INFLUENCE OF ORGANIC MANURE AND PHOSPHOROUS LEVEL ON THE PERFORMANCE OF SOYBEAN

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CERTIFICATE

*This is to certify that the thesis entitled "**INFLUENCE OF ORGANIC MANURE AND PHOSPHOROUS LEVEL ON THE PERFORMANCE OF SOYBEAN**" submitted to the Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka in partial fulfillment of the requirements for the degree of Master of Science (M.S.) in Agronomy, embodies the result of a piece of bona fide research work carried out by **Afroja khatun, Registration No. 18-09130** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:
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DEDICATED TO

MY

BELOVED PARENTS

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ABSTRACT

A field experiment was accomplished in the central farm of Sher-e-Bangla Agricultural University, Dhaka during the period from February, 2019 to May, 2019 to observe the influence of organic manure and phosphorous level on the performance of soybean. The experiment comprised of three levels of organic manure viz., i) O_0 = control, O_1 = cowdung, O_2 = poultry litter, and five levels of P viz., P_0 = control, P_1 = 25% less than recommended P, P_2 = recommended P, P_3 =25% higher than recommended P and P_4 = 50% higher than recommended P were used in this experiment arranged in Split plot Design (SPD) with three replications. Data on different growth and yield attributes parameters were taken in which all the treatment showed significant variations. The result revealed that organic manure treatment O_2 (poultry litter) showed the highest grain yield (2.22 t ha^{-1}) than the other organic manure treatment which may be attributed to the maximum plant height (69.93 cm), number of leaves $plant^{-1}$ at all growth stages, number of branches $plant^{-1}$, dry weight $plant^{-1}$, pod length (3.72 cm) seeds pod^{-1} (3.22), 100 seed weight (10.99 g), stover yield (3.47 t ha^{-1}), biological yield (5.70 t ha^{-1}) and harvest index (38.16 %) in this treatment. Considering P level, although P_4 (50% higher than recommended P) gave the highest yield and yield attribute parameter but P_3 (25% higher than recommended P) dose also showed statistically similar and higher yield as well as higher plant characters, pod length (3.94 cm), seeds $plant^{-1}$ (3.02), 100 seed weight (10.52 g), stover yield (2.33 tha^{-1}) and harvest index (38.71 %). On the other hand, interaction of O_2P_4 performed best by producing maximum yield than other parameters but O_2P_3 (poultry litter with 25% higher than recommended P) treatment showed statistically similar performance with O_2P_4 which may perhaps the maximum pod length (4.05 cm), seeds pod^{-1} (3.43), 100 seed weight (11.30 g), stover yield (3.92 t ha^{-1}) and biological yield (6.57 t ha^{-1}) in this interaction treatments. Considering the sustainable yield and sound environment, poultry litter + 25% higher than recommended doses of P (O_2P_3) seem promising for soybean cultivation.

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ABBREVIATIONS AND ACORONYMS

AEZ	Agro-ecological Zone
SAIC	SAARC Agricultural Information Center
DAFF	Department of Agriculture, Forestry and Fisheries
Agric.	Agricultural
NSB	National Seed Board
ANOVA	Analysis of Variance
DF	Degree of freedom
BARI	Bangladesh Agricultural Research Institute
Biol.	Biology
CV	Coefficient of variance
DAS	Days After Sowing
et al.	And others
Ex.	Experiment
FAO	Food and Agriculture Organization of the United Nations
g	Gram
Hort.	Horticulture
i.e.	That is
J.	Journal
Kg	Kilogram
LSD	Least Significance difference
mm	Millimeter
SPD	Spilt Plot Design
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
spp.	Species
Technol.	Technology
UNDP	United Nations Development Programme
Viz.	Namely
%	Percent
LAI	Leaf Area Index
RGR	Relative Growth Rate
NAR	Net Assimilation Rate
MSTAT	Michigan State University Statistical Package for Data Analysis
etc.	Etcetera
B	Boron
Atm	Atmospheric
BBS	Bangladesh Bureau of Statistics
No.	Number
m	Meter

m^2	Meter squares
NS	Non significant
SRDI	Soil Resources and Development Institute
t ha^{-1}	Ton per hectare
^0C	Degree Centigrade
hr	Hour(s)
MP	Muriate of Potash
P	Phosphorus
HI	Harvest Index
t ha^{-1}	Tons per hectare

CHAPTER I
INTRODUCTION

Soybean (*Glycine max* L.), the most important oil seed crop in the world, belongs to the family Fabaceae, under sub family Faboideae provides vegetable protein for millions of people and ingredients for hundreds of chemical products, widely grown for its edible bean which has numerous uses. It has been classified more as an oil seed crop than as a pulse (Devi *et al.,* 2012). It is also known as an important grain legume of the world and a new prospective crop for Bangladesh (Rahman *et al.,* 2011).

Soybean contains 40-45% protein and 19-22% oil (FAO, 2013). Worldwide the total annual production of soybean is 271.53 million tons from an area of 112.89 million hectares (FAO, 2019). The main production of soybeans was the United States (35%), Brazil (27%), Argentina (19%), China (6%) and India (4%). In Bangladesh soybean is cultivated mainly as pulse crops. In Bangladesh, the cultivated area under soybean cultivation is 60893 hectares which produces 112024 tons of oil per year (BBS, 2020).

