ENHANCEMENT OF YIELD AND SEED QUALITY OF SOYBEAN THROUGH ORGANIC NUTRIENT MANAGEMENT

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CERTIFICATE

*This is to certify that thesis entitled **"ENHANCEMENT OF YIELD AND SEED QUALITY OF SOYBEAN THROUGH ORGANIC NUTRIENT MANAGEMENT"** submitted to the **INSTITUTE OF SEED TECHNOLOGY,** Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN SEED TECHNOLOGY,** embodies the result of a piece of bona fide research work carried out by **S. M. MOMIN, Registration no. 14-06050** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2021
Place: Dhaka, Bangladesh

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DEDICATED

TO

MY BELOVED

PARENTS

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ENHANCEMENT OF YIELD AND SEED QUALITY OF SOYBEAN THROUGH ORGANIC NUTRIENT MANAGEMENT

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ABSTRACT

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October, 2019 to February, 2020 to enhancement of yield and seed quality of soybean through organic nutrient management. The experiment was laid out in Randomized Complete Block Design (2 factor) replicated with three times. For this study, factor A- V_1: BARI Soybean 4 and V_2: Bina soybean 1 and factor B- T_1: Farm yard manure (10 t/ha); T_2: Cowdung (10 t/ha); T_3: Vermicompost (5 t/ha), T_4: Trichoderma (2 t/ha), T_5: Biochar (10 t/ha), T_6: Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, Gypsum and boric acid, respectively), T_7: Rhizobium Inoculum and T_0: Control. The yield attributing characteristics i.e. plant height (51.23 cm), number of leaves/plant (13.83), number of pods/plant (50.25), pod length (3.10 cm), seeds per pod (2.25), 1000 seeds weight (123.4 g), seed yield (2.24 t/ha), stover yield (3.89 t/ha), biological yield (6.13 t/ha), harvest index (36.41 %) and seed quality i.e. seed viability (71.63 %) and seed germination (83.63 %) were highest and the timing of 1st flowering (30.38 days) and timing of pod maturity (51.38 days) were lowest for BARI Soybean 4. The yield attributing characteristics i.e. plant height (54.60 cm), number of leaves/plant (15.11), number of pods/plant (62.50), pod length (3.27 cm), seeds per pod (3.50), 1000 seeds weight (137.5 g), seed yield (2.59 t/ha), stover yield (4.34 t/ha), biological yield (6.93 t/ha) and harvest index (37.34 %) and seed quality i.e. seed viability (78.50 %) and seed germination (91.50 %) were highest and the timing of 1st flowering (28.00 days) and timing of pod maturity (49.50 days) were lowest for Biochar (10 t/ha) treatment. Again, BARI Soybean 4 along with Biochar (10 t/ha) showed the best performance in the yield attributing characteristics i.e. plant height (56.23 cm), number of leaves/plant (15.33), number of pods/plant (67.00), pod length (3.31 cm), seeds per pod (4.00), 1000 seeds weight (138.4 g), seed yield (2.67 t/ha), stover yield (4.41 t/ha), biological yield (7.07 t/ha), harvest index (37.68 %), seed quality i.e. seed viability (82.00 %) and seed germination (93.00 %) and the timing of 1st flowering (27.00 days) and timing of pod maturity (49.00 days) were lowest. Among the treatment combinations, BARI Soybean 4 along with Biochar (10 t/ha) seemed to be more promising for obtaining higher yield of soybean.

LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	**Full meaning**
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
CV	Coefficient of variation
$^{\circ}C$	Degree Celsius
et al.	And others
FAO	Food and Agriculture Organization
G	Gram
Ha	Hectare
J.	Journal
K	Potassium
Kg	Kilogram
LSD	Least Significant Difference
Mg	Milligram
Ml	Milliliter
MP	Muriate of Potash
N	Nitrogen
P	Phosphorus
%	Percent
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate

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CHAPTER I

INTRODUCTION

Soybean (*Glycine max* L.) is the most important oil seed in the world. It is one of the most valuable crops in the world, not only as an oil seed crop and feed for livestock and aquaculture, but also as a good source of protein for the human diet and as a biofuel feedstock. World soybean production increased by 4.6 % annually from 1961 to 2007 and reached average annual production of 217.6 million metric tons in 2005-07. World production of soybeans is predicted to increase by 2.2 % annually to 371.3 million metric tons by 2030 using an exponential smoothing model with a dampened trend (Masuda and Goldsmith, 2009). Soybean oil is used directly in food and preventing high blood pressure caused by arteriosclerosis. It also contains lot of the essential vitamins for the body. Soybean cultivation in Egypt started in 1976. Soybean production in Egypt has increased to about 966 ha. Yield levels have stabilized at about 2895 metric ton per hectare (El -Agroudy *et al.*, 2011).

It is a good source of oil, protein, unsaturated fatty acids, minerals like Ca and P including vitamins A, B and D (Rahman, 1982). It contains 40-45 % protein, 18-20 % edible oil, 24-26 % carbohydrate and a good amount of vitamins. Moreover, soybean being a leguminous crop has the ability to fix atmospheric nitrogen (N) through root nodule bacteria (*Bradyrhizobium japonicum*) and thus it enriches the soil fertility (Kaul and Das, 1996). The oil of soybean contains 85% unsaturated fatty acid and is cholesterol free. The oil content of soybean is about 20%, while all other pulse contain about 1-2% oil (Rahman, 1992). Soybean has 3% lecithin which is helpful for brain development. The common people of Bangladesh can`t afford to buy animal protein like egg, meat, and fish in their daily diet because of their high cost.

For the agricultural development, fertilizer management is an important factor. The magnitude of soybean yield losses due to nutrient deficiency also varies among the nutrients (Ali *et al.*, 2002). Deficiencies of N, P, Fe, B and S may cause soybean yield losses up to 10 %, 29-45 %, 22-90 %, 100 % and 16-30 %, respectively, depending on soil fertility, climate and plant factors. Yield is also limited by nutrient toxicities, which are more common with micronutrients (Hellal and Abdelhamid 2013).

Organic fertilizer is decreasing in the agricultural practices of Bangladesh. Ultimately the effect of chemical fertilizer is not so good. The continuous use of high level of chemical fertilizers has led to problem of soil reduce the need for chemical degradation, which is proving detrimental to crop production in our country. Conventional farming systems contain higher levels of nitrate, which is a nutritional disadvantage (Mader, *et al.*, 2002). So we need balanced organic nutrient for crop production. But combined application of poultry manure as an organic fertilizer may reduce chemical fertilizer dependency to a great extent, allowing the small farmers to save a part of the cost of production. Soybean N_2 requirements are met in a complex manner, as this crop is capable of utilizing both soil nitrogen and atmospheric nitrogen (Falodun and Osaigbovo, 2010). Biofertilizers are ecofriendly, cost effective and a renewable source of plant nutrients in sustainable agricultural systems (Mohammadi and Sohrabi, 2012). Organic manures and biochar have been associated with desirable soil properties, improve the higher plant available water holding capacity, can foster beneficial microorganisms (Lehmann, 2007; Drinkwater, *et al.*, 1995) and lead to high crop productivity.

Thus global environment pollution can be controlled considerably by reducing the use of chemical fertilizer and increasing the use of organic source. For increasing seed viability and improvement of soybean organic nutrient management is essential. High viability gives high plant population in the field or nursery (Abram j.Bicksler, 2011).

For this study some objectives were given below:

1. To study the effect of varieties on the yield and seed viability of soybean
2. To study the effect of organic nutrient management on the yield and seed viability of soybean.
3. To study the combined effect of varieties and organic nutrient management on the yield and seed viability of soybean.

CHAPTER II

REVIEW OF LITERATURE

Soybean is quite wide spread in different regions of the world and seems to grow well from the tropical and subtropical regions. Researches on the enhancement of yield and seed quality of soybean through organic nutrient management have been carried out by a large number of researchers throughout the world. However, some important findings have been reviewed in this chapter under the following headings.

2.1. Nutrient function of soybean

Hardarson *et al.* (1984) reported that the % N derived from atmosphere was much more affected when the soybean were inoculated with *B. Japonicum* strain RCR 3412 compared to inoculation with 61A24a, when 20 or 100 kg N ha^{-1} were applied to the soybean and the N_2 nitrogen fixation measured using 15N methodology. In this context, starter N doses as low as 20-40 kg of N ha^{-1} may decrease nodulation and N_2 fixation rates, with no benefits to yield. Indeed, in more than 50 experiments where inoculation and fertilization with 200 kg of N ha^{-1} have been compared (split application of N at sowing and flowering), no increases in yield due to N-fertilizer use have been observed. Similarly, there were no benefits when N-fertilizer was applied at a rate of 400 kg N ha^{-1}, split across ten applications (Hungria *et al.*, 2006).

Afza *et al.* (1987) found that foliar application of N may slightly increase soybean yields without significantly decreasing biological N_2 fixation. They carried out a field experiment, which shown that it is possible to increase soybean yields by applying 40 kg N ha^{-1} as a foliar spray without significantly reducing the amount of N_2 fixed. Clearly, biological nitrogen fixation (BNF) is the most sustainable and lowest cost source of N, and in many cases there is no response to added N. Hence, the issues of when, where and why soybean sometimes responds to applied N remains an important research issue.

Nitrogen (N) is required for protein production in plants and animals and is a component of the nucleic acids DNA and RNA. It is a component of chlorophyll, which gives the green color to plants and is vital for photosynthesis. Crops do not use N very efficiently, and significant quantities are often lost to leaching, volatilization, or denitrification. The bacteria infect their roots and convert nitrogen in the air into a form the plants can use. It is important to inoculate legumes with proper N-fixing bacteria if that particular crop has not been grown in the field for several years. Therefore, legumes that has active N-fixing bacteria do not need additional N fertilization. The bacteria will produce less N if it is provided (Hellal and Abdelhamid, 2013).

Manna *et al.*, (2001) observed, in a 3-year field study (1996-99), the performance of four different composts obtained from legume straw (*Glycine max* Merr.L.), cereal straw (*Triticurn aestivum*), oilseed straw (*Brassica juncea* L.), city rubbish and compared with chemical fertilizers in terms of degree of maturity, quality of compost, improvement in soil organic matter, biological activities of soil and yields of soybean and wheat. The matured compost increased total P, water soluble P, citrate soluble P, total N and NO_3-N and the application of phosphocompost at the rate of 10 t/ha gave plant growth, dry matter accumulation, seed yield and P uptake by soybean equivalent to single super phosphate at 26.2 kg P/ha.

Vessey (2003) reported that combined application of 5 kg Zn and 10 t FYM /ha increased grain yield, NPK contents and uptake by soybean seed. The highest grain yield (1790 kg/ha) was recorded in Zn +FYM treatment with a record of 18.2% increase over control (1515 kg/ha) while the application of B +FYM (13.6%) was on with seed treatment with Na molybdate (13.1%).

A long-term experiment was conducted by Behera (2003) during 1995-2002 under the fine-textured Vertisols at Indore, India to study the effect of combined use of Farm Yard Manure (FYM), poultry manure, vermicompost and biofertilizers (Azotobacter - phosphate solubilizing bacteria) with 50 and 100% NPK on wheat, and residual effect on following soybean. Grain yield of aestivum wheat in the initial 2 years and durum wheat in the later 3 years was significantly increased with 50% NPK + poultry manure @: 2.5 t/ha or FYM @ 10 vim compared with 50 or 100% NPK alone. Soybean did not show much response to residual effect of treatments in most years, although the yield were comparatively better under the combined use of 100% NPK -FYM or poultry manure given to wheat.

Reddy *et al.* (2004) conducted a field experiment on a Typic Haplustert from 1992 to 1995 where in the annual treatments included four rates of fertilizer P (0, 11, 22 and 44kg ha applied to both soybean and wheat) in the absence and presence of 16 t ha^{-1} of manure (applied to soybean only). They observed that with regular application of fertilizer P to each crop the level of Olsen P increased significantly and linearly through the years in both manured and unmanured plots. The mean P balance required to raise Olsen P by 1 mg kg^{-1} was 17.9 kg ha^{-1} of fertilizer P in unmanured plots and 5.6 kg ha^{-1} of manure plus fertilizer P in manured plots.

Hati *et al.* (2006) found that application of 10 mg farmyard manure and recommended NPK (NPK + FYM) to soybean for three consecutive years improved the organic carbon content of the surface (0-15 cm) soil from an initial value of 4.4 g kg^{-1} to 6.2 g kg^{-1} and also increased seed yield and water-use efficiency by 103% and 76%, respectively over the control. Root length density (RLD) up to the 30cm depth was highest in the NPK + FYM plots and it was 31.9% and 70.5% more than NPK and control plots.

Ghosh *et al.* (2006) observed that yield and land equivalent ratio (LER) of the intercrops increased over sole crops though based on aggressivity and relative crowding coefficient (RCC), sorghum is more competitive than soybean. Soybean did not benefit from intercropping to the same degree as sorghum tinder N-P-K. Nutrient application influenced LFR, RCC and monetary advantage index and was found in the order of N-P-K plus farmyard manure (FYM)> N-P-K plus poultry manure (PM) > N-P-K plus phosphocompost (PC) > N-P-K > control. However, based on competition ratio, yield advantage was greater under N-P-K plus PM.

A field experiment on maize with soybean intercropping system was done by Shil *et al.* (2007) during rabi season of 2005-2006. There were 8 treatments comprising 2 sets of planting geometry (PG_1 & PG_2) and 4 doses (NM_1, NM_2, NM_3 and NM_4) of nutrient management package. The interaction effect between planting geometry and nutrient management was statistically non-significant for the main crop (hybrid maize). In case of companion crop (soybean), the highest seed yield (564 and 504 kg/ha) was obtained with NM_3 x PG_2, which was significantly higher over rest of the combinations.

A long-term (30 years) soybean-wheat experiment was conducted by Kundu *et al.* (2006) at Hawalbagh, Almora and observed that maximum yields of soybean (2.84 Mg ha^{-1}) and residual wheat (1.88 Mg ha^{-1}) were obtained in the plots tinder NPK farmyard manure (FYM) treatment, which were significantly higher than yields observed tinder other treatments.

