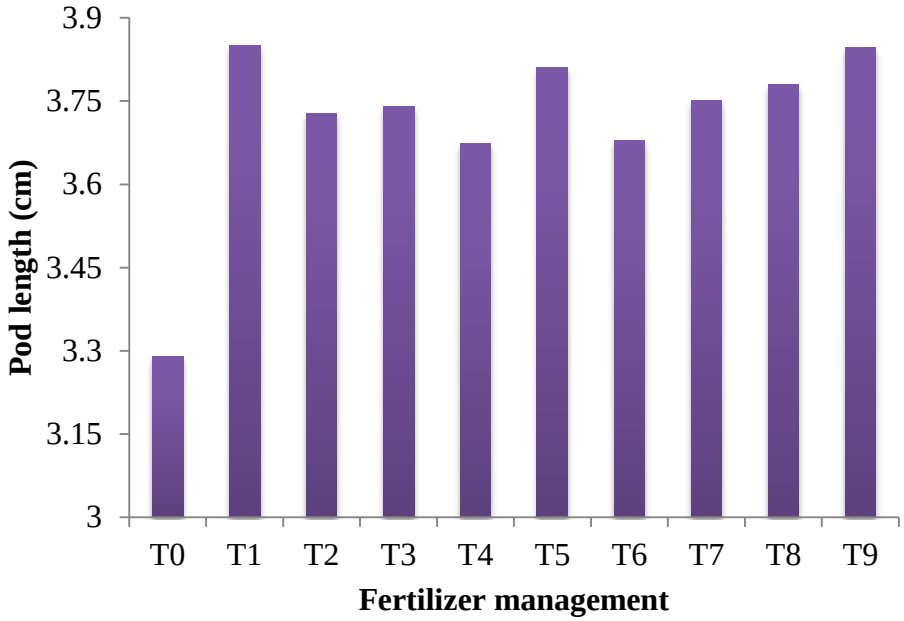

Figure 5. Effect of organic and inorganic fertilizers on pod length of soybean ($LSD_{(0.05)}$ = 0.48)

T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD

4.7 Weight of 100 grains (g)

A significant variation was found on weight of 100 grains of soybean due to different inorganic and organic fertilizers, and their combinations treatments (Figure 6). The heaviest 100 grains weight was recorded from T_1 (11.74 g), which was statistically similar with treatments T_9, T_8, T_7, T_6, T_5, T_3 and T_2 and the lightest weight was recorded from T_0 (9.98 g) which was statistically similar with T_4, T_8, T_7, T_6, T_5, T_3 and T_2. Better 100 grains weight depends on optimum dry matter partitioning during reproductive stage of plant. Nutrient elements from organic and inorganic sources ensure long term and optimum nutrient supply from the source to sink which ensure maximum accumulation of photosynthates to the pod; consequently increase the 100 grainweight. Vermicompost application delayed leaf senescence and this might be the reason for increased seed weight. Better growth and development of crop plants due to phosphorus supply and nitrogen uptake might have increased the supply of assimilates to seed, which ultimately gained more weight. Similar achievements on hundred seed weight with phosphorus were observed by Begum *et al.* (2015); Anchal *et al*., 1997; Chauhan *et al*., 1992; Singh and Hiremath 1990; Kar *et al*., 1989; Raju and Verma (1984).

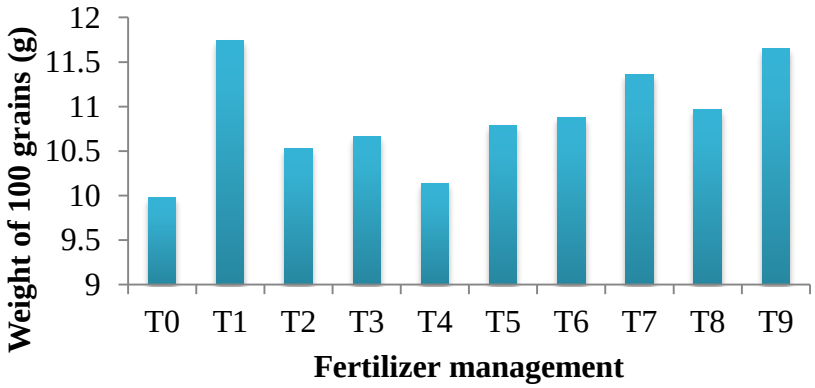

Figure 6. Effect of organic and inorganic fertilizers on weight of 100 grains of soybean (LSD $_{(0.05)}$ = 1.48)

T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD

4.8 Shelling percentage (%)

Shelling percentage of soybean varied significantly due to application of different inorganic and organic fertilizers, and their combinations (Figure 7). The highest shelling percentage was recorded from T_6 (84.36%) which shown similarity with T_1 and T_4 and the lowest shelling percentage was recorded from T_2 (72.17)which shown similarity with rest of the treatments except T_6 and T_1. This might be due to better 100 grains weight which helped to increase the shelling percentage.