Bangladesh has to import 1.9 million tonnes of soybean cooking oil in each year at the cost of more than 1.6 billion USD and soybean meal with about 26.63 million USD per year (Quaiyum *et al.,* 2015). Recently the soybean production area is increasing and in the year 2018 it reached to above 62500 ha (Chowdhury *et al.,* 2014). The world average yield of soybean is about 3 t ha^{-1} while it is only 1.3 t ha^{-1} in Bangladesh (SAIC, 2018). This is mainly due to use of low yield potential varieties and poor agronomic management practices. However, there is a scope for improvement of this yield through judicious application of chemical fertilizers. It is reported that Bangladesh could meet 41 percent of its soybean oil demand by producing soybean locally (Anon, 2019).

If farmer uses modern technologies as well as appropriate fertilizer management in soybean cultivation the yield of the crop will be increased which can meet up our local demand and able to save foreign currency for importation as like other countries.

Use of organic manure in combination of chemical fertilizer will help to improve physio-chemical properties of soils providing a good substrate for the growth of microorganisms maintaining a favorable nutritional balance. Judicious use of fertilizers provided to be responsible for higher yield and with reduced fertilizer pollution (Bobde *et al.,* 1998). 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).

Plants require phosphorus for growth throughout their life cycle, especially during the early stages of growth and development. In soybeans, the demand for P is the greatest during pod and seed development where more than 60% of P ends up in the pods and seeds (Usherwood, 1998). Its uptake and utilization by soybean is essential for ensuring proper nodule formation and improving yield and quality of the crop (Anon, 2004). Very high soil phosphate depressed seed protein and oil content, while yield would be low if available phosphorus was less than 30 kg P ha^{-1} (DAFF, 2010). The most important phosphorus sources in arable soils are chemical fertilizers, though 75 to 90 percent of the phosphorus is fixed with iron, calcium and aluminums in soil (Turan *et al.,* 2006). Therefore, the use of phosphate solubilizing bacteria is essential to solve the problem. It has been proven that P increases weight and number of root nodules and also can enhance the pod yield (Jones *et al.,* 1977). Different reports revealed that the increase in soybean yield could not be expected when soil P concentration prevailed above 20 mg kg^{-1} (Webb *et al.,* 1992; Borges and Mallarino, 2003).

Phosphorous has beneficial effects on both nodulation and nitrogen fixation capacity in soybean. Phosphorous deficiency is reported to reduce nodule formation growth while an adequate supply leads to good development of nodules (Wall *et al.*, 2000). Researchers have been conducted several researches on application of chemical fertilizers on the performance of soybean in our country. Despite voluminous works done at home and abroad, more research is needed to specify the amount of influence of organic manure and P level for exploiting the maximum productivity of soybean, which is rather a new but promising crop in Bangladesh. The purpose of the present study was to determine the optimum level of influence of organic manure and P fertilizer as well as their combination for the maximum growth and yield performance of soybean. Very few research findings are available in our country on influence of organic manure and P level on the performance of soybean. So, there is a wide scope to taken research on. Therefore, the present study has been conducted with the following objectives:

Objectives of the Research work:

1. To find out the effect of organic manure on the growth and yield of Soybean,
2. To observe the performance of P level on growth and yield of Soybean, and
3. To find out the interaction effect of organic manure and P level on growth and yield of Soybean.

CHAPTER II
REVIEW OF LITERATURE

Soybean is a well recognized oil and protein containing crop which has given conventionally less attention by the researchers on various aspects of production technology. Because normally this crop can grow with minimum care or minimum agronomic and management practices. That is why a very few researches have been carried out in our country. However, researches in home and abroad trying to maximize the yield of soybean with different management practices especially on different fertilizer, spacing, variety, weeding, biofertilizers etc, but very few researches were conducted on organic manure and phosphorous. Organic manure and phosphorous play an important role in improving soybean growth and yield. But research works related to organic manure and phosphorous are limited in Bangladesh. However, some of the important and informative works and research findings related to the organic manure and phosphorous so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1 Effect of organic manure on plant growth, yield attributes and yield parameter of Soybean

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 result showed that, the mean tallest

plant (63.21 cm) was observed from T_7 treatment while the shortest one (45.80 cm) from control treatment (T_1). The maximum branches plant^{-1} (8.70), dry matter accumulation plant^{-1} (36.71 g), pods plant^{-1} (58.53) and seeds plant^{-1} (163.20), 100 grain weight (14.20 g), grain yield (24.72 q ha^{-1}), stover yield (31.24 q ha^{-1}), biological yield (55.96 q ha^{-1}) while maximum harvest index (45.60%) was observed from T_6 treatment while the minimum value of above parameters was found with T_1 treatment.

Khaim *et al*. (2013) a field experiment was conducted 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 (RDCF100%), 50% RDCF (RDCF50%), cowdung 10 t ha^{-1} (CD10 t ha^{-1}), 50% RDCF + CD 5 t ha^{-1} (RDCF50% + CD5 t ha^{-1}), 75% RDCF + CD 3t ha^{-1} (RDCF75% + CD 3 t ha^{-1}), poultry manure 3 t ha^{-1} (PM3 t ha^{-1}), 50% RDCF + PM 1.5 t ha^{-1} (RDCF50% + PM 1.5 t ha^{-1}) and 75% RDCF + PM 1 t ha^{-1} (RDCF75% + PM1 t ha^{-1}) were tested. The result revealed that at harvest, the tallest plant (47.77 cm) was recorded from RDCF100%, branches plant^{-1} (4.67), application of RDCF100% produced the highest number of grains plant^{-1} (52.25), the highest value of the 100-grain weight was found in RDCF100% (12.64 g) which was identical with RDCF75% +PM1 t ha^{-1} (12.62 g) and the lowest weight was observed in control (10.20 g) treatment, the highest grain yield (2699 kg ha^{-1}) was obtained in RDCF, which was statistically identical to RDCF75% + PM1 t ha^{-1} and the lowest grain yield (1570.27 kg ha^{-1}) was recorded from control treatment, the highest stover yield (4660 kg ha^{-1}) was obtained in the treatment RDCF75% +PM1 t ha^{-1} which was statistically identical to RDCF100% but dissimilar to other treatments. The lowest stover yield (3010 kg ha^{-1}) was recorded in the control treatment, the highest biological yield was recorded from RDCF100%