During 2002 and 2003, a study was carried out by Miladinovic *et al.* (2004) to determine the effects of yield, oil content and growing season duration on protein content in new soybean varieties' seeds. In both years, high negative correlations were found between protein content and the other traits under investigation. Path coefficient analysis showed that only oil content had a significant direct effect on protein content.

The effects of irrigation (40, 60, 80 and 100 mm of water evaporated from a class A pan) and plant density (30, 40, 50 and 60 plants/m^2) on the seed yield, and protein and oil content of soyabean cultivars Hobbit. Williams and Hill were determined in a field experiment conducted in Iran during 2000-01. Grain yield per plant and per hectare, as well as 100-seed weight were highest in cv. Williams and with 60 mm irrigation. Grain yield per plant, 100-seed weight and seed oil content decreased, whereas seed protein content increased with increasing plant density. Seed oil content decreased, whereas seed protein content increased with increasing irrigation regimes. Seed protein content was highest in cv. Hobbit (Khajouci-Nejad *et al.*, 2004).

Deshmukh *et al.* (2005) reported that application of recommended dose of NPK (20:40:20 kg ha^{-1}) along with FYM (2.5 tonnes ha^{-1}) recorded the highest grain yield of soybean (12.49 q ha^{-1}), energy (183.60 MJ ha^{-1}) and protein (502.30 kg ha^{-1}) yields as compared to other treatments and farmer's practice. Similar trends were also obsersed in the uptake of N, P and K (118.79, 5.61 and 66.61 kg ha^{-1}, respectively).

2.2. Organic manure and bio fertilizer on soybean

Application of organic manure, biofertilizer and yeast (*Candida tropicales*) on growth, yield and seed quality of soybean (*Glycine max* L.). The results indicated that application of organic manure at a rate of 20 ton per acre as a sole treatment and also when it is associated with biofertilizer as one treatment had more plant height and dry weight per plant. Seed yield (g per plant), pods weight (g per plant), as well as, number of pods per plant, seeds per pod and 1000-seed weight were decreased by adding biofertilizer singly, but when it was associated with organic manure it showed the highest seed and pods weight. Application of organic manure+yeast as one treatment resulted in increased yield and yield attributes of soybean plants. P concentration was only increased when plants received yeast only and also when yeast was associated with biofertilizer. Zn concentration tended to increase as plants were treated by bio.+ organic manure+yeast followed by bio.+ organic as one treatment. Mn concentration was high when plants received yeast singly or when it was associated with biofertilizer, while Fe concentration tended to increase due to adding bio.+ organic manure + yeast followed by bio.+ organic as one treatment (Mekki and Ahmed, 2005).

A field experiment was conducted by Ranwa and Singh (1999) at Hisar, Haryana, India during the winter seasons of 1994-96 to study the effect of integration of nitrogen with vermicompost on wheat crop. The treatment comprised 5 levels of organic manures, viz., no organic manure, farmyard manure at 10 t ha^{-1}, vermicompost (at 5, 7.5 and 10 t ha^{-1}) and 5 levels of N viz. 0, 50, 100, 150 kg ha^{-1} and recommended fertilizer dose. They reported that the application of organic manures improved yield attributes and grain, straw and biological yields of wheat. Application of vermicompost at 7.5 or l0 t ha^{-1} resulted in higher yields than 10 t ha^{-1} FYM.

Rao *et al.* (2000) from a field experiment carried out at the Indian Agricultural Research Institute, New Delhi, revealed that application of 3 t vermicompost ha^{-1} to chickpea improved dry mailer accumulation, grain yield and grain protein content in chickpea, soil N and P and bacterial count, dry fodder yield of succeeding maize, total N and P uptake by the cropping system over no vermicompost.

An experiment was conducted in India on two wheat cultivars to investigate the effect of chemical fertilizers (NPK fertilizer), and organic manure (vermicompost). Results showed that plant height, dry matter production and grain yield were higher at higher dose of vermicompost. Number of tillers and leaves per plant were very low at early stages of growth and suddenly increased after adding different concentrations of vermicompost and organic manure (Khandal and Nagendra, 2002).

The combined application of organic and inorganic N sustained the productivity. Soil available nutrients like N, P and K increased significantly with the application of various organic sources of nutrients in combination with fertilizers over the fertilizer alone. The highest grain yields of rabi sorghum and chickpea were obtained with 50 percent N through green manure plus 50 percent fertilizer N (Tolanur and Badanur, 2003).

Cheung and Wong (1983) carried out an experiment on animal manures and sewage sludge for growing vegetables and stated that chicken manures and pig manures resulted in better growth than sewage sludge.

Maslo and Gamayunov (1989) conducted an experiment on four crops rotations (cucumber, tomato, cabbage and potato). They added 65 t ha^{-1} cattle manure per rotation, including 40 t ha^{-1} for cabbage. Lime was applied once per rotation, mineral fertilizers were applied at N-308, P-390, K-390. The most positive effect on soil fertility was observed following combined mineral and organic fertilizer application. Yield was increases by 57-136% and productivity by 11-33% more than manuring alone.

Xiong and Liu (1992) observed that applications of FYM increased soil structure conditions for root growth in soybean.

Lu and Edwards (1994) suggested that, application of 26 to 106 g poultry manure kg^{-1} soil resulted the maximum DM yield in cabbage grown in a greenhouse pot study in USA.

Devliegher and Rooster (1997) carried out another experiment in Belgium on cauliflower, using standard peat-based compost alone or supplemented with green compost or a GFT-compost. They observed that plant growth was the greatest for plants raised in standard compost and harvest date was earlier.

Beneficial effects of organic fertilizer applications on growth and yield of some field crops were shown by Radwan and Hussein (1996), Mekki *et al.* (1999) and El-Kholy and Gomaa (2000). Currently, emphasis has already been placed on research and development activities that led to the concept of multistrain biofertilizers i.e. the application of soil microorganism groups, having a definite beneficial role in supporting bio-control of soil born disease (Saber and Gomaa, 1993). Bread yeast (candida) has demonstrated a large on growth and yield of millit crop (El- Kholy and Gomaa, 2000).

PGPR present in biofertilizer and organic manures enhance the plant growth by producing growth regulators that enhance the activity of other beneficial microorganisms, accelerating the mineralization of plant nutrients and uptake of certain nutrients. Increased leaf area, chlorophyll concentration and total biomass production in wheat was observed (Panwar *et al.*, 2000).

Biofertilizer and organic manures that contain PGPR affect nutrient uptake in plant and enhance growth and development of plant roots, leading to root systems with larger surface area and increased number of root hairs, which are then able to access more nutrients (Adesemoye *et al.*, 2008).

Mehasen and Saeed (2005) studied the effects of bacterial inoculation as well as mineral and organic fertilization on the yield and yield components of soybean Giza 22 and Giza 111 cultivars. They concluded that there is a significant effect for the interaction between soybean cultivars and fertilization treatments on seed weight per plant only.

Integrated use of organic manure with efficient microbes and half dosage NPK fertilizer yielded similar to the yield obtained from full recommended NPK fertilizer (Khaliq *et al.*, 2006).

Seed protein content was increased in response to application of phosphate solubilizing microorganisms and these phosphate solubilizing microorganisms increase the uptake of N of soybean (Sharma and Namdeo, 1999). Biofertilizer alone or in combination with nitrogen fertilizer increased crude protein level by uptake of N from soil (Tiwana *et al.*, 1992). The increase in the crude protein yield is an expected result to successive increase in N level in response to biofertilizer treatment (Patel *et al.*, 1992).

Asewar *et al.*, (2003) carried out man experiment to investigate the integrated use of vermicompost and inorganic fertilizer in chickpea cv. Vijay during 2000-01 and 2001-02 in Badnapur, Maharastra, India. Treatments comprised: four vermicompost levels (0,1,2,3 t ha^{-1}) and three fertilizer levels 0 (control); 50% and 100% recommended rate of fertilizer (REF, 25 kg N and 50 kg P ha^{-1}). They found that, vermicaompost application increased the growth characters, plant height and number of branches $plant^{-1}$ and yield contributing characters, pods per plant, grain yield and straw yield compare to the control.

The performance of 3 kabli gram (*Cicer arietinum*) genotypes under various organic manures was in Faisalabad, Pakistan, during 1999-2000 and 2000-01. The fertilizer levels had significant effects on the seed yield of gram genotypes. The difference among the varietal means were not significant during the 1st year but significant during resulted in the greatest seed yield (Muhammad *et al.*, 2004).

Kumari and Kumari (2002) from an experiment stated that verrnicompost is a potential source of organic manure due to the presence of readily available plant nutrients, growth enhancing substances and number of beneficial microorganisms like N fixing, P solubilizing and celulose decomposing organisms.

Vermicompost contains 2.29 folds more organic carbon. 1.76 times total nitrogen. 3.02 folds phosphorous and 1.60 times potassium than normal compost. Earthworms decrease the C:N ratio from 14.21 to 10.11 and an average 56.03% of organic waste can be converted into vermicompost by the activities of earthworms in short time (Sohrab and Sarwar, 2001).

Vermicompost contain high organic matter, N, P. S. Ca and Mg. It was shown that worm-worked coinposts have better lexture and soil enhancing properties, hold typically higher percentages of N, P and K (Fatma and Sweelam, 2000).

Earthworms influence the changes in various chemical parameters governing the compost maturity of local grass, mango leaves and farm wastes. There was a decrease in C:N ratio, while humic acid, cation exchange capacity and water soluble carbohydrates increased up to 150 days of composting. Compost maturation was achieved up to a period of 120 and 150 days in farm wastes and mango leaves, respectively, while more than 150 days would be required to reach the maturity in case of local grass. Inoculation of earthworms reduced the duration of composting by 13 days (Talashilkar *et al.*, 1999).

Saerah *et al.* (1996) conducted an experiment on the effect of compost in optimizing the physical condition of sandy soil. Compost at the rate of 0.0, 16.5, 33.0, 49.5 and

66.0 t ha^{-1} was incorporated into the soil and then wheat was grown. The results indicated that the various application rates were significantly correlated with improvement in physical properties of soil as well as straw and grain yields of wheat.

2.3. Seed germination and seed vigor of soybean:

Santos *et al.* (1996) studied five soybean genotypes and six osmotic potential levels induced by manitol and reported that the increase in vigour in the less vigourous seeds under this condition could be explained by the reduction in the water entry speed in the cells during the seed imbibition process (Peske and Delouche, 1985), bearing in mind that not very vigourous seeds have disarrangements in the cell membranes that favor faster water absorption and solute loss, that can result in tissue death.

CHAPTER III

MATERIALS AND METHOD

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, intercultural operations, data collection and statistical analyses.

3.1. Location

The field experiment was conducted at the Agronomy research field, SAU, Dhaka during the period from October 2019 to February 2020. Geographically the experimental field is located at 23°46' N latitude and 90° 22' E longitude at an elevation of 8.2 m above from the sea level belonging to the Agro-ecological Zone “AEZ-28” of Madhupur Tract (BBS, 2011). The location of the experimental site has been shown in Appendix I.

3.2. Climate

The experimental area is situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of April to September (kharif season) and scanty rainfall during the rest period of the year. The Rabi season (October to March) is characterized by comparatively low temperature and plenty of sunshine from November to February.

3.3. Soil

The soil of the research field is slightly acidic in reaction with low organic matter content. The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done from Soil Resources Development Institute (SRDI), Dhaka. The experimental plot was also high land, having pH 5.8. The physicochemical property and nutrient status of soil of the experimental plots are given in Appendix II.

3.4. Plant materials and features

The varieties of soybean used in this experiment was BARI Soybean 4 and BINA Soyabean-1. The seed of this variety was collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur and Bangladesh Institute of Nuclear Agriculture, Mymensingh, respectively. These released varieties has excellent seed quality and superior to others.

3.5. Experimental treatments

The experiment consisted of two treatment factors as mentioned below:

Factor A: Varieties

V_1 = BARI Soybean 4

V_2= Bina soybean 1

Factor B: Different organic fertilizers and manure

T_0 = Control

T_1 = Farm yard manure (10 t/ha)

T_2 = Cowdung (10 t/ha)

T_3 =Vermicompost (5 t/ha)

T_4 = Trichoderma (2 t/ha)

T_5 = Biochar (10 t/ha)

T_6 = Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively)

T_7 = Rhizobium Inoculum

3.6. Design and layout

The experiment was laid out in two factor Randomized Complete Block Design with three replications. The size of the individual plot was 4 m x 2.5 m and total numbers of plots were 48. There were 16 treatment combinations. Each block was divided into 16 unit plots. Varieties along the main plot and organic fertilizers and manures were placed in the sub plot. Layout of the experiment was done on October 27, 2019 with inter plot spacing of 0.50 m and inter block spacing of 0.75 m.

3.7. Land preparation

The land of the experimental field was first opened on October 20, 2019 with a power tiller. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field.

3.8. Fertilizer application

The fertilizers were applied as per treatment.

3.9. Seed sowing

Sowing was done on 28 October, 2019. Seeds were sown in 30 cm apart rows and seed to seed distances were maintained at first in 5cm and later in 10 cm to conform the exact plant density. Furrows were made by hand rake and seeds were placed in the furrows by hand and then covered properly with soil.

3.10. Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop.

3.10.1. Thinning

At 15 DAS, excess plants were thinned out and maintained plant to plant distance 10 cm.

3.10.2. Weeding

The crop was weeded twice. First weeding was done at 25 days after sowing (DAS) and second weeding was done at 45 DAS. Demarcation boundaries and drainage channels were also kept weed free.

3.10.3. Irrigation

Irrigation was done at 30 DAS after sowing (pre-flowering) stage and then at 60 DAS (pod formation stages) as per recommendation (BARI, 2011). Proper drainage system was also made for draining out excess water.