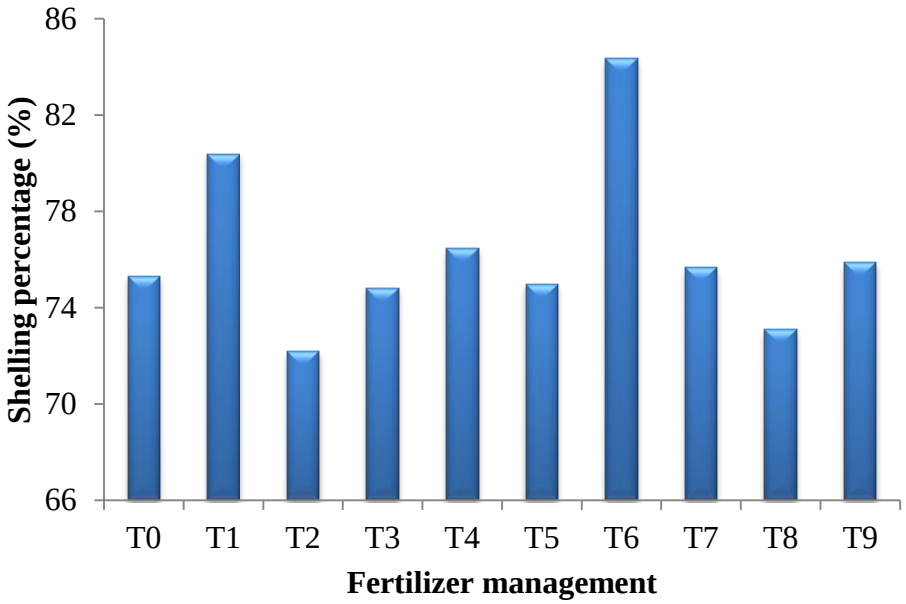

Figure 7. Effect of organic and inorganic fertilizers on shelling percentage of soybean (LSD $_{(0.05)}$ = 8.11)

T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD

4.9 Grain yield (kg ha^{-1})

Grain yield ha^{-1}varied significantlydue to different inorganic and organic fertilizers, and their combinations (Table 2). The highest yield was recorded from T_9 (2166 kg ha^{-1}), which was statistically at per with T_7 and T_1 (respectively for 2073 kg ha^{-1}and 2053 kg ha^{-1}). On the other hand, the lowest yield was found in T_0 (1185 kg ha^{-1}). The result revealed that treatment T_9,T_7 and T_1produced 82.78%,74.94% and 73.25% higher yield over control (T_0) treatment. The maximum grain yield might be attributed to maximum dry matter weight plant^{-1}, number of pods plant^{-1}, seeds plant^{-1} and 100 seed weight. This might be due to adequate supply of nutrient element at the right time from organic and inorganic sources which helped optimum dry matter partitioning from the source to sink during reproductive stage of plant that maximize accumulation of photosynthates to the pod; consequently increase the grain yield of soybean. Similar results also found by Falodun *et al.* (2015) who reported that the increase in the number of pods, pod weight and yield with the application rate of 2.5 t ha^{-1} poultry litter + 150 kg ha^{-1} NPK could be due to the rate of release of nutrients which were much higher in the inorganic fertilizers since they provided major elements at the early stage of plant growth and development. Thus, plants showed accelerated growth and organic manure in combination complements this effect at the later stage of growth. The effect of the nutrients in increasing growth and yield of onion was relatively higher when in association with one another. Bayu *et al.* (2006) stated that combine application of organic and inorganic fertilizer gave better results than their sole application in onion production, they emphasized that high and sustainable crop yield can be obtained with judicious use of combine application. This observation is in agreement with the work of Arisha *et al*. (2003) who recorded an improvement in yield of onion and also in the soil physical and chemical properties when organic manure was applied in combination with inorganic fertilizer. The quick response to combine use of fertilizer by soybean plant may be due to the fact that mineral fertilizers mineralized quickly, releases its nutrients to crop faster and eventually leached beyond the root zone of crops and organic manure in combination complements this effect by exerting their effect for a longer periods compared to sole application of these fertilizer thereby resulting in better crop growth and yield of the crop. The control plot produced the lowest values for grain yield of soybean, due to the absence