(7373 kg ha^{-1}) treatment and the lowest from control (4581 kg ha^{-1}) treatment, the highest harvest index was observed in RDCF100% (37.09%) treatment and the lowest value (34.24%) was observed in control treatment. The treatments CD10 t ha^{-1}, RDCF75% +CD 3 t ha^{-1}, PM3 t ha^{-1}, RDCF50%+PM 1.5 t ha^{-1} and RDCF75% + PM1 t ha^{-1} showed the statistically identical harvest index.

Myint *et al.* (2009) The field experiment was carried out 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. 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. 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 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. 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.

2.2 Effect of phosphorus fertilizer on plant growth, yield attributes and yield parameters of Soybean

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), 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. 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}, 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}, the highest dry weight of plant (20.81g) 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}, 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}, 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), 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}, 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 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.

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, 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, 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.

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).

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.

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 V_3: 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 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. 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. 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.

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 maxL. 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, 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, 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, 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, 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, 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.

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).

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 fertilizers.

2.3 Effect of organic manure and phosphorus fertilizer on plant growth, yield and yield parameters of Soybean

A field experiment was conducted by Akter (2016) 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).

Nine treatments *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, T7= Vermicompost + 75% FRD, T8= Poultry litter + 50% FRD and T_9= Poultry litter + 75% FRD were tested. The result revealed that at 75 DAS, the tallest plant (55.53 cm) was recorded from Vermicompost + 75% FRD, which was statistically different from other treatments but identical with Fertilizer at Recommended Dose (FRD). The shortest plant (45.80 cm) was found in control, which was statistically identical with fertilizer at Recommended Dose (FRD). The minimum number of branches plant^{-1} (1.37) was found in control, which was statistically identical with Poultry litter + 50% FRD. The highest dry weight (g) plant^{-1} (9.21 g) was recorded from Fertilizer at Recommended Dose (FRD), which was statistically different from other treatments but identical with Poultry litter + 75% FRD. The lowest dry weight (g) plant^{-1} (5.33 g) was found in control, which was statistically identical with Biofertilizer + 50% FRD, the maximum number of pods plant^{-1} (26.47) was recorded from Poultry litter + 75% FRD, which was statistically different from other treatments but identical with Fertilizer at Recommended Dose (FRD). The lowest number of pods plant^{-1} (19.00) was found in control, which was statistically similar with rest of the treatments except T_1, T_7 and T_8, the maximum number of grain pod^{-1} (2.67) was recorded from Poultry litter + 75% FRD, 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), the maximum 100 grains weight(11.74 g) was recorded from Fertilizer at Recommended Dose (FRD), which was statistically similar with rest of the treatments T_9, T_8, T_7, T_6, T_5, T_3 and T_2, again the lightest weight was recorded from T_0 (9.98 g) which was statistically similar with rest of the treatment except T_4, T_8, T_7 and T_9, the highest yield was recorded from T9 (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 maximum stover yield was observed in T_1 (2464 kg ha^{-1}), which was statistically at par with T9 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}). 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 highest harvest index was recorded from T_5 (47.78) and the lowest harvest index was recorded from T_0 (43.33%).

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), the effect of fertilizer application was not significant on the number of branches. 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). 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.

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 P2O5 ha^{-1}). Each farmer represented one replication. Results indicated that, in AEZ3, 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}), in AEZ 3, for the variable shoot dry weight, the highest value was found with FA3 strain + 50 kg of P_20_5 ha^{-1} (22.2 g per plant). In AEZ 5, the highest shoot dry weight was 23 g $plant^{-1}$ (STM3045 + 50 kg of P205 ha^{-1}). The lowest value was found with control without P (6 g $plant^{-1}$), the highest mean values grain yield (2739 kg ha^{-1}) was found in FA_3+ 50 kg of P_20_5 ha^{-1} treatment compare to the control (770 kg ha^{-1}) in AEZ 3, the highest mean values straw yield (5274 kg ha^{-1}) was found in FA_3+ 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. 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 (24.13 cm) was recorded in control treatment, 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, 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. 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, 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}) 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, 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, 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}. At 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 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.

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 V_3: 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 D3: 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, 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.

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, 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. 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 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 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 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. 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 M3: 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 tha^{-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 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 F1 and the minimum number of seeds pod^{-1} (1.90) was recorded from F_0. 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.

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), 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, 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}), 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}), 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_2O5-K_2O kg ha^{-1}).

CHAPTER III
MATERIALS AND METHODS

In this chapter the details of different materials used and methodology followed for this experiment are described.

3.1 Experimental site

The research work was carried out at the experiment field of Agronomy farm of She-e–Bangla Agricultural University, Dhaka during the period from February 2019 to May 2019. The experimental field belongs to the agro-ecological zone of the Madhupur Soil Tract (AEZ-28). For better understanding about the experimental site, it has been shown in the map of AEZ of Bangladesh in Appendix-I.

3.2 Climate

The climate of the study area was characterized by moderate temperature high humidity and moderate rainfall. The weather data during the growing period of experimentation has been shown in Appendix-II.

3.3 Soil

The land belongs to general soil type Shallow Red Brown Terrace Soil under Tejgaon soil series. The samples from 0 –15 cm depths were collected from the experimental field. The physical and chemical properties of the soil have been presented in Appendix-III.