3.10.4. Plant protections

The soybean plants were infested by cutworms (*Agrotis ipsilon*) at early growth stage which were controlled by applying Darsban 20 EC @ 5ml/L of water. Diseased or off type plants were uprooted as and when required.

3.11. General observations of the experimental field

Regular observations were made to see the growth stages of the crop. In general, the field looked nice with normal green plants which were vigorous and luxuriant in the treatment plots than that of control plots.

3.12. Sampling and harvesting

Maturity of crop was determined when 95 % of the pods become brown in colour. Three sample plants were collected from each plot before harvesting for taking yield attributes data. The plants of central 1 m^2 area were harvested by placing quadrates at random for recording yield data. Harvesting was done on 28 February, 2020. The harvested crops from each plot were tied up into bundles separately, tagged and brought to the clean threshing floor. The same procedure was followed for sample plants.

3.12.1. Threshing

The crop bundles were sun dried for four days by spreading them on the threshing floor. Seeds were separated from the stover by hand machine and rubbing.

3.12.2. Drying

Seeds and stover were cleaned and dried in the sun for four consecutive days. After proper drying of seeds to a moisture content of 12 % were kept in polythene bags. Moisture contents were determined by moisture meter.

3.12.3. Cleaning and weighing

Dried seeds and stover was weighed plot wise. After that the weights were converted into t ha^{-1}.

3.13. Collection of data

Three plants in each plot were selected and tagged. All the growth data (except dry weight) were recorded from those three selected plants.

The following data were collected –

A. Crop growth characters

1. Plant height (cm) at harvest

2. Number of leaves $plant^{-1}$

3. Time of flowering (days)

B. Yield contributing characters

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

2. Length of pod (cm)

3. Number of seeds pod^{-1}

4. Time of maturity (days)

5. 1000-seed weight (g)

C. Yield and harvest index

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

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

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

4. Harvest index (%)

D. Seed quality test

1. Seed germination (%)

2. Seed viability (%)

3.14. Methods of recording data

A. Crop growth parameters

1. Plant height (cm): The height of soybean plants was recorded at harvest. The heights of three preselected sample plants were measured from the ground level to the tip of the shoot. Then the data was averaged and expressed in cm.

2. Number of leaves $plant^{-1}$: All the leaves of the preselected three sample plants in each plot were counted and averaged them to have number of leaves $plant^{-1}$ and recorded it separately.

3. Time of flowering (days): Each plant of the experiment plot was kept under close observation to count days of flowering of soybean. Total number of days from the date of sowing to the flowering was recorded.

B. Yield contributing characters

1. Number of pods $plants^{-1}$: All the pods of the preselected three sample plants in each plot were counted and averaged them to have pods $plant^{-1}$.

2. Pod length: The lengths of three randomly selected pods taken from sample plants were measured. Mean data was expressed in centimeter (cm).

3. Number of seeds pod^{-1}: Number of total seeds of three sample plants from each plot was noted and the mean number was expressed pod^{-1} basis.

4. Time of maturity (days): Each plant of the experiment plot was kept under close observation to count days of pod maturity of soybean. Total number of days from the date of sowing to the pod maturity was recorded.

5. Weight of 1000-seed (g): One thousand sun dried cleaned seeds were counted randomly from the seed stock of sample plants. Weight of 1000 seeds were then recorded by means of a digital electrical balance and expressed in gram (g).

C. Yield and harvest index

1. Seed yield: Seeds obtained from harvested (1.0 m^2) area of each unit plot were dried in the sun and weighed. The seed weight was expressed as t ha-1 on 12% moisture basis. Grain moisture content was measured by using digital moisture meter.

2. Stover yield: The stover yields obtained from the harvested 1.0 m^2 area of each unit plot were dried separately and weights were recorded. These weights were converted to t ha^{-1}.

3. Biological yield: Biological yield was calculated by using the following formula:

Biological yield= Grain yield + stover yield

4. Harvest index (%): Harvest index is the relationship between grain yield and biological yield

(Gardner *et al.*, 1985). It was calculated by using the following formula:

$$\text{HI (\%)} = \frac{Grain\ yield}{Biological\ yield} \times 100$$

D. Seed quality test

Seed germination (%) and seed viability (%): Carried out with two sub-samples of 50 seeds for each treatment and replication, which were preconditioned on paper towels moistened with distilled water for 16 hr in a germinator set at 25°C ± 2°C. After this period, the seeds were transferred to plastic cups (50 mL) and were completely submerged in 0.075% tetrazolium solution for three hours, in an incubator set at 40°C in the dark. After staining, the seeds were classified for germination and viability at levels from 1 to 8, according to the criteria proposed by França-Neto *et al.* (1998). The viability and germination potentials were expressed as a percentage (França-Neto *et al.*, 1999).

3.15. Statistical analysis

The data collected on different parameters were statistically analyzed to obtain the level of significance by using MSTAT-C computer package program. The significant differences among the treatment means were compared by LSD and Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

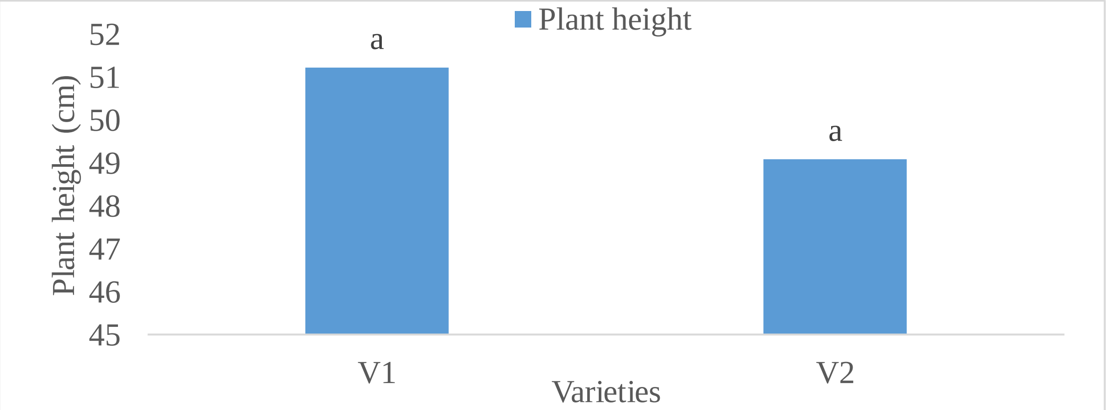
RESULTS AND DISCUSSION

The experiment was conducted at the farm of SAU, Dhaka to find out the yield of soybean through organic nutrient management and in laboratory condition studied the enhancement of seed viability of soybean. The analyses of variance (ANOVA) of the data on different recorded parameters are presented in Appendix III-VIII. The findings of the experiment have been presented and discusses with the help of Table and Graphs and possible interpretations were given under the following headings:

4.1. Crop growth parameters

4.1.1. Plant height (cm)

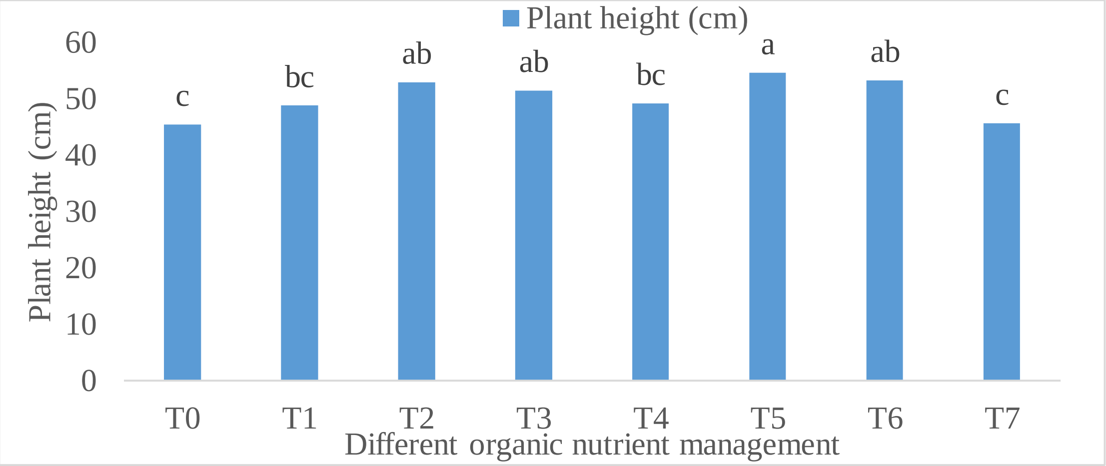
Plant height of soybean showed statistically non-significant variation due to different varieties at harvest. The tallest plant (51.23 cm) was recorded from V_1 (BARI Soybean 4), which was statistically similar (49.09) with V_2 (Bina soybean 1) (Figure 1). From this figure it was revealed that, BARI Soybean 4 showed the best performance in terms of plant height in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 1: Effect of varieties on plant height of soybean ($LSD_{0.05}$ = 4.74)

Different organic nutrient management differed significantly in terms of plant height of soybean at harvest. The tallest plant (54.60 cm) was found from T_5 (Biochar) which was statistically different from others, while the shortest plant (45.45 cm) was observed from T_0 (Control) treatment (Figure 2). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer increases the plant height of soybean.

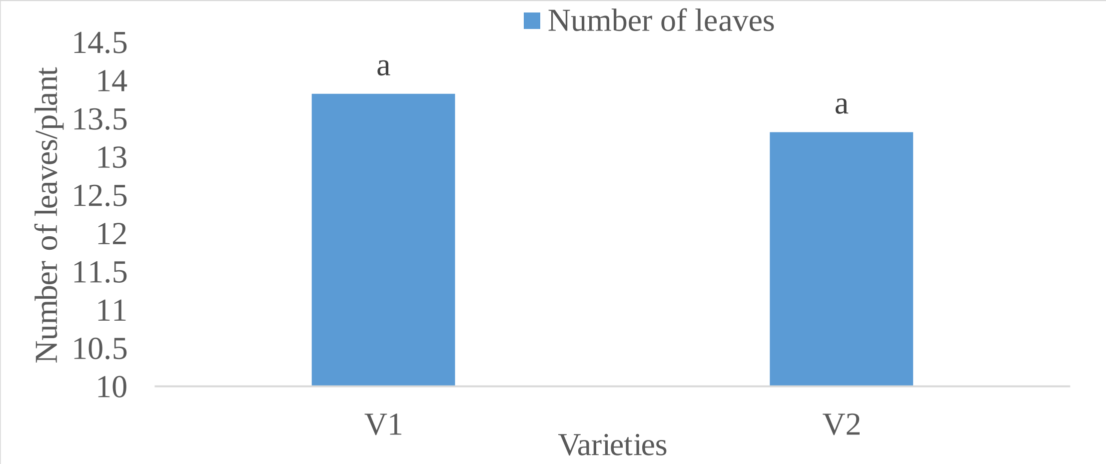


Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 2: Effect of different organic nutrient management on plant height of soybean ($LSD_{0.05}$= 4.73)

Interaction effect of varieties and different organic fertilizer nutrient management showed statistically significant variation on plant height of soybean at harvest. The tallest plant (56.23 cm) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (54.67), V_2T_2 (53.88), V_2T_5 (52.97), V_1T_2 (51.97), V_1T_6 (51.83), V_2T_3 (51.56), V_1T_3 (51.36) and V_2T_1 (50.96) followed by V_2T_4 (50.47 cm). On the other hand the lowest plant height (44.67 cm) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (45.46), V_2T_7 (45.82), V_2T_0 (46.23), V_1T_1 (46.56) and V_1T_4 (47.88 cm) (Table 1).

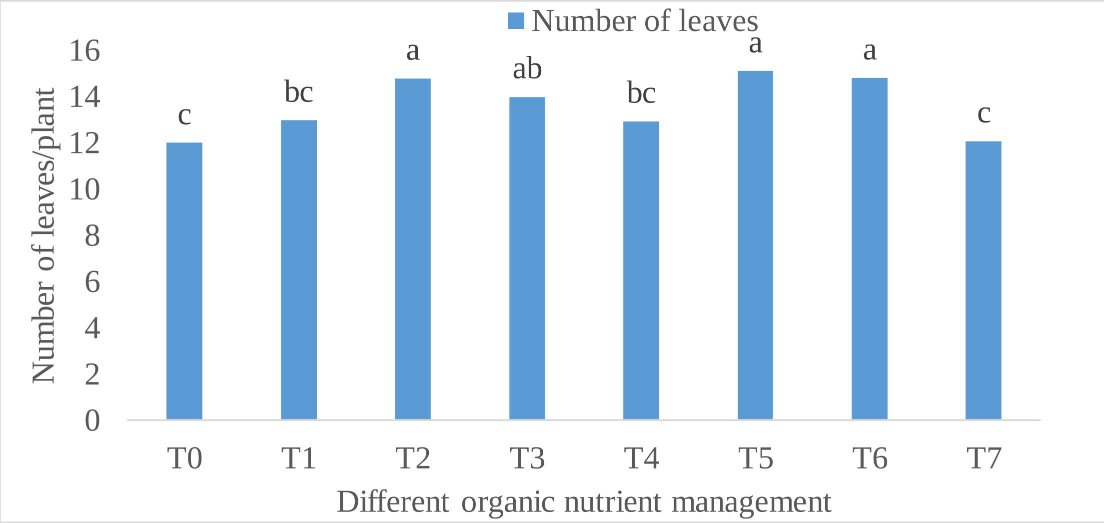
4.1.2. Number of leaves plant^{-1}: Number of leaves per plant of soybean showed statistically non-significant variation due to different varieties at harvest. The highest number of leaves (13.83 leaves) was recorded from V_1 (BARI Soybean 4), which was statistically similar (13.33 leaves) with V_2 (Bina soybean 1) (Figure 3). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of number of leaves of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 3: Effect of varieties on number of leaves per plant of soybean ($LSD_{0.05}$ = 1.28)

Different organic nutrient management differed significantly in terms of number of leaves per plant of soybean at harvest. The highest number of leaves (15.11 leaves) was found from T_5 (Biochar) which was statistically different from others, while the lowest number of leaves (12.00 leaves) was observed from T_0 (Control) treatment (Figure 4). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer increases the number of leaves of soybean.