of adequate nutrient level which an important factor is needed for proper growth and development of every plant including soybean and so the plants had to depend on the inherent soil nutrient which was low. The combined use and organic sources causing sustained nutrient supply to the crop and better utilization of nutrient through microbial activity that involved in nutrient transformation and fixation. Similar finding were reported by Bacchav (1996) and Dev and Tilak (1976). Begum *et al*. (2015) and Singh *et al.* (1992) mentioned that moderate application of nitrogen and phosphorous increase the number of pods per plant, seeds per pod,seed weight and seed yield of soya bean. Phosphate solubilizing bacteria enhance the phosphorus availability to plants by mineralizing organic P in the soil and by solubilizing precipitated phosphate (Chen *et al*., 2006; Kang *et al*., 2002; Pradhan and Sukla, 2005). Badret (1986) and Dubey *et al.* (1997) have also reported significant increases in grain yield of soybean due to co-inoculation of phosphorus solubilizers. Higher crop yields resulted from solubilization of fixed soil P and applied phosphates by PSB (Zaidi, 1999). Phosphorus has important effects on photosynthesis, nitrogen fixation, root development, flowering, seed formation, fruiting and improvement of crop quality (Brady, 2002). Son and Ramaswami (1997) reported that the lower dose of inorganic fertilizer conjunction with composted paddy straw or Inoculants could achieve same grain yield of soybean under rice-based cropping system. Khaim *et al.* (2013) observed that, poultry manure showed better performance in producing grain yield with respect to other organic manures. Yamika and Ikawati (2012) found that the combination of inorganic with organic fertilizers (0, 0.5 and 1 t ha^{-1}) increased the seed yield up to 3.5 t ha^{-1}. Mahesbabu *et al.* (2008) also observed that application of recommended dose of N: K: S with CD 5 t ha^{-1} produced grain yield (2235 kg ha^{-1}). Among various levels of vermicompost showed that highest seed yield was observed from application of ten tone vermicompost with 1699kg ha^{-1} and lowest was observed from non application of vermicompost with 1419 kg ha^{-1} (Moghadam *et al.*, 2014).

4.10 Stover yield (kg ha^{-1})

Different inorganic and organic fertilizers and their combinations exerted significant variation on stover yield of soybean (Table 2). The maximum stover yield was observed

in T_1 (2464 kg ha^{-1}), which was statistically at par with T_9 and T_7 (2372 and 2278 kg ha^{-1}, respectively). Again the lowest yield was recorded from T_0 (1552 kg ha^{-1}) which was statistically at par with T_2 (1777 kg ha^{-1}). This result is full agreement of Khaim *et al.* (2013) who reported that, the stover yield of soybean was maximum because poultry manure with chemical fertilizers added much of organic matter in soil, which influenced the vegetative growth of soybean plant. Dikshit and Khatik (2008) observed that application of organic and inorganic fertilizers increased the stover yield of soybean. Forhad and Malik (2010) also reported that application of P and K also increased the stover yield. Stover yield increased over control was the highest in RDCF100%. Devi *et al*. (2013) reported that, significantly higher stover yield (2.04 t ha^{-1}) was produced by the integration of 75% RDF with vermicompost at the rate of 1 t ha^{-1} and PSB and the lowest (0.97 t ha^{-1}) from control. Begum *et al.* (2015) and Leelavathi *et al.* (1991) obtained the similar findings in case of stover yield.

4.11 Biological yield (kg ha^{-1})

Different organic and inorganic fertilizer and their combinations exerted significant variation on biological yield of soybean (Table 2). However, the highest biological yield was found in T_9 (4538 kg ha^{-1}) which was followed by with T_1 and T_7 (4517 and 4352 kg ha^{-1}, respectively) and that of the lowest 2736 kg ha^{-1} from T_0. The result revealed that combination of organic and inorganic fertilizer increased the biological yield which might be due to the cumulative favorable effect of grain and straw yield. These findings are in accordance with the results ofKhaim *et al.* (2013),who reported that biological yield was also increased in the RDCF75%+PM1 t ha^{-1} and CD10 t ha^{-1} where poultry manure and cowdung were applied in decomposed form and they were identical the highest yield of RDCF 100%.