3.4 Description of the cultivar

The variety of soybean used in this experiment was BARI Soybean-5. The seed of this variety was collected from Bangladesh Agricultural Research Institute (BARI),

Joydbpur, Gazipur. This released variety has excellent seed quality and superior to existing other ones. BARI Soybean-5 was developed BARI and released by National Seed Board (NSB) during 2002. Its field duration was about 95-115 days. Plant height was about 40-60 cm. Flower colour was pinkish. Seed colour was cream. Seed size was medium. Seed yield was 1.6-2.0 t ha^{-1} (BARI, 2002).

3.5 Experimental details

3.5.1 Treatments

Two sets of treatment factors, included in the experiment, were as follows:

Factor A: Organic manure- 3 plot (Main plot)

i. O_0 = Control (without organic manure)
ii. O_1 = Cowdung at the dose of 10 t ha^{-1}
iii. O_2 = Poultry Litter at the dose of 5 t ha^{-1}

Factor B: P Level-5 (Sub plot)

i. P_o = Control (without P)
ii. P_1 = 25% less then recommended dose of P
iii. P_2 = Recommended dose of P
iv. P_3 = 25% higher than recommended dose of P
v. P_4 = 50% higher than recommended dose of P

N.B. The rate of organic manure and p fertilizer has been presented in section 3.7.2. All chemical fertilizers were applied at their recommended dozes except p.

3.6 Design and Layout of the Experiment

The experiment was laid out following two factor split plot design with 3 replications. The field was divided into 3 blocks to represents 3 replications. Each block was divided into 3 main plots to accommodate the organic manure treatments and each main plot into 5 sub plots to accommodate the fertilizer treatments. There were 45 plots in the experiment and the size of each unit plot was 3.0 m × 2.0 m. The distance between unit plots, blocks and replication were 0.50 m, 0.75 m and 1.0

m, respectively.

3.7 Experimental procedure

3.7.1 Land preparation

The land was first opened on 5, February 2019 with a power tiller. Final land preparation was done by country plough on February 14, 2019. The land was thoroughly prepared by four ploughings and stubble were removed from the field. Final layout was done on February 15, 2019 followed by the design adopted.

3.7.2 Fertilizer application

Urea, Triple Super Phosphate (TSP), Muriate of potash (MoP), gypsum, boron and biochemical were used as a source of nitrogen, phosphorous, potassium, sulphur and boron, respectively. The fertilizers urea, TSP, muriate of potash, gypsum and boric acid were applied at the rate of 60, 225, 120, 100 and 10 kg ha^{-1}, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation (BARI, 2011). All of the fertilizers were applied in broadcast during final land preparation as per treatment. The rate of cowdung and poultry litter were 10 and 5 t ha^{-1}, respectively. Organic fertilizers were applied 7 days prior of final land preparation.

3.7.3 Sowing of seeds

Seeds of the variety BARI soybean-5 was sown on February 16, 2019 in lines maintaining a line to line distance of 30 cm and plant to plant distance of 6 cm in the well prepared plot.

3.8 Intercultural operation

The following Intercultural operations were done to ensure the normal growth of the plant.

3.8.1 Gap filling

Gap filling was done on 26 February, 2019 which was 10 days after sowing.

3.8.2 Thinning

Thinning was done as per required plant density within 15 DAS.

3.8.3 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.

3.8.4 Irrigation

Irrigation was done at 30 DAS after sowing (pre-flowering) stage and then at 60 DAS (pod formation stages) as per recommendation (BARI, 2005).

3.8.5 Mulching

After each irrigation the soils of the irrigation treated plots were loosen in between two rows by nirani.

3.8.6 Plant protections

The soybean plants were infested by hairy caterpillars (*Dlaerisia oblique*) and cutworm at early growth stage which were controlled by applying Sumithion 50 EC @ 1.01 ha^{-1}. On the other hand, picking of infested leaves with caterpillar larvae was also done as a control measure.

3.8.7 General observation

The field was frequently observed to notice any change in plant characters from sowing till harvest.

3.8.8 Sampling and harvesting

Five plants in each plot were tagged from which growth data were collected. Maturity of crop was determined when 95 % of the pods become brown in colour. Ten 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 for recording yield data. Harvesting was done on May 25, 2019. 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.

3.8.9 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 rubbing.

3.8.10 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.

3.8.11 Cleaning and weighing

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

3.9 Collection of data

The following data were collected –

a. Growth characteristics data

1. Plant height (cm) (taken at 30, 45, 60, 75 DAS and at harvest)
2. Number of leaves $plant^{-1}$ (taken at 45, 60 and 75 DAS)
3. Number of branches $plant^{-1}$ (taken at 45, 60 and 75 DAS)
4. Dry weight $plant^{-1}$ (g) (taken at 30, 45, 60, 75 DAS and at harvest)

b. Yield attributes data

5. Pod length (cm)
6. Number of pods plant^{-1}
7. Number of seeds pod^{-1}
8. Weight of 100-seeds (g)

c. Yield data

9. Grain yield (t ha^{-1})
10. Stover yield (t ha^{-1})
11. Seed yield (t ha^{-1})
12. Biological yield (t ha^{-1})
13. Harvest index (%)

3.10 Procedures of recording data

3.10.1 Plant height (cm)

The height of pre-selected 5 sample plants were measured from the ground level to the tip of the shoot. Then the data was averaged and expressed in cm. Plant height data were recorded at 30, 45, 60, 75 DAS and at harvest time.

3.10.2 Number of leaves plant^{-1}

The total number of leaves plant was counted from 5 pre-selected plants each plot. Data were recorded as the average of 5 plants at 30, 45, 60 and 75 DAS.