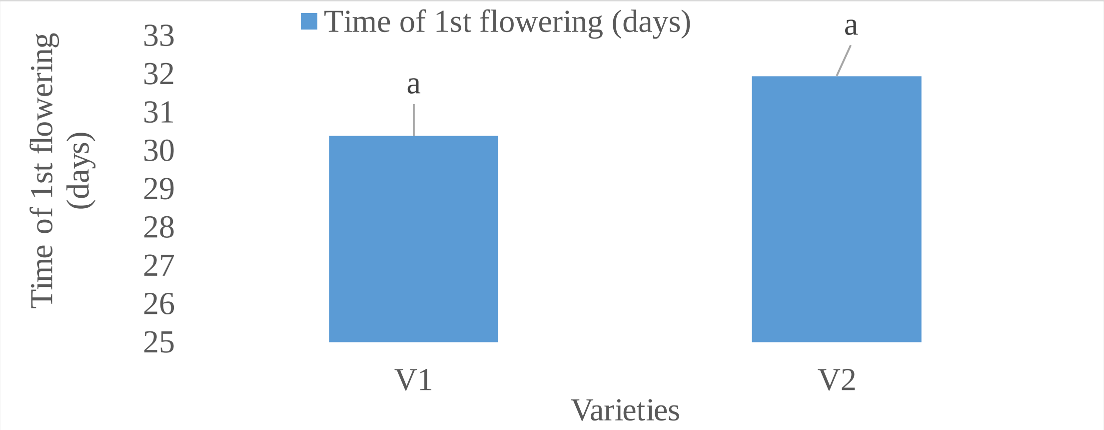


Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 4: Effect of different organic nutrient management on number of leaves per plant of soybean ($LSD_{0.05}$ = 1.283)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on number of leaves per plant of soybean at harvest. The highest number of leaves (15.33 leaves) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (15.11), V_2T_2 (14.92), V_2T_5 (14.88), V_1T_2 (14.66), V_1T_6 (14.48) and V_2T_3 (14.31) followed by V_1T_3 (13.67) and V_2T_1 (13.27 leaves). On the other hand the lowest number of leaves (11.67 leaves) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (11.87), V_2T_7 (12.29), V_2T_0 (12.33), V_1T_1 (12.66), V_1T_4 (12.76) and V_2T_4 (13.11 leaves) (Table 1).

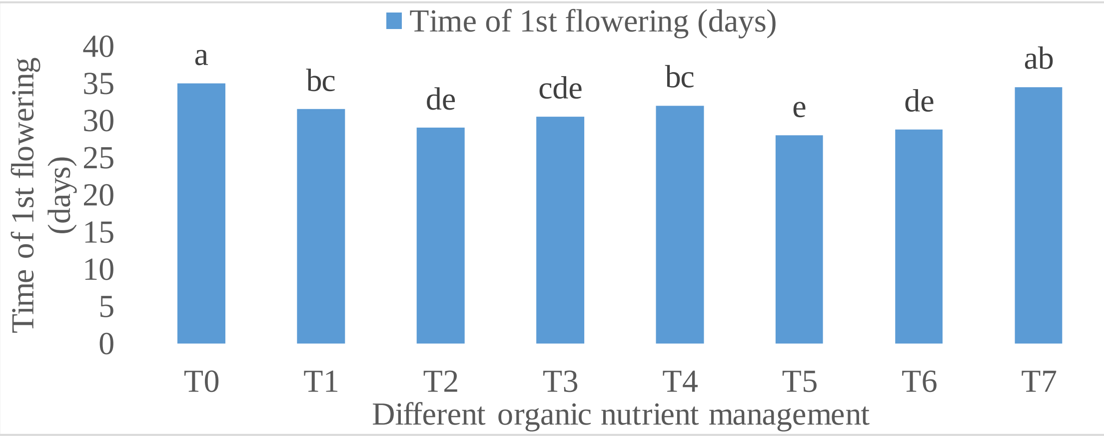
3. Time of 1st flowering (days): Time of 1st flowering of soybean showed statistically non-significant variation due to different varieties. The lowest time for 1st flowering (30.38 days) was recorded from V_1 (BARI Soybean 4), which was statistically similar (31.94 days) with V_2 (Bina soybean 1) (Figure 5). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of time for 1st flowering of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 5: Effect of varieties on time of 1st flowering of soybean ($LSD_{0.05}$ = 2.71)

Different organic nutrient management differed significantly in terms of time of 1st flowering of soybean. The lowest time for 1st flowering (28.00 days) was found from T_5 (Biochar) which was statistically different from others, while the highest time for 1st flowering (35.00 days) was observed from T_0 (Control) treatment (Figure 6). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer decreases the time for 1st flowering of soybean.



Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 6: Effect of different organic nutrient management on time of 1st flowering of soybean ($LSD_{0.05}$ = 2.705)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on time for 1st flowering of soybean. The lowest time for 1st flowering (27.00 days) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (28.00), V_2T_2 (28.00), V_2T_5 (29.00), V_1T_6 (29.50), V_1T_2 (30.00) and V_2T_3 (30.00) followed by V_1T_3 (31.00) and V_2T_1 (31.00 days). On the other hand the highest time for 1st flowering (37.00 days) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (35.00) followed by V_2T_7 (34.00), V_2T_0 (33.00), V_1T_1 (32.00), V_1T_4 (32.00) and V_2T_4 (32.00 days) (Table 1).

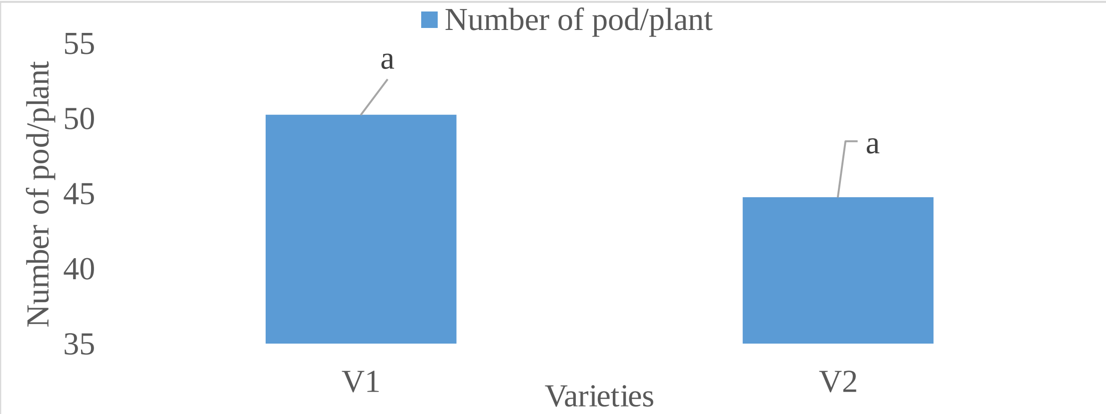
Table 1: Combined effect of varieties and different organic nutrient management on plant height, number of leaves per plant and time of 1st flowering of soybean

Varieties	Treatments	Plant height (cm)	Number of leaves per plant	Time of 1st flowering (days)
V_1	T_0	44.67 h	11.67 g	37.00 a
	T_1	46.56 defgh	12.66 efg	32.00 bcde
	T_2	51.97 abcd	14.66 abc	30.00 defg
	T_3	51.36 abcde	13.67 bcde	31.00 cdef
	T_4	47.88 cdefgh	12.76 efg	32.00 cde
	T_5	56.23 a	15.33 a	27.00 g
	T_6	51.83 abcd	14 48 abcd	29.50 efg
	T_7	45.46 gh	11.87 fg	35.00 ab
V_2	T_0	46.23 efgh	12.33 efg	33.00 bcd
	T_1	50.96 abcdef	13.27 cdef	31.00 cdef
	T_2	53.88 ab	14.92 ab	28.00 fg
	T_3	51.56 abcde	14.31 abcd	30.00 defg
	T_4	50.47 bcdefg	13.11 defg	32.00 bcde
	T_5	52.97 abc	14.88 ab	29.00 efg
	T_6	54.67 ab	15.11 ab	28.00 fg
	T_7	45.82 fgh	12.29 efg	34.00 bc
$LSD_{(0.05)}$		4.73	1.28	2.71
CV (%)		5.74	5.75	5.28

[Here, V_1= BARI Soybean 4, V_2= Bina soybean 1, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum]

4.2. Yield contributing characters

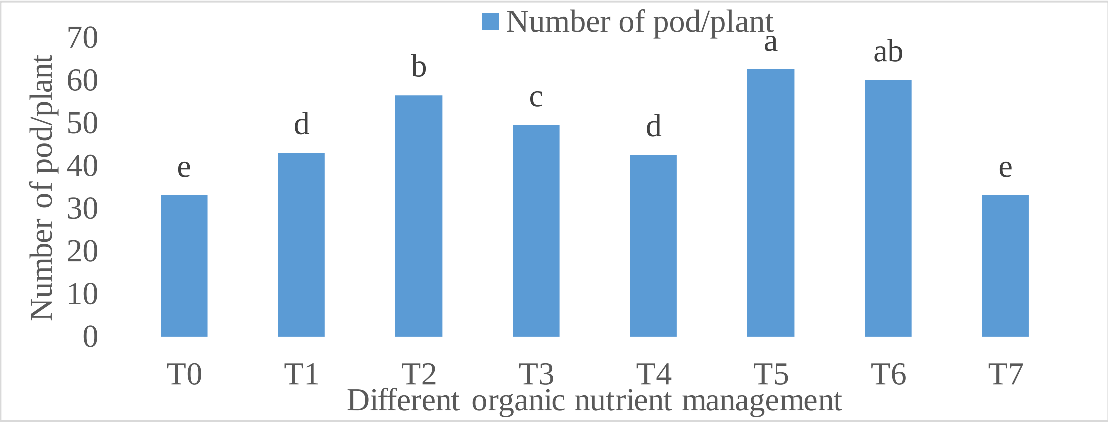
4.2.1. Number of pods plants^{-1}: Number of pods per plant of soybean showed statistically significant variation due to different varieties at harvest. The highest number of pods (50.25 pods) was recorded from V_1 (BARI Soybean 4), whereas the lowest number of pods (44.76 pods) was recorded from V_2 (Bina soybean 1) (Figure 7). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of number of pods per plant of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 7: Effect of varieties on number of pod/plant of soybean ($LSD_{0.05}$ = 5.63)

Different organic nutrient management differed significantly in terms of number of pods per plant of soybean at harvest. The highest number of pods (62.50 pods) was found from T_5 (Biochar) which was statistically different from others, while the lowest number of pods (33.00 pods) was observed from T_0 (Control) treatment (Figure 8). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer increases the number of pods of soybean.

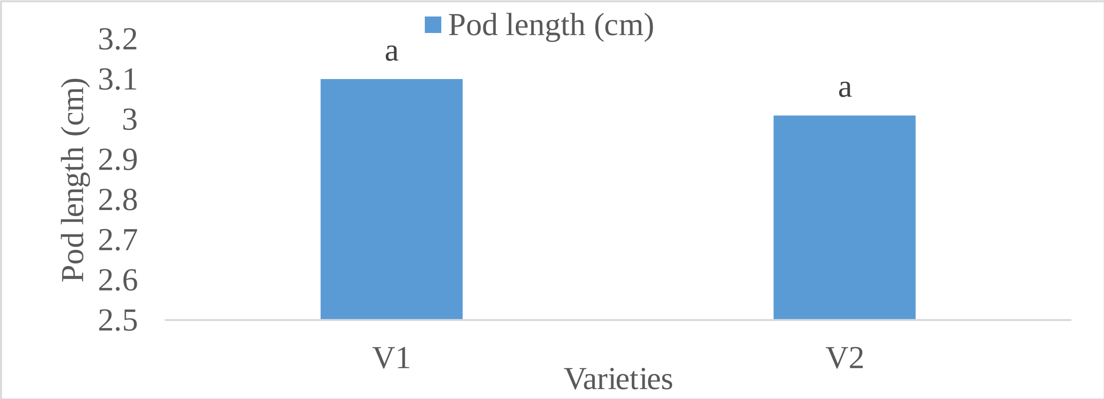


Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 8: Effect of different organic nutrient management on number of pod per plant of soybean ($LSD_{0.05}$ = 5.625)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on number of pods per plant of soybean at harvest. The highest number of pods (67.00 pods) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (65.00) followed by V_2T_2 (61.00), V_2T_5 (58.00), V_1T_6 (55.07), V_1T_2 (52.00), V_2T_3 (50.00), V_1T_3 (49.00) and V_2T_1 (45.00 pods). On the other hand the lowest number of pods (29.00 pods) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (32.00) and V_2T_7 (34.00) followed by V_2T_0 (37.00), V_1T_1 (41.00), V_1T_4 (42.00) and V_2T_4 (43.00 pods) (Table 2).