4.12 Harvest index (%)

Harvest index of soybean showed non significant variation for different inorganic and organic fertilizers, and their combinations (Table 2). However the highest harvest index was recorded from T_5 (47.78) and the lowest harvest index was recorded from T_0 (43.33%). These findings are contradictory with the results ofKhaim *et al.* (2013), who reported that harvest index was influenced by the application of organic and inorganic

fertilizer with other fertilizers. This might be due to RDCF and other organic fertilizers, which affected the biological yield and grain yield. Moghadam *et al.* (2014) and Soleymani *et al* (2010) showed that harvest index is one of the most important traits that affected seed yield, more fertilizer increased the harvest index due to more grains and the weight of 1000 grains in the plant and application of bacteria increased harvest index of soybean.

Table 2. Combined effect of organic and inorganic fertilizers on grain yield, stover yield, biological yield and harvest index of soybean

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_0	1185 d	1552 c	2736 d	43.33
T_1	2053 a	2464 a	4517 a	45.42
T_2	1511 c	1777 bc	3288 c	45.97
T_3	1624 bc	1814 b	3438 bc	47.25
T_4	1610 bc	1828 b	3438 bc	46.82
T_5	1786 b	1951 b	3737 b	47.78
T_6	1694 bc	1904 b	3597 bc	47.04
T_7	2073 a	2278 a	4352 a	47.64
T_8	1768 b	1977 b	3778 b	46.79
T_9	2166 a	2372 a	4538 a	47.74
LSD $_{(0.05)}$	**221.80**	**254.30**	**398.40**	**NS**
CV (%)	**7.4**	**7.44**	**6.21**	**8.24**

T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD

CHAPTER V
SUMMARY AND CONCLUSION

The present research work was conducted at the exprimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from November, 2015 to March, 2016 to study the influence of different combinations of inorganic and organic fertilizer in soybean (var.BARI Soybean 6) The experiment comprised 10 different treatments of organic and inorganic fertilizer and their combination *viz.*, T_0= Control, T_1= Fertilizer at Recommended Dose (FRD), T_2= Biofertilizer + 50% FRD, T_3= Biofertilizer + 75% FRD, T_4= Mixed fertilizer + 50% FRD, T_5= Mixed fertilizer + 75% FRD, T_6= Vermicompost + 50% FRD, T_7= Vermicompost + 75% FRD, T_8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD . The size of unit plot was 6 m^2 (3.0 m × 2 m).The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

Results showed plant height of soybean varied significantly at 30, 45, 60, 75 DAS, and at harvest for different combinations of chemical and organic fertilizer. However, At 30 DAS, the tallest plant (23.23cm) was recorded in T_9 (Poultry litter + 75% FRD) and the shortest plant (20.35cm) was recorded in T_7 (Vermicompost + 75% FRD). The tallest plant (40.83, 52.55, 55.53 and 52.72 cm at 45, 60, 75 DAS and at harvest, respectively) was recorded in T_1 (Fertilizer at Recommended Dose, FRD), T_1 (Fertilizer at Recommended Dose, FRD), T_7 (Vermicompost + 75% FRD) and T_1 (Fertilizer at Recommended Dose, FRD), respectively. The shortest plant (33.07, 40.21, 48.13 and 45.80cm at 45, 60, 75 DAS and at harvest, respectively) was recorded in T_0 (control). Treatment T_1 (Fertilizer at Recommended Dose, FRD) produced the maximum number of branches $plant^{-1}$ (1.67, 1.73, 1.87 and 1.87 at 45, 60, 75 DAS and at harvest, respectively) while T_0 produced the minimum number of branches $plant^{-1}$ (0.90, 1.37 and 1.37 at 45, 75 DAS and at harvest, respectively) and T_8 (Poultry litter + 50% FRD) produced the minimum number of branches $plant^{-1}$ (1.13) at 60 DAS. Dry matter weight $plant^{-1}$ was the highest (0.50g) in T_6 (Vermicompost + 50% FRD) at 30 DAS. T_1 produced maximum dry matter weight $plant^{-1}$ (2.22, 5.33 and 9.21g at 45, 60 DAS and at harvest, respectively) and T_9 produced maximum dry matter weight $plant^{-1}$ (7.53g) at 75 DAS. On

the other hand, T_0 consistently produced minimum dry matter weight plant^{-1} (0.27, 1.33, 3.20, 4.67 and 5.33g at 30, 45, 60, 75 DAS and at harvest, respectively).