3.10.3 Number of branches plant^{-1}

Total number of primary branches of 5 pre-selected plants of each plot were counted and averaged than to have number of branches plant^{-1} was done at 45, 60, 75 DAS and at harvest time.

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

Five plants were collected randomly from each plot from the inner rows and dried separately for 72 hours in an electric oven set at 70°C. The dry weight of the samples

was taken using a sensitive digital electric balance. The mean weight was calculated to have individual plant weight and expressed in g. Dry weight data were collected 5 times at 30, 45, 60 and 75 DAS and at harvest.

3.10.5 Pod lengths (cm)

The length of 10 pods taken from sample plants were measured and mean length was expressed in cm.

3.10.6 Number of pods plant^{-1}

All the pods of the ten sample plants in each plot were counted and averaged them to have pods plant^{-1}.

3.10.7 Number of seeds pod $^{-1}$

Number of total seeds of ten sample plants from each plot was noted and the mean number was expressed per pod basis.

3.10.8 Weight of 100-seed

One hundred sun dried seeds were counted at random from the seed stock of sample plants. Weight of 100 seeds were then recorded by means of a digital electrical balance and expressed in g.

3.10.9 Grain yield

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

3.10.10 Stover yield

The stover collected from one-meter square meter of each plot was sun dried

properly. The weight of stover was taken and converted the yield in t ha^{-1}.

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

Biological yield was calculated by using the following formula:

Biological yield = Seed yield + Stover yield

3.10.12 Harvest index (%)

Harvest index was calculated as the ratio of economic yield to biological yield and expressed as percentage. It was calculated by using following formula.

$$\text{Harvest index (\%)} = \frac{\text{Seed yield (t ha}^{-1})}{\text{Biological yield (t ha}^{-1})} \times 100$$

Where, Biological yield (t ha^{-1}) = Seed yield (t ha^{-1}) + Stover yield (t ha^{-1}).

3.11 Statistical Analysis

The recorded data on various parameters were statistically analyzed by using MSTAT-C statistical package programme. The mean for all the treatments was calculated and analysis of variance for all the characters was performed by F-test. Difference between treatment means were determined by Least Significance Difference (LSD) at 5% level of significance.

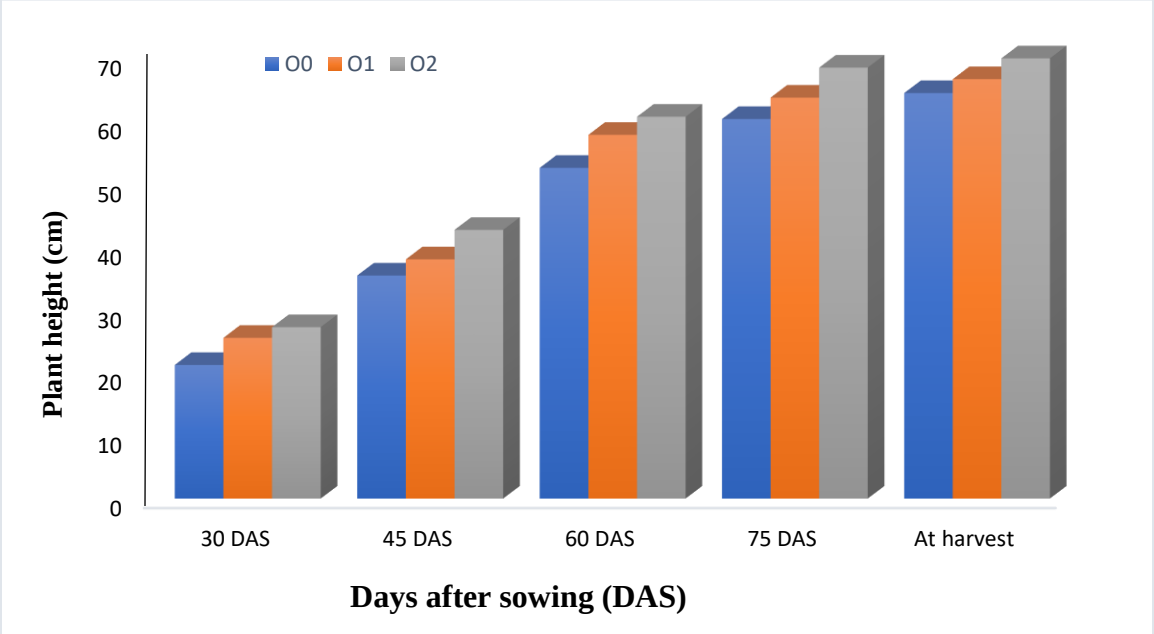
CHAPTER IV
RESULTS AND DISCUSSION

The experiment was conducted at the farm condition of Sher-e-Bangla Agricultural University, Dhaka to find out influence of organic manure and P level on the performance of soybean. Data on different growth parameter, yield attributes and yield percentage were recorded. The analyses of variance (ANOVA) of the data on different recorded parameters are presented in Appendix IV-IX. The findings of the experiment have been presented and discusses with the help of Tables and Graphs and possible interpretations were given under the following headings:

4.1 Plant height

Plant height of BARI soybean-5 showed statistically significant variation due to different levels of organic manure at 30, 45, 60, 75 days after sowing (DAS) and at harvest (Figure 1 and Appendix IV). The figure showed a gradual increase in trend of plant height with the advances of growth stages and the highest increase was found with at harvest time irrespective organic manure application. However, the rate of increase was much higher in the early stage of growth upto 60 DAS after that the rate was slower. At 30, 45, 60, 75 DAS and at harvest, the tallest plant (27.23, 42.68, 6 0 .66, 68.46 and 69.93 cm, respectively) was recorded from O_2 (poultry litter), which were statistically similar (25.53, 38.01, 57.78, 63.70 and 66.63 cm, respectively) with O_1 (cowdung), whereas the shortest plant (21.22, 35.43, 52.54, 60.30 and 64.41 cm, respectively) was found from O_0 (control) treatment. 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. It was revealed that as a necessary element of organic manure for the growth and development of soybean and with the increase of organic manure, plant height increased upto a certain level then decreases. organic manure

application can rapidly help plants to recover from stress due to drought, high heat, pests and diseases.