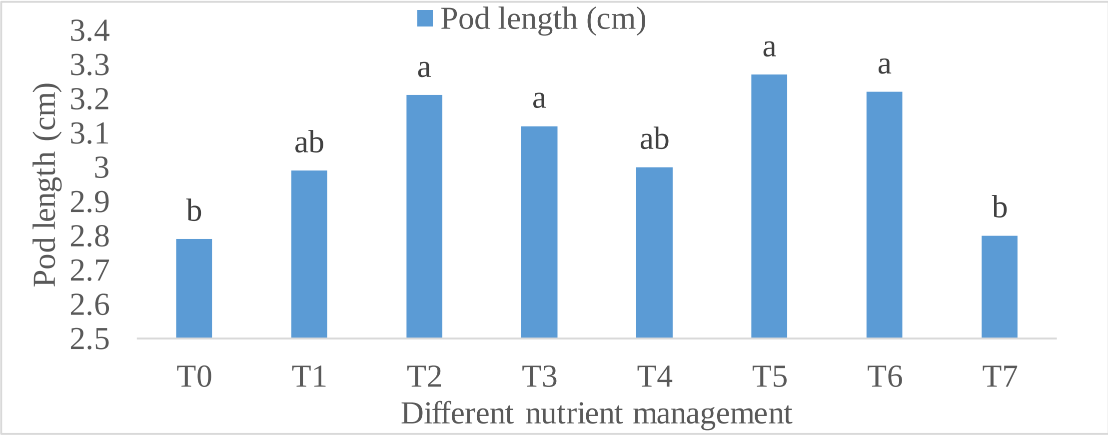
4.2.2. Pod length: Pod length of soybean showed statistically non-significant variation due to different varieties at harvest. The highest pod length (3.10 cm) was recorded from V_1 (BARI Soybean 4), whereas the lowest pod length (3.01 cm) was recorded from V_2 (Bina soybean 1) (Figure 9). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of pod length of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 9: Effect of varieties on pod length of soybean ($LSD_{0.05}$ = 0.2845)

Different organic nutrient management differed significantly in terms of pod length of soybean at harvest (Appendix VII). The highest pod length (3.27 cm) was found from T_5 (Biochar) which was statistically different from others, while the lowest pod length (2.79 cm) was observed from T_0 (Control) treatment (Figure 10). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer increases the pod length of soybean.

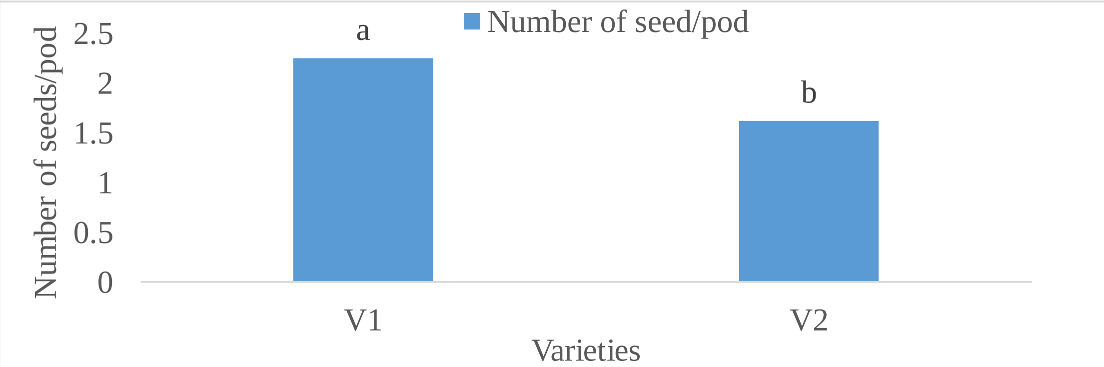


Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 10: Effect of different organic nutrient management on pod length of soybean ($LSD_{0.05}$ = 0.2845)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on pod length of soybean at harvest. The highest pod length (3.31 cm) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (3.28), V_2T_2 (3.24), V_2T_5 (3.22), V_1T_2 (3.18), V_1T_6 (3.16), V_2T_3 (3.13), V_1T_3 (3.11), V_2T_1 (3.07) and V_2T_4 (3.03 cm). On the other hand the lowest pod length (2.69 cm) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (2.77), V_2T_7 (2.83), V_2T_0 (2.88), V_1T_1 (2.92) and V_1T_4 (2.96 cm) (Table 2).

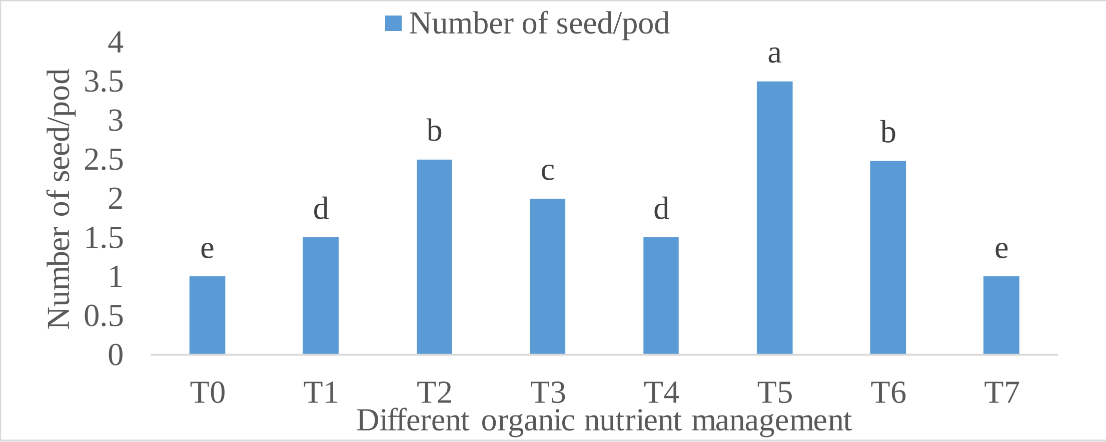
4.2.3. Number of seeds pod^{-1}: Number of seeds per pod of soybean showed statistically significant variation due to different varieties at harvest. The highest number of seeds per pod (2.25 seeds) was recorded from V_1 (BARI Soybean 4), whereas the lowest number of seeds per pod (1.62 seeds) was recorded from V_2 (Bina soybean 1) (Figure 11). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of number of seeds per pod of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 11: Effect of varieties on number of seeds/pod of soybean ($LSD_{0.05}$ = 0.3366)

Different organic nutrient management differed significantly in terms of number of seeds per pod of soybean at harvest. The highest number of seeds per pod (3.50 seeds) was found from T_5 (Biochar) which was statistically different from others, while the lowest number of seeds per pod (1.00 seed) was observed from T_0 (Control) treatment (Figure 12). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer increases the number of seeds per pod of soybean.

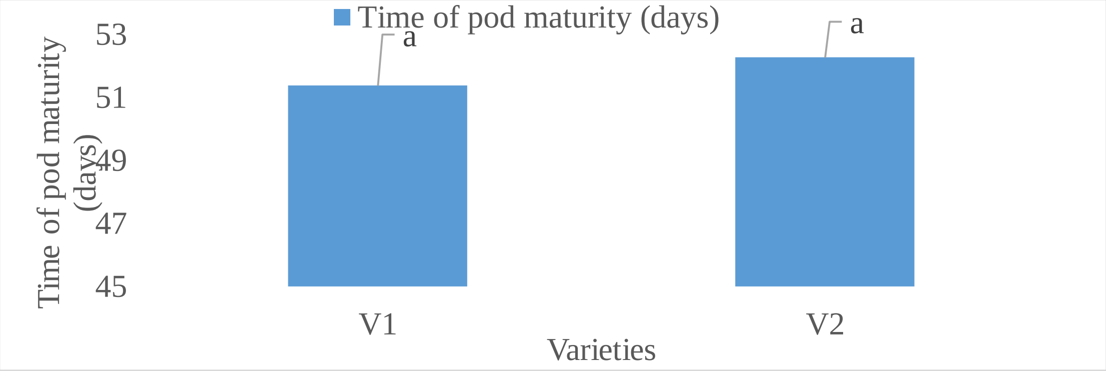


Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 12: Effect of different organic nutrient son number of seed per pod of soybean ($LSD_{0.05}$ = 0.3366)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on number of seeds per pod of soybean at harvest. The highest number of seeds per plot (4.00 seeds) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically different from others followed by V_2T_6 (3.00), V_2T_2 (3.00), V_2T_5 (3.00), V_1T_2 (2.00), V_2T_4 (2.00), V_2T_3 (2.00), V_1T_3 (2.00), V_2T_1 (2.00) and V_1T_6 (1.97 seeds). On the other hand the lowest number of seeds per pod (1.00 seed) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (1.00), V_2T_7 (1.00), V_2T_0 (1.00), V_1T_1 (1.00) and V_1T_4 (1.00 seed) (Table 2).

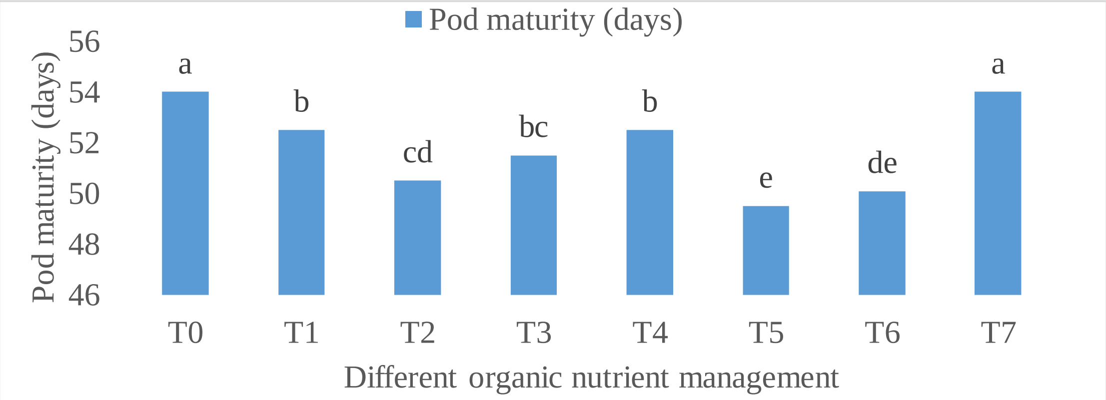
4.2.4. Time of pod maturity (days): Time of pod maturity of soybean showed statistically non-significant variation due to different varieties. The lowest time for pod maturity (51.38 days) was recorded from V_1 (BARI Soybean 4), which was statistically similar (52.27 days) with V_2 (Bina soybean 1) (Figure 13). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of time for pod maturity of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 13: Effect of varieties on timing of pod maturity of soybean ($LSD_{0.05}$ = 4.524)

Different organic nutrient management were differed significantly in terms of time of pod maturity (days) of soybean. The lowest time for pod maturity (49.50 days) was found from T_5 (Biochar) which was statistically different from others, while the highest time for pod maturity (54.00 days) was observed from T_0 (Control) treatment (Figure 14). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer decreases the time for pod maturity of soybean.

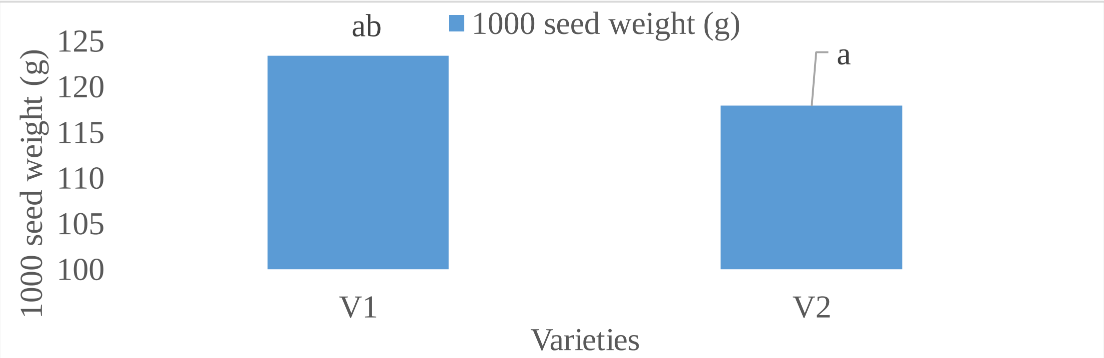


Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 14: Effect of different treatments on timing of pod maturity of soybean ($LSD_{0.05}$ = 4.524)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on time for pod maturity of soybean. The lowest time for pod maturity (49.00 days) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (50.00), V_2T_2 (50.00), V_2T_5 (50.00), V_1T_6 (50.15), V_1T_2 (51.00), V_2T_3 (51.00), V_1T_3 (52.00), V_2T_1 (52.00), V_2T_4 (53.00), V_1T_4 (53.00), V_1T_1 (53.00), V_2T_0 (54.00) and V_2T_7 (54.00 days). On the other hand the highest time for pod maturity (55.00 days) was recorded from V_1T_0 (BARI Soybean 4 with control) (Table 2).

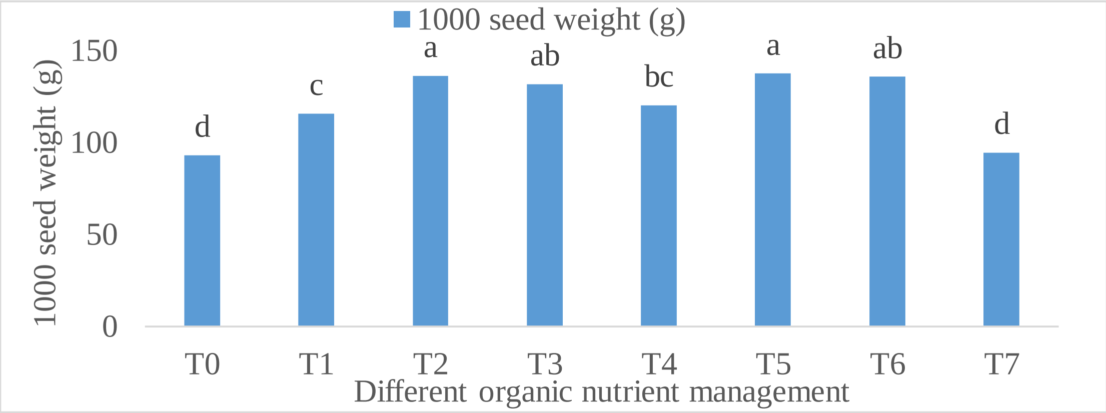
4.2.5. Weight of 1000-seed (g): Weight of 1000 seeds of soybean showed statistically significant variation due to different varieties at harvest. The highest weight (123.4 g) was recorded from V_1 (BARI Soybean 4), whereas the lowest weight (117.9 g) was recorded from V_2 (Bina soybean 1) (Figure 15). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of weight of 1000 seeds of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 15: Effect of varieties on 1000 seed weight of soybean ($LSD_{0.05}$ = 11.80)

Different organic nutrient management differed significantly in terms of weight of 1000 seeds of soybean. The highest weight (137.5 g) was found from T_5 (Biochar) which was statistically different from others, while the lowest weight (93.00 g) was observed from T_0 (Control) treatment (Figure 16). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer increases the weight of 1000 seeds of soybean.



Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 16: Effect of treatments on 1000 seed weight of soybean ($LSD_{0.05}$ = 11.80)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on weight of 1000 seeds of soybean. The highest weight (138.40 g) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (137.60), V_2T_2 (137.30), V_2T_5 (136.60), V_1T_2 (135.30), V_1T_6 (133.80), V_2T_3 (132.20), V_1T_3 (131.30) and V_2T_1 (125.70) followed by V_2T_4 (123.40) and V_1T_4 (117.30 g). On the other hand the lowest weight (89.60 g) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (93.30), V_2T_7 (95.80), V_2T_0 (96.40) followed by V_1T_1 (105.70 g) (Table 2).

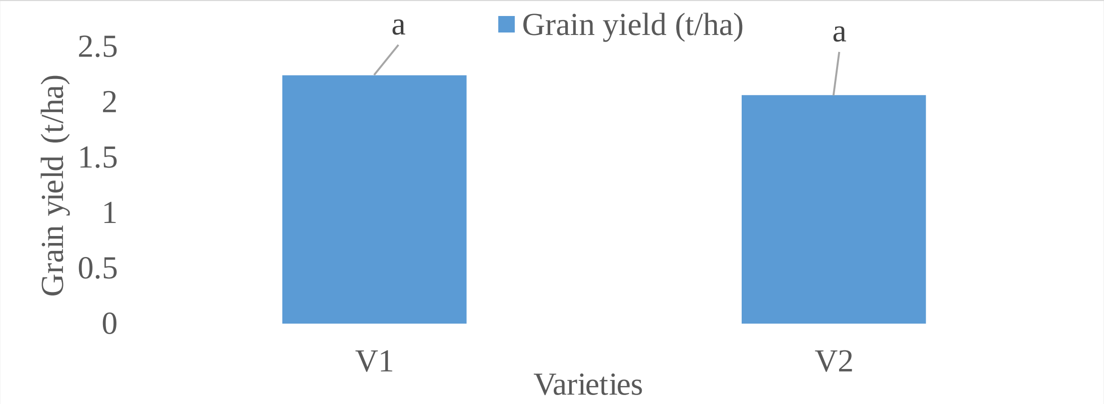
Table 2: Combined effect of varieties and different organic nutrient management on number of pod per plant, pod length, number of seeds per pod, time of pod maturity and 1000 seeds weight of soybean

Varieties	Treatments	Number of pod/plant	Pod length (cm)	Number of seeds/pod	Time of pod maturity (days)	1000 seed weight (g)
V_1	T_0	29.00 j	2.69 g	1.00 d	55.00 a	89.60 f
	T_1	41.00 gh	2.92 cdefg	1.00 d	53.00 ab	105.70 df
	T_2	52.00 e	3.18 abcd	2.00 c	51.00 ab	135.30 ab
	T_3	49.00 ef	3.11 abcde	2.00 c	52.00 ab	131.30 ab
	T_4	42.00 gh	2.96 cdefg	1.00 d	53.00 ab	117.30 cd
	T_5	67.00 a	3.31 a	4.00 a	49.00 b	138.40 a
	T_6	55.07 de	3.16 abcde	1.97 c	50.15 ab	133.80 ab
	T_7	32.00 ij	2.77 fg	1.00 d	54.00 ab	93.30 ef
V_2	T_0	37.00 hi	2.88 defg	1.00 d	53.00 ab	96.40 ef
	T_1	45.00 fg	3.07 abcde	2.00 c	52.00 ab	125.70 abc
	T_2	61.00 bc	3.24 abc	3.00 b	50.00 ab	137.30 a
	T_3	50.00 ef	3.13 abcde	2.00 c	51.00 ab	132.20 ab
	T_4	43.00 gh	3.03 abcde	2.00 c	52.00 ab	123.40 bc
	T_5	58.00 cd	3.22 abc	3.00 b	50.00 ab	136.60 ab
	T_6	65.00 ab	3.28 ab	3.00 b	50.00 ab	137.60 a
	T_7	34.00 ij	2.83 efg	1.00 d	54.00 ab	95.80 ef
$LSD_{(0.05)}$		5.63	0.29	0.34	4.52	11.80
CV (%)		7.21	5.65	10.64	5.31	5.95

[Here, V_1= BARI Soybean 4, V_2= Bina soybean 1, Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum]

4.3. Yield and harvest index

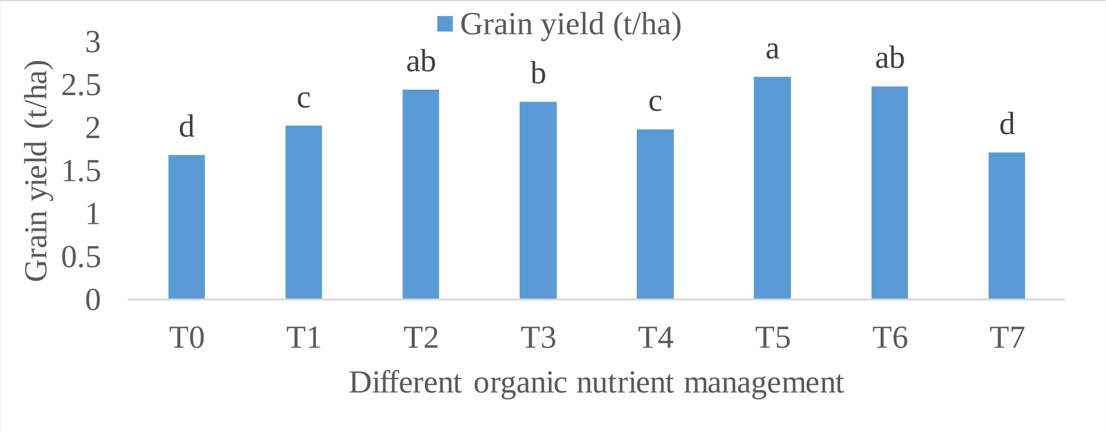
4.3.1. Seed yield: Seed (grain) yield of soybean showed statistically non-significant variation due to different varieties at harvest. The highest seed yield (2.24 t/ha) was recorded from V_1 (BARI Soybean 4), whereas the lowest seed yield (2.06 t/ha) was recorded from V_2 (Bina soybean 1) (Figure 17). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of seed yield of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 17: Effect of different varieties on grain yield of soybean ($LSD_{0.05}$ = 0.2264)

Different organic nutrient management differed significantly in terms of seed yield of soybean. The highest seed yield (2.59 t/ha) was found from T_5 (Biochar) which was statistically different from others, while the lowest seed yield (1.68 t/ha) was observed from T_0 (Control) treatment (Figure 18). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer increases the seed yield of soybean.

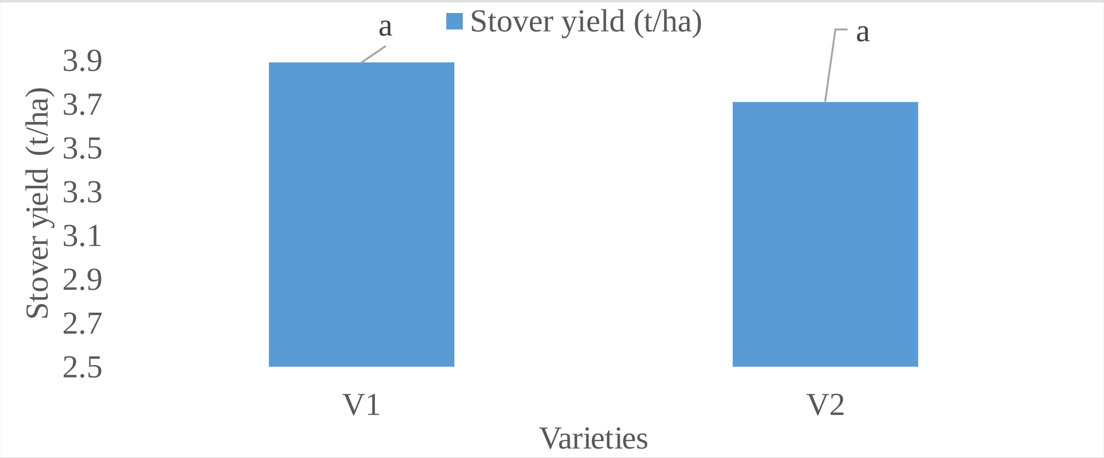


Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 18: Effect of different organic nutrient management on grain yield of soybean ($LSD_{0.05}$ = 0.2264)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on seed yield of soybean. The highest seed yield (2.67 t/ha) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (2.59), V_2T_2 (2.51) and V_2T_5 (2.51) followed by V_1T_2 (2.37), V_1T_6 (2.37), V_2T_3 (2.33), V_1T_3 (2.27) and V_2T_1 (2.16 t/ha). On the other hand the lowest seed yield (1.52 t/ha) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (1.63) followed by V_2T_7 (1.79), V_2T_0 (1.83), V_1T_1 (1.88), V_1T_4 (1.93) and V_2T_4 (2.03 t/ha) (Table 3).

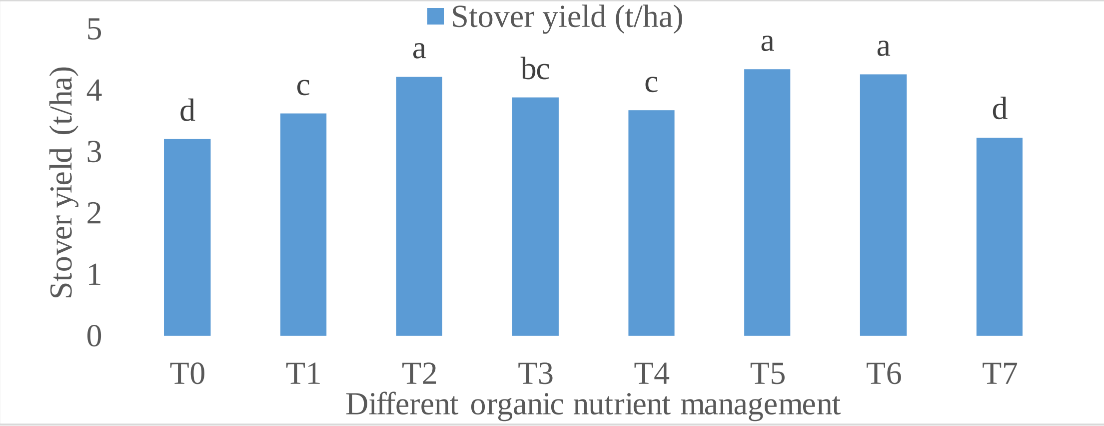
4.3.2. Stover yield: Stover yield of soybean showed statistically non-significant variation due to different varieties at harvest. The highest stover yield (3.89 t/ha) was recorded from V_1 (BARI Soybean 4), whereas the lowest stover yield (3.71 t/ha) was recorded from V_2 (Bina soybean 1) (Figure 19). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of stover yield of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 19: Effect of different varieties on stover yield of soybean ($LSD_{0.05}$ = 0.3673)

Different organic nutrients differed significantly in terms of stover yield of soybean. The highest stover yield (4.34 t/ha) was found from T_5 (Biochar) which was statistically different from others, while the lowest stover yield (3.20 t/ha) was observed from T_0 (Control) treatment (Figure 20). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer increases the stover yield of soybean.

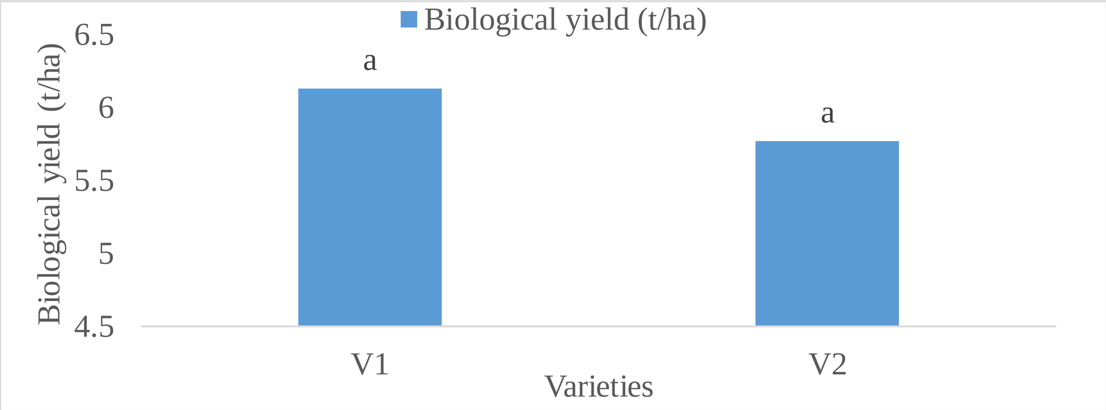


Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 20: Effect of different organic nutrient management on stover yield of soybean ($LSD_{0.05}$ = 0.3673)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on stover yield of soybean. The highest stover yield (4.41 t/ha) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (4.37), V_2T_2 (4.33), V_2T_5 (4.27), V_1T_2 (4.14) and V_1T_6 (4.11) followed by V_2T_3 (3.89), V_1T_3 (3.87) and V_2T_1 (3.78 t/ha). On the other hand the lowest stover yield (3.07 t/ha) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (3.19), V_2T_7 (3.27), V_2T_0 (3.33) and V_1T_1 (3.46) followed by V_1T_4 (3.56) and V_2T_4 (3.77 t/ha) (Table 3).