Significant variation was recorded in yield and yield contributing characters of soybean for different organic and inorganic fertilizer and their combinations. The maximum number of pod plant^{-1} and seed pod^{-1} (26.47 and 2.67) was found in T_9 and minimum number of pod plant^{-1} and seeds pod^{-1} (19.00 and 2.08) was found in T_0 and T_7, respectively. The maximum pod length and 100 seed weight (3.85cm and 11.74g) was found in T_1 and minimum pod length and 100 seed weight (3.29cm and 9.98g) was found in T_0. The maximum shelling percentage (84.36%) was recorded from T_6 and minimum shelling percentage (72.17%) was recorded from T_2. The highest grain yield (2166 kg ha^{-1}**)** was obtained from T_9 treatment. On the other hand, the lowest grain yield (1185 kg ha^{-1}) was found in T_0 treatment. T_9 produced 82.79% and 5.51% higher grain yield over control and FRD (fertilizer at recommended dose). The highest stover yield was observed in T_1 (13.97 t ha^{-1}). The maximum stover and biological yield (2464 and 4538 kg ha^{-1}) was produced by T_1 and T_9 treatment, respectively whereas the minimum stover and biological yield (1552 and 2736 kg ha^{-1}) was produced by control treatment. Harvest index was not significantly influenced by fertilizer treatments. Numerically highest harvest index (47.78%) was recorded from T_5 and lowest one (43.33) from T_1 (control).

From the above results, it may be concluded that inorganic fertilizer at recommended dose, vermicompost + 75% FRD and poultry litter + 75% FRD showed the better performance on most of the growth and yield contributing characters of soybean. Considering the yield and sound environment, vermicompost + 75% FRD or poultry litter + 75% FRD may be possible to use in replacing inorganic fertilizer which will reduce production cost without significant yield reduction.

Recommendations

To reach a specific conclusion and recommendation, more research work regarding this issue on soybean should be done in different Agro-ecological zones of Bangladesh with this treatment variable.

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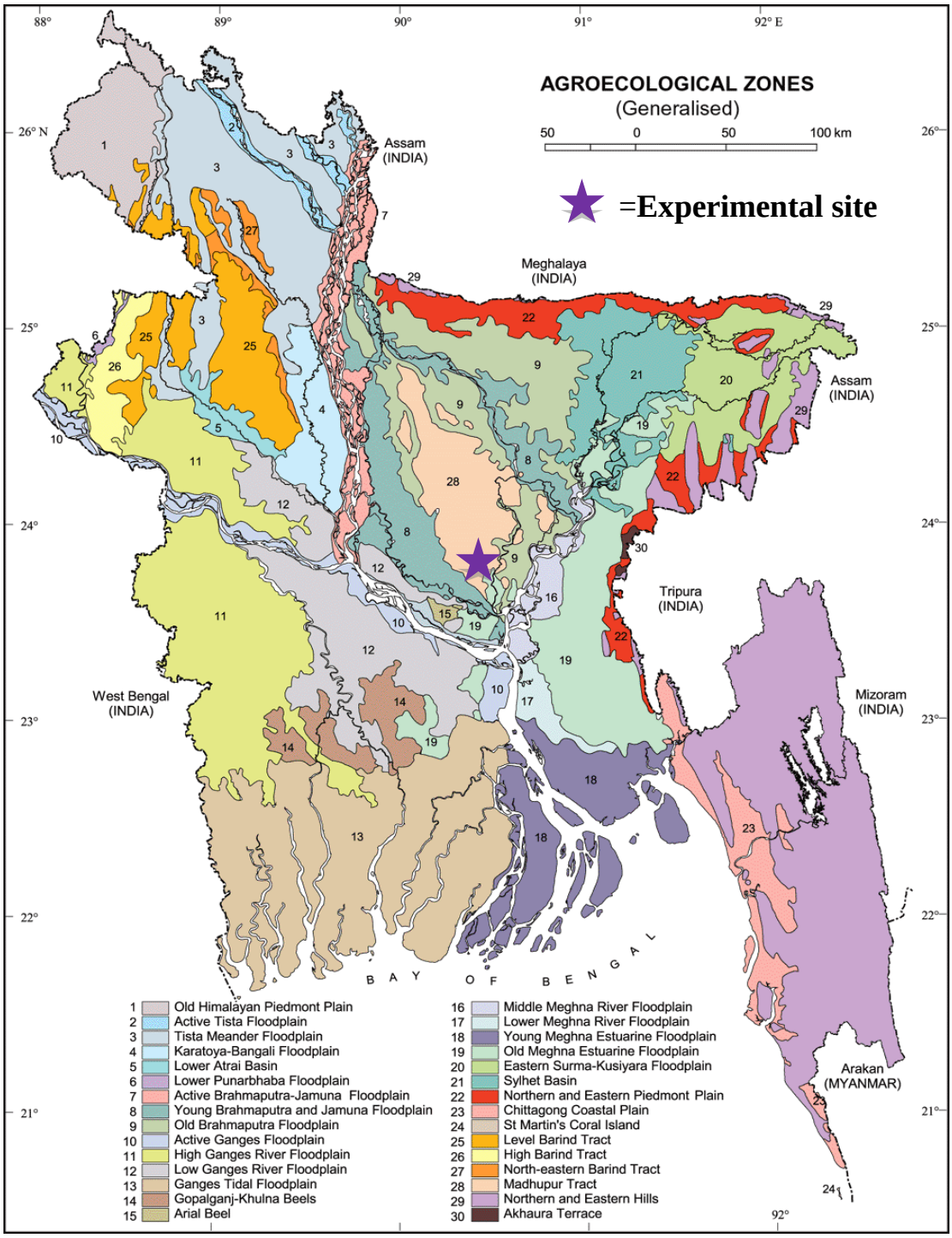
APPENDICES