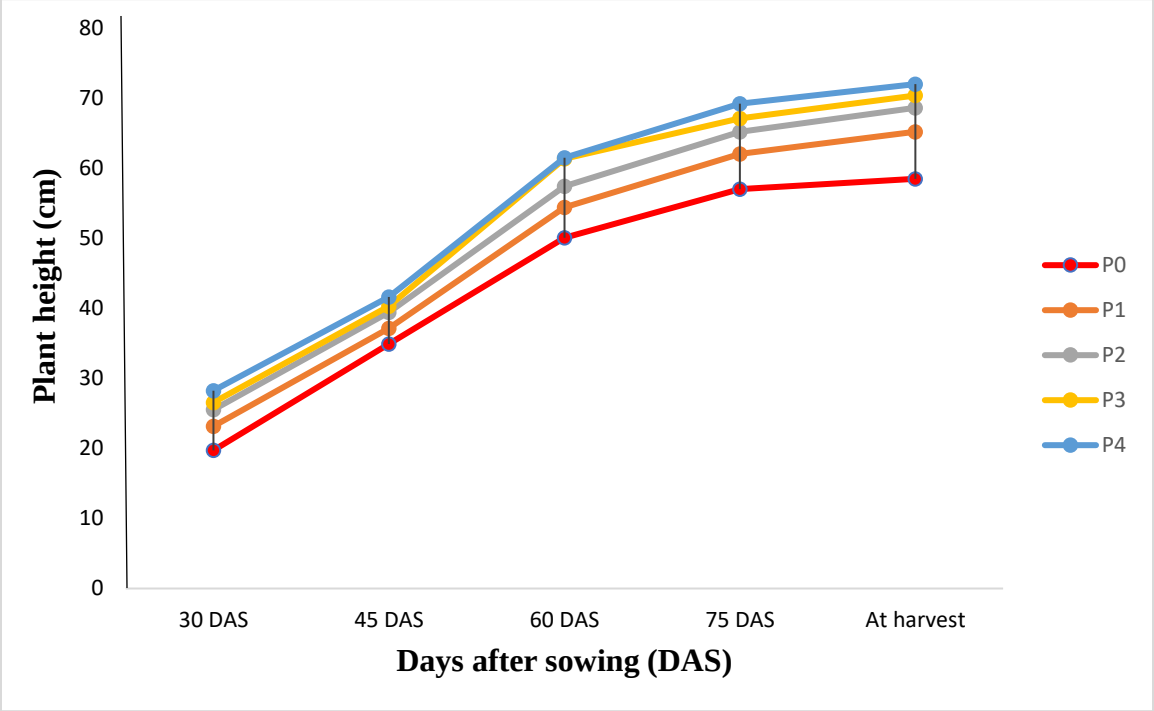


Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Figure 1. Effect of organic manure on plant height of soybean at different days after sowing (LSD $_{(0.05\%)}$ = 1.46, 0.63, 2.13, 1.18 and 0.99 at 30. 45, 60, 75 DAS and at harvest, respectively)

Plant height differed significantly due to different levels of phosphorous in BARI soybean-5 at 30, 45, 60, 75 DAS and at harvest (Figure 2 and Appendix V). The figure revealed that plant height showed a steady increase in trend irrespective of P level treatments and the tallest plant was found with last sampling date (at harvest). The phosphorous treatment P_4 showed its superiority in producing plant height for all sampling dates and that of lowest was at P_0 treatment. At 30, 45, 60, 75 DAS and at harvest, the tallest plant (28.27, 41.63, 61.54, 69.24 and 72.06 cm, respectively) was found from P_4 (50% higher than recommended dose of P) which were statistically similar (26.58, 40.32, 61.40, 67.14 and 70.43 cm, respectively) with P_3 (25% higher than recommended dose of P), while the shortest plant (19.74, 34.93, 50.12, 57.06 and 58.53 cm, respectively) was observed from P_0 (control) treatment. This observation confirms the findings of Falodun *et al.* (2015), Khaim

et al. (2013) and Espinoza (2001). 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 which helps to increase in plant height.



Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

Figure 2. Effect of phosphorous on plant height of soybean at different days after sowing (LSD (0.05%) = 0.91, 0.80, 1.37, 0.68 and 0.86 at 30. 45, 60, 75 DAS and at harvest, respectively)

Interaction effect of different levels of organic manure and phosphorous showed statistically significant variation on plant height of BARI soybean-5 at 30, 45, 60, 75 DAS and at harvest (Table 1 and Appendix IV). At 30, 45, 60, 75 DAS and at harvest, the tallest plant (30.53, 45.22, 64.99, 72.90 and 74.56 cm, respectively) was recorded from O_2P_4 (poultry litter and 50% higher than recommended dose of P) which were statistically similar (29.07, 44.17, 63.46, 71.14 and 73.41 cm, respectively) with O_2P_3 (poultry litter and 25% higher than recommended dose of

P), and the shortest plant (14.56, 31.28, 45.57, 53.10 and 57.31 cm, respectively) was observed from O_0P_0 (control) treatment combination.