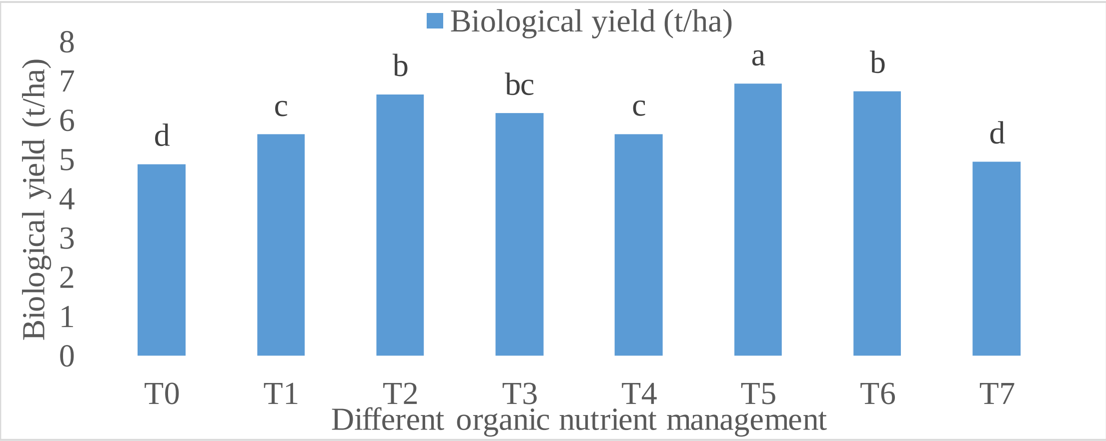
4.3.3. Biological yield: Biological yield of soybean showed statistically significant variation due to different varieties at harvest. The highest biological yield (6.13 t/ha) was recorded from V_1 (BARI Soybean 4), whereas the lowest biological yield (5.77 t/ha) was recorded from V_2 (Bina soybean 1) (Figure 21). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of biological yield of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 21: Effect of varieties on biological yield of soybean ($LSD_{0.05}$ = 0.5922)

Different organic nutrient management differed significantly in terms of biological yield of soybean. The highest biological yield (6.93 t/ha) was found from T_5 (Biochar) which was statistically different from others, while the lowest biological yield (4.88 t/ha) was observed from T_0 (Control) treatment (Figure 22). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer increases the biological yield of soybean.

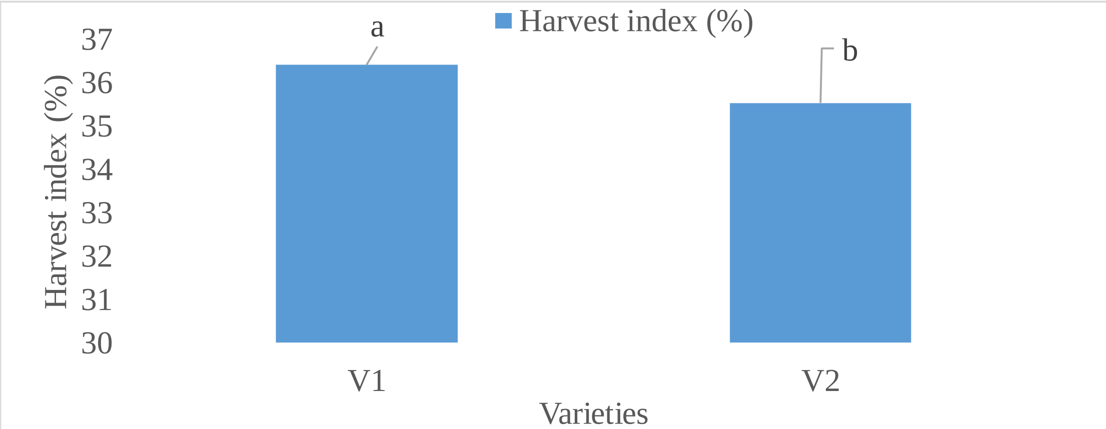


Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 22: Effect of different organic nutrient management on biological yield of soybean ($LSD_{0.05}$ = 0.5922)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on biological yield of soybean. The highest biological yield (7.07 t/ha) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (6.96), V_2T_2 (6.84), V_2T_5 (6.79), V_1T_2 (6.51) and V_1T_6 (6.48) followed by V_2T_3 (6.22), V_1T_3 (6.14) and V_2T_1 (5.94 t/ha). On the other hand the lowest biological yield (4.59 t/ha) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (4.82), V_2T_7 (5.06) and V_2T_0 (5.16) followed by V_1T_1 (5.34), V_1T_4 (5.49) and V_2T_4 (5.80 t/ha) (Table 3).

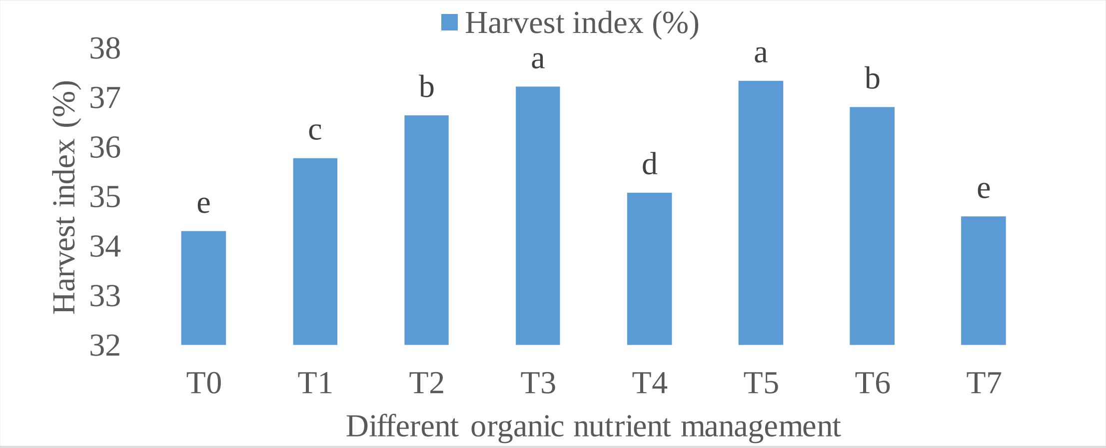
4.3.4. Harvest index (%): Harvest index of soybean showed statistically significant variation due to different varieties at harvest. The highest harvest index (36.41 %) was recorded from V_1 (BARI Soybean 4), whereas the lowest harvest index (35.53 %) was recorded from V_2 (Bina soybean 1) (Figure 23). From this figure it was revealed that, BARI Soybean 4 showed the better performance in terms of harvest index of soybean in field condition.



Here, V_1= BARI Soybean 4, V_2= Bina soybean 1

Figure 23: Effect of varieties on harvest index of soybean ($LSD_{0.05}$ = 0.3446)

Different organic nutrient management differed significantly in terms of harvest index of soybean. The highest harvest index (37.34 %) was found from T_5 (Biochar) which was statistically different from others, while the lowest harvest index (34.30 %) was observed from T_0 (Control) treatment (Figure 24). Panwar *et al.*, 2000 and Adesemoye *et al.*, 2008 also reported that organic and bio fertilizer increases the harvest index of soybean.



Here, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum

Figure 24: Effect of different organic nutrient management on harvest index of soybean ($LSD_{0.05}$ = 0.3446)

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on harvest index of soybean (Appendix XIV). The highest harvest index (37.68 %) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (37.46) followed by V_2T_2 (37.21), V_2T_5 (37.01), V_1T_2 (36.97), V_1T_6 (36.70), V_2T_3 (36.57), V_1T_3 (36.40) and V_2T_1 (36.36 %). On the other hand the lowest harvest index (33.14 %) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically different from others and followed by V_1T_7 (33.82), V_2T_7 (35.00), V_2T_0 (35.15), V_1T_1 (35.21), V_1T_4 (35.38) and V_2T_4 (35.47 %) (Table 3).

Table 3: Combined effect of varieties and different organic nutrient management on seed yield, stover yield, biological yield and harvest index of soybean

Varieties	Treatments	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
V_1	T_0	1.52 h	3.07 g	4.59 j	33.14 i
	T_1	1.88 f	3.46 efg	5.34 fghi	35.21 fg
	T_2	2.37 bcd	4.11 abc	6.48 abcd	36.57 e
	T_3	2.27 cd	3.87 bcd	6.14 cde	36.97 cd
	T_4	1.93 ef	3.56 def	5.49 fgh	35.15 fg
	T_5	2.67 a	4.41 a	7.07 a	37.68 a
	T_6	2.37 bcd	4.14 abc	6.51 abcd	36.40 e
	T_7	1.63 gh	3.19 fg	4.82 ij	33.82 h
V_2	T_0	1.83 fg	3.33 fg	5.16 ghij	35.47 f
	T_1	2.16 de	3.78 cde	5.94 def	36.36 e
	T_2	2.51 abc	4.33 a	6.84 ab	36.70 de
	T_3	2.33 cd	3.89 bcd	6.22 bcde	37.46 ab
	T_4	2.03 ef	3.77 cde	5.80 efg	35.00 g
	T_5	2.51 abc	4.27 ab	6.79 abc	37.01 cd
	T_6	2.59 ab	4.37 a	6.96 a	37.21 bc
	T_7	1.79 fg	3.27 fg	5.06 hij	35.38 f
$LSD_{(0.05)}$		0.23	0.37	0.59	0.35
CV (%)		6.37	5.90	6.05	0.59

[Here, V_1= BARI Soybean 4, V_2= Bina soybean 1, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum]

4.4. Seed quality test

4.4.1. Seed viability: According to tetrazolium test, there was no statistically significant variation due to different varieties in case of seed viability. V_1 (BARI Soybean 4) showed the best performance (71.63 %) at seed viability, whereas the lowest performance was showed (68.22 %) by V_2 (Bina soybean 1) (Table 4). From this table it was revealed that, BARI Soybean 4 showed the better performance in terms of seed viability in laboratory condition.

Different organic nutrient management differed significantly in terms of seed viability of soybean. The highest seed viability (78.50 %) was found from T_5 (Biochar) which was statistically similar with T_6 (75.38) and T_2 (74.50 %), while the lowest seed viability (63.50 %) was observed from T_0 (Control) treatment (Table 4).

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on seed viability of soybean. The highest seed viability (82.00 %) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (78.00), V_2T_2 (77.00) and V_2T_5 (75.00) followed by V_1T_2 (72.77), V_1T_6 (72.00), V_2T_3 (71.00), V_1T_3 (69.00) and V_2T_1 (68.00). On the other hand the lowest seed viability (62.00 %) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (64.00), V_2T_7 (65.00), V_2T_0 (65.00), V_1T_1 (65.00), V_1T_4 (66.00) and V_2T_4 (67.00 %) (Table 4).

4.4.2. Seed germination: According to tetrazolium test, there was no statistically significant variation due to different varieties in case of seed germination. V_1 (BARI Soybean 4) showed the best performance (83.63 %) at seed germination, whereas the lowest performance was showed (81.32 %) by V_2 (Bina soybean 1) (Table 4). From this table it was revealed that, BARI Soybean 4 showed the better performance in terms of seed germination in laboratory condition.

Different organic nutrient management differed significantly in terms of seed germination of soybean. The highest seed germination (91.50 %) was found from T_5 (Biochar) which was statistically similar with T_6 (88.77) and T_2 (88.50 %), while the lowest seed germination (75.00 %) was observed from T_0 (Control) treatment in laboratory condition (Table 4).

Interaction effect of varieties and different organic nutrient management showed statistically significant variation on seed germination of soybean. The highest seed germination (93.00 %) was recorded from V_1T_5 (BARI Soybean 4 with Biochar), which was statistically similar with V_2T_6 (91.00), V_2T_2 (90.00), V_2T_5 (90.00), V_1T_2 (87.00) and V_1T_6 (86.53) followed by V_2T_3 (83.00), V_1T_3 (82.00) and V_2T_1 (80.00 %). On the other hand the lowest seed germination (73.00 %) was recorded from V_1T_0 (BARI Soybean 4 with control), which was statistically similar with V_1T_7 (76.00), V_2T_7 (76.00), V_2T_0 (77.00), V_1T_1 (78.00), V_1T_4 (78.00) and V_2T_4 (79.00 %) (Table 4).

Table 4: Effect of varieties and different organic nutrient management on seed viability and seed germination of soybean in laboratory condition

Varieties	Treatments	Seed viability (%)	Seed germination (%)
Effect of different varieties			
V_1	-	71.63 a	83.63 a
V_2	-	68.22 a	81.32 a
Effect of different organic nutrient management			
-	T_0	63.50 c	75.00 c
-	T_1	66.50 c	79.00 c
-	T_2	74.50 ab	88.50 ab
-	T_3	70.00 bc	82.50 bc
-	T_4	66.50 c	78.50 c
-	T_5	78.50 a	91.50 a
-	T_6	75.38 ab	88.77 ab
-	T_7	64.50 c	76.00 c
Combined effect of varieties and different organic nutrient management			
V_1	T_0	62.00 f	73.00 g
	T_1	65.00 def	78.00 efg
	T_2	72.00 bcd	87.00 abcd
	T_3	69.00 cdef	82.00 cdefg
	T_4	66.00 def	78.00 efg
	T_5	82.00 a	93.00 a
	T_6	72.77 bcd	86.53 abcde
	T_7	64.00 ef	76.00 fg
V_2	T_0	65.00 def	77.00 fg
	T_1	68.00 cdef	80.00 defg
	T_2	77.00 ab	90.00 abc
	T_3	71.00 bcde	83.00 bcdef
	T_4	67.00 def	79.00 defg
	T_5	75.00 abc	90.00 abc
	T_6	78.00 ab	91.00 ab
	T_7	65.00 def	76.00 fg
$LSD_{(0.05)}$		6.75	7.73
CV (%)		5.88	5.71

[Here, V_1= BARI Soybean 4, V_2= Bina soybean 1, T_0= Control, T_1= Farmyard manure, T_2= Cowdung, T_3= Vermicompost, T_4= Trichoderma, T_5= Biochar, T_6= Recommended dose of fertilizer (50, 150, 100, 50 & 8 kg/ha of urea, TSP, MoP, gypsum and boric acid, respectively), T_7= Rhizobium inoculum]

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy field of SAU, Dhaka, under the Modhupur Tract (AEZ-28) during the period from October 2019 to February 2020 to enhancement of seed viability and yield of soybean through organic nutrient management. The experiment was laid out in RCBD with three replications. The summary and conclusion of this study have been presented below:

5.1. Summary

5.1.1. Varietal performance

The tallest plant (51.23 cm) was recorded from V_1 (BARI Soybean 4), which was statistically similar (49.09) with V_2 (Bina soybean 1).