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



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

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

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	**Value**
pH	6.8
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.071
Available P (ppm)	7.42
Exchangeable K (me/100 g soil)	0.08

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

Appendix III. Analysis of variance of the data on plant height (cm) of soybean as influenced by combined effect of organic and inorganic fertilizers

Source of variation	df	Mean square of plant height (cm) at different days after sowing (DAS)				
		30	45	60	75	At harvest
Replication	2	9.90	21.80	13.38	8.60	4.02
Fertilizers (A)	9	1.90*	13.53^{NS}	38.57^{NS}	15.75*	15.57*
Error	18	1.85	6.66	5.09	6.04	10.03

*Significant at 5% level of significance

^{NS} Non significant

Appendix IV. Analysis of variance of the data on number of branches plant^{-1} of soybean as influenced by combined effect of organic and inorganic fertilizers

Source of variation	df	Mean square of number of branches plant^{-1} at different days after sowing (DAS)			
		45	60	75	At harvest
Replication	2	0.001	0.001	0.01	0.00
Fertilizers (A)	9	0.21*	0.10*	0.08*	0.08*
Error	18	0.01	0.01	0.01	0.02

*Significant at 5% level of significance

^{NS} Non significant

Appendix V. Analysis of variance of the data on dry weight plant^{-1} of soybean as influenced by combined effect of organic and inorganic fertilizers

Source of variation	df	Mean square of dry weight plant^{-1} at different days after sowing (DAS)				
		30	45	60	75	At harvest
Replication	2	0.001	0.02	0.06	0.05	0.15
Fertilizers (A)	9	0.015*	0.25*	1.65*	2.57*	5.48*
Error	18	0.001	0.02	0.16	0.31	0.22

*Significant at 5% level of significance

^{NS} Non significant

Appendix VI. Analysis of variance of the data on yield contributing characters of soybean as influenced by combined effect of organic and inorganic fertilizers

Source of variation	df	Mean square value of				
		No. of pods plant^{-1}	No. of seeds pod^{-1}	Pod length	100 seed weight	Shelling percentage
Replication	2	4.14	0.02	0.04	0.32	151.66
Fertilizers (A)	9	20.53*	0.11*	0.08*	1.03*	38.19*
Error	18	3.82	0.05	0.08	0.74	22.37

*Significant at 5% level of significance

^{NS} Non significant

Appendix VII. Analysis of variance of the data on yield characters of soybean as influenced by combined effect of organic and inorganic fertilizers

Source of variation	df	Mean square value of			
		Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	35971.90	58322.53	489104.93	6.74
Fertilizers (A)	9	262108.07*	252549.44*	1010140.55*	5.65NS
Error	18	16713.20	21968.61	53927.67	14.73

*Significant at 5% level of significance

NS Non significant