Table 1. Interaction effect of organic manure and phosphorous fertilizer application on plant height of soyabean at different days after sowing (DAS)

Interaction	Plant height (cm) at				
	30 DAS	**45 DAS**	**60 DAS**	**75 DAS**	**At harvest**
O_0P_0	14.56 i	31.28 i	45.57 g	53.10 j	57.31 h
O_0P_1	20.71 h	33.46 h	50.21 f	58.53 h	61.72 f
O_0P_2	21.92 f-h	36.26 fg	53.83 e	61.78 g	65.53 e
O_0P_3	23.43 e-g	37.28 ef	55.78 de	63.78 ef	68.10 d
O_0P_4	25.52 d	38.87 d	57.35 cd	64.31 e	69.39 cd
O_1P_0	21.54 gh	34.88 g	50.06 f	55.72 i	58.27 h
O_1P_1	23.47 ef	36.56 f	54.23 e	61.48 g	64.84 e
O_1P_2	26.62 cd	38.26 de	57.37 cd	64.30 e	68.03 d
O_1P_3	27.26 b-d	39.52 cd	64.97 a	66.50 d	69.78 c
O_1P_4	28.77 ab	40.82 bc	62.30 ab	70.52 bc	72.25 b
O_2P_0	23.13 fg	38.65 de	54.75 de	62.37 fg	60.02 g
O_2P_1	25.37 de	41.51 b	58.87 c	66.28 d	69.20 cd
O_2P_2	28.08 bc	43.86 a	61.26 b	69.64 c	72.46 b
O_2P_3	29.07 ab	44.17 a	63.46 ab	71.14 b	73.41 ab
O_2P_4	30.53 a	45.22 a	64.99 a	72.90 a	74.56 a
LSD (0.05)	**1.61**	**1.39**	**2.38**	**5.19**	**1.45**
CV %	**6.67**	**7.14**	**9.67**	**8.32**	**5.33**

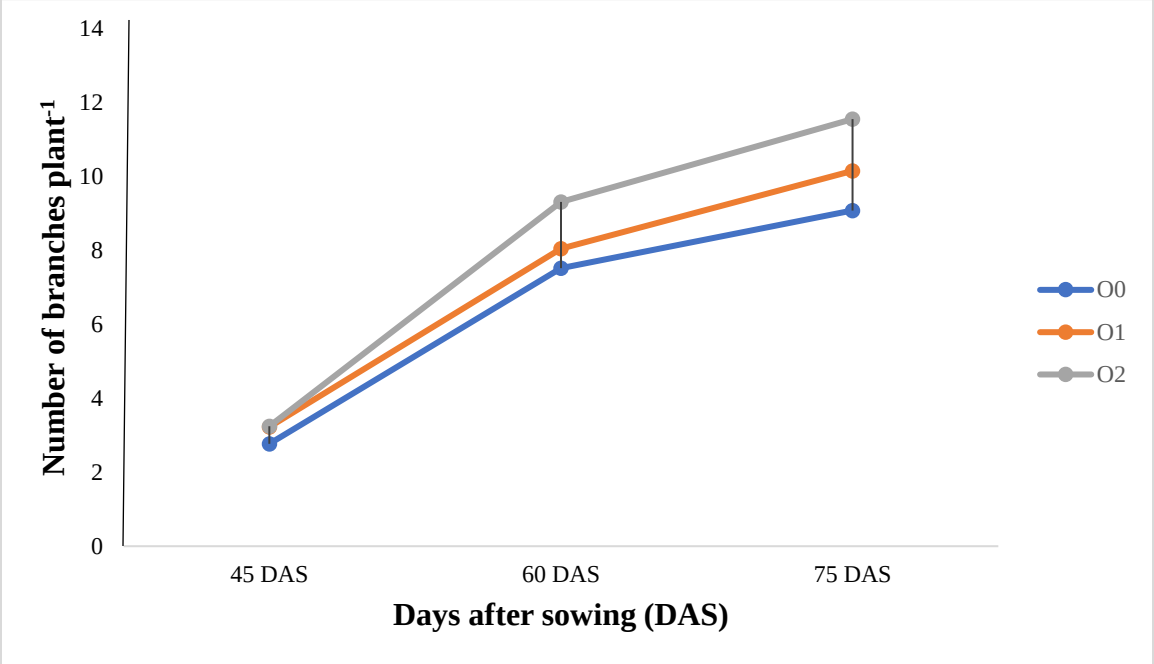
Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

4.2 Number of branches plant^{-1}

Statistically significant variation was recorded in terms of number of branches plant^{-1} of BARI soybean-5 due to different levels of organic manure at 45, 60 and 75 DAS (Figure 3 and Appendix V). The figure showed that O_2 (poultry litter) treatment showed its superiority by producing higher branches plant^{-1} for all sampling dates than other organic manure treatment. At 45, 60 and 75 DAS, the maximum number of branches plant^{-1} (3.24, 9.31 and 11.55, respectively) was recorded from O_2 (poultry litter), which were statistically similar (3.22, 8.05 and 10.15, respectively)

with O_1 (cowdung), whereas the minimum number of branches plant^{-1} (2.76, 7.52 and 9.08, respectively) was found from O_0 (control) treatment. 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.