The highest number of leaves (13.83 leaves) was recorded from V_1 (BARI Soybean 4), which was statistically similar (13.33 leaves) with V_2 (Bina soybean 1).

The lowest time for 1st flowering (30.38 days) was recorded from V_1 (BARI Soybean 4), which was statistically similar (31.94 days) with V_2 (Bina soybean 1).

The highest number of pods (50.25 pods) was recorded from V_1 (BARI Soybean 4), whereas the lowest number of pods (44.76 pods) was recorded from V_2 (Bina soybean 1).

The highest pod length (3.10 cm) was recorded from V_1 (BARI Soybean 4), whereas the lowest pod length (3.01 cm) was recorded from V_2 (Bina soybean 1).

The highest number of seeds per pod (2.25 seeds) was recorded from V_1 (BARI Soybean 4), whereas the lowest number of seeds per pod (1.62 seeds) was recorded from V_2 (Bina soybean 1).

The lowest time for pod maturity (51.38 days) was recorded from V_1 (BARI Soybean 4), which was statistically similar (52.27 days) with V_2 (Bina soybean 1).

The highest weight of 1000 seeds of soybean (123.4 g) was recorded from V_1 (BARI Soybean 4), whereas the lowest weight of 1000 seeds of soybean (117.9 g) was recorded from V_2 (Bina soybean 1).

The highest seed yield (2.24 t/ha) was recorded from V_1 (BARI Soybean 4), whereas the lowest seed yield (2.06 t/ha) was recorded from V_2 (Bina soybean 1).

The highest stover yield (3.89 t/ha) was recorded from V_1 (BARI Soybean 4), whereas the lowest stover yield (3.71 t/ha) was recorded from V_2 (Bina soybean 1).

The highest biological yield (6.13 t/ha) was recorded from V_1 (BARI Soybean 4), whereas the lowest biological yield (5.77 t/ha) was recorded from V_2 (Bina soybean 1).

The highest harvest index (36.41 %) was recorded from V_1 (BARI Soybean 4), whereas the lowest harvest index (35.53 %) was recorded from V_2 (Bina soybean 1).

V_1 (BARI Soybean 4) showed the best performance (71.63 %) at seed viability, whereas the lowest performance was showed (68.22 %) by V_2 (Bina soybean 1).

V_1 (BARI Soybean 4) showed the best performance (83.63 %) at seed germination, whereas the lowest performance was showed (81.32 %) by V_2 (Bina soybean 1).

5.1.2. Effect of different organic nutrient management

The tallest plant (54.60 cm) was found from T_5 (Biochar) which was statistically different from others, while the shortest plant (45.45 cm) was observed from T_0 (Control) treatment.

The highest number of leaves (15.11 leaves) was found from T_5 (Biochar) which was statistically different from others, while the lowest number of leaves (12.00 leaves) was observed from T_0 (Control) treatment.

The lowest time for 1st flowering (28.00 days) was found from T_5 (Biochar) which was statistically different from others, while the highest time for 1st flowering (35.00 days) was observed from T_0 (Control) treatment.

The highest number of pods (62.50 pods) was found from T_5 (Biochar) which was statistically different from others, while the lowest number of pods (33.00 pods) was observed from T_0 (Control) treatment.

The highest pod length (3.27 cm) was found from T_5 (Biochar) which was statistically different from others, while the lowest pod length (2.79 cm) was observed from T_0 (Control) treatment.

The highest number of seeds per pod (3.50 seeds) was found from T_5 (Biochar) which was statistically different from others, while the lowest number of seeds per pod (1.00 seed) was observed from T_0 (Control) treatment.

The lowest time for pod maturity (49.50 days) was found from T_5 (Biochar) which was statistically different from others, while the highest time for pod maturity (54.00 days) was observed from T_0 (Control) treatment.

The highest weight of 1000 seeds of soybean (137.5 g) was found from T_5 (Biochar) which was statistically different from others, while the lowest weight of 1000 seeds of soybean (93.00 g) was observed from T_0 (Control) treatment.

The highest seed yield (2.59 t/ha) was found from T_5 (Biochar) which was statistically different from others, while the lowest seed yield (1.68 t/ha) was observed from T_0 (Control) treatment.

The highest stover yield (4.34 t/ha) was found from T_5 (Biochar) which was statistically different from others, while the lowest stover yield (3.20 t/ha) was observed from T_0 (Control) treatment.

The highest biological yield (6.93 t/ha) was found from T_5 (Biochar) which was statistically different from others, while the lowest biological yield (4.88 t/ha) was observed from T_0 (Control) treatment.

The highest harvest index (37.34 %) was found from T_5 (Biochar) which was statistically different from others, while the lowest harvest index (34.30 %) was observed from T_0 (Control) treatment.

The highest seed viability (78.50 %) was found from T_5 (Biochar) which was statistically similar with T_6 (75.38) and T_2 (74.50 %), while the lowest seed viability (63.50 %) was observed from T_0 (Control) treatment.

The highest seed germination (91.50 %) was found from T_5 (Biochar) which was statistically similar with T_6 (88.77) and T_2 (88.50 %), while the lowest seed germination (75.00 %) was observed from T_0 (Control) treatment in laboratory condition.

5.1.3. Combined effect of varieties and different organic nutrient management

The tallest plant (56.23 cm) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest plant height (44.67 cm) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest number of leaves (15.33 leaves) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest number of leaves (11.67 leaves) was recorded from V_1T_0 (BARI Soybean 4 with control).

The lowest time for 1^{st} flowering (27.00 days) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the highest time for 1^{st} flowering (37.00 days) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest number of pods (67.00 pods) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest number of pods (29.00 pods) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest pod length (3.31 cm) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest pod length (2.69 cm) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest number of seeds per plot (4.00 seeds) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest number of seeds per pod (1.00 seed) was recorded from V_1T_0 (BARI Soybean 4 with control).

The lowest time for pod maturity (49.00 days) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the highest time for pod maturity (55.00 days) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest weight of 1000 seeds of soybean (138.40 g) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest weight of 1000 seeds of soybean (89.60 g) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest seed yield (2.67 t/ha) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest seed yield (1.52 t/ha) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest stover yield (4.41 t/ha) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest stover yield (3.07 t/ha) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest biological yield (7.07 t/ha) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest biological yield (4.59 t/ha) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest harvest index (37.68 %) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest harvest index (33.14 %) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest seed viability (82.00 %) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest seed viability (62.00 %) was recorded from V_1T_0 (BARI Soybean 4 with control).

The highest seed germination (93.00 %) was recorded from V_1T_5 (BARI Soybean 4 with Biochar). On the other hand the lowest seed germination (73.00 %) was recorded from V_1T_0 (BARI Soybean 4 with control).

5.2. Conclusion

From this above discussion it can be concluded that, organic fertilizer influenced soybean growth, yield and seed quality. Although different varieties have their own characteristics, the combination varieties and organic fertilizer showed the positive response. The combined effect of BARI Soybean 4 with Biochar showed the best performance in case of increasing soybean growth, yield and seed quality then the other combined treatments in this study.

CHAPTER VI

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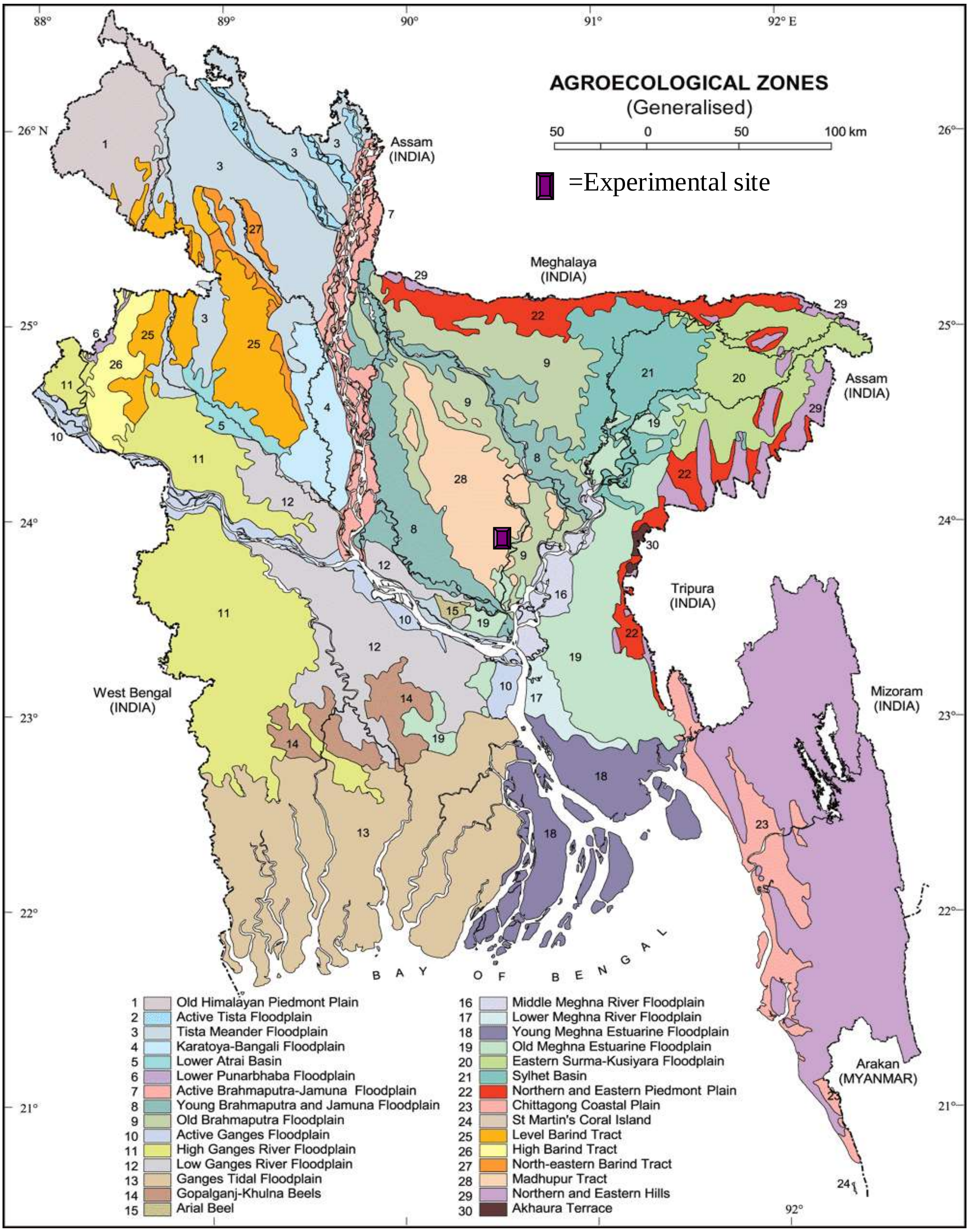
CHAPTER VII

APPENDIXES

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



Appendix II. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0-15 cm depth)

Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.54
Total nitrogen (%)	0.027
Phosphorus	6.3 µg/g soil
Sulphur	8.42 µg/g soil
Magnesium	1.17 meq/100 g soil
Boron	0.88 µg/g soil
Copper	1.64 µg/g soil
Zinc	1.54 µg/g soil
Potassium	0.10 meg/100g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka

Appendix III: Analysis of variance of the data on plant height of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	723.781
Factor A	1	54.955
Factor B	7	72.121
A×B	7	3.081
Error	30	8.302

Appendix IV: Analysis of variance of the data on number of leaves of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	52.928
Factor A	1	3.025
Factor B	7	9.41
A×B	7	0.035
Error	30	0.61

Appendix V: Analysis of variance of the data on timing of 1st flowering of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	269.382
Factor A	1	29.297
Factor B	7	40.815
A×B	7	2.083
Error	30	2.711

Appendix VI: Analysis of variance of the data on number of pod plant^{-1} of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	670.203
Factor A	1	361.901
Factor B	7	799.572
A×B	7	22.587
Error	30	11.729

Appendix VII: Analysis of variance of the data on pod length of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	2.673
Factor A	1	0.109
Factor B	7	0.209
A×B	7	0.005
Error	30	0.03

Appendix VIII: Analysis of variance of the data on seeds pod^{-1} of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	1.21
Factor A	1	4.75
Factor B	7	4.457
A×B	7	0.407
Error	30	0.042

Appendix IX: Analysis of variance of the data on pod maturity of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	753.88
Factor A	1	9.585
Factor B	7	17.744
A×B	7	0.564
Error	30	7.586

Appendix X: Analysis of variance of the data on 1000 seed weight of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	4187.459
Factor A	1	360.748
Factor B	7	2013.733
A×B	7	58.162
Error	30	51.578

Appendix XI: Analysis of variance of the data on seed yield of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	1.381
Factor A	1	0.38
Factor B	7	0.749
A×B	7	0.011
Error	30	0.019

Appendix XII: Analysis of variance of the data on stover yield of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	4.167
Factor A	1	0.411
Factor B	7	1.215
A×B	7	0.015
Error	30	0.05

Appendix XIII: Analysis of variance of the data on biological yield of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	10.328
Factor A	1	1.573
Factor B	7	3.856
A×B	7	0.045
Error	30	0.13

Appendix XIV: Analysis of variance of the data on harvest index of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	0.017
Factor A	1	9.161
Factor B	7	8.628
A×B	7	0.959
Error	30	0.044

Appendix XV: Analysis of variance of the data on seed viability of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	1412.891
Factor A	1	139.06
Factor B	7	187.228
A×B	7	7.003
Error	30	16.889

Appendix XVI: Analysis of variance of the data on seed germination of soybean as influenced by varieties and different organic nutrient management

Source of variance	Degrees of freedom	Mean square
Replication	2	1949.323
Factor A	1	63.941
Factor B	7	242.584
A×B	7	3.712
Error	30	22.155