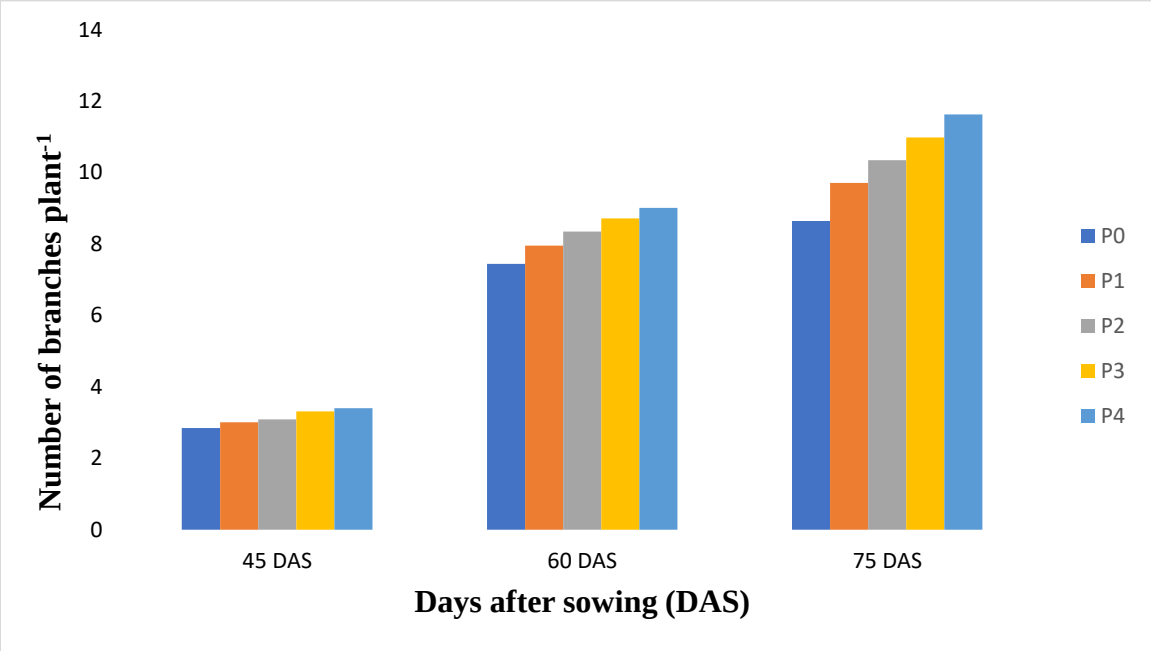


Here, O_0= Control, O_1= Cowdung, O_2= Poultry litter

Figure 3. Effect of organic manure on number of branches plant^{-1} of soybean at different days after sowing (LSD (0.05) = 0.24, 0.39 and 0.56 at 45, 60, and 75 DAS, respectively)

Different levels of phosphorous differed significantly in terms of number of branches plant^{-1} of BARI soybean-5 at 45, 60 and 75 DAS (Figure 4 and Appendix V). It can be seen from the result that irrespective of P levels, the number of branches plant^{-1} increased with the increases of growth stages. Higher P level was found superior in producing branches plant^{-1} for all sampling dates. However, at 45, 60 and 75 DAS, the maximum number of branches plant^{-1} (3.40, 9.01 and 11.63, respectively) was found from P_4 (50% higher than recommended dose of P) which were statistically similar (3.41, 8.71 and 10.98, respectively) with P_2 (25% higher than recommended dose of P), while the minimum number of branches (2.85, 7.44

and 8.64, respectively) was observed from P_0 (control) treatment (Figure 4). Khaim *et al.* (2013) and Falodun and Osaigbovo (2010) stated that total number of branches plant^{-1} was enhanced by inorganic fertilizers.



Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

Figure 4. Effect of phosphorous on number of branches plant^{-1} of soybean at different days after sowing (LSD (0.05) = 0.15, 0.22 and 0.48 at 45, 60, and 75 DAS, respectively)

Interaction effect of different levels of organic manure and phosphorous showed statistically significant variation on number of branches plant^{-1} of BARI soybean 5 at 45, 60 and 75 DAS (Table 2 and Appendix V). At 45, 60 and 75 DAS, the maximum number of branches plant-1 (3.73, 10.26 and 13.27, respectively) was recorded from O_2P_4 (poultry litter and 50% higher than recommended dose of P) which were statistically similar (3.60, 9.86 and 12.15, respectively) with O_2P_3 (poultry litter and 25% higher than recommended dose of P), and the minimum no. of branches (2.61, 7.06 and 7.53, respectively) was observed from O_0P_0 (control) treatment combination.

Table 2. Interaction effect of organic manure and phosphorous fertilizer application on number of branches plant^{-1} of soyabean at different days after sowing (DAS)

Interaction	Number of branches plant^{-1} at		
	45 DAS	**60 DAS**	**75 DAS**
O_0P_0	2.61 i	7.06 h	7.53 i
O_0P_1	2.70 hi	7.26 gh	8.55 h
O_0P_2	2.75 g-i	7.53 e-g	9.26 f-h
O_0P_3	2.86 f-i	7.83 ef	9.93 d-f
O_0P_4	2.92 e-h	7.93 de	10.16 de
O_1P_0	2.90 f-i	7.33 f-h	8.86 gh
O_1P_1	3.06 d-g	7.73 e-g	9.73 ef
O_1P_2	3.13 d-f	7.86 e	9.86 ef
O_1P_3	3.46 a-c	8.46 cd	10.87 cd
O_1P_4	3.56 a-c	8.86 c	11.46 bc
O_2P_0	3.06 e-g	7.93 de	9.53 e-g
O_2P_1	3.26 c-e	8.86 c	10.86 cd
O_2P_2	3.40 b-d	9.66 b	11.95 b
O_2P_3	3.60 ab	9.86 ab	12.15 b
O_2P_4	3.73 a	10.26 a	13.27 a
LSD (0.05)	**0.27**	**0.41**	**0.83**
CV %	**5.16**	**9.48**	**10.57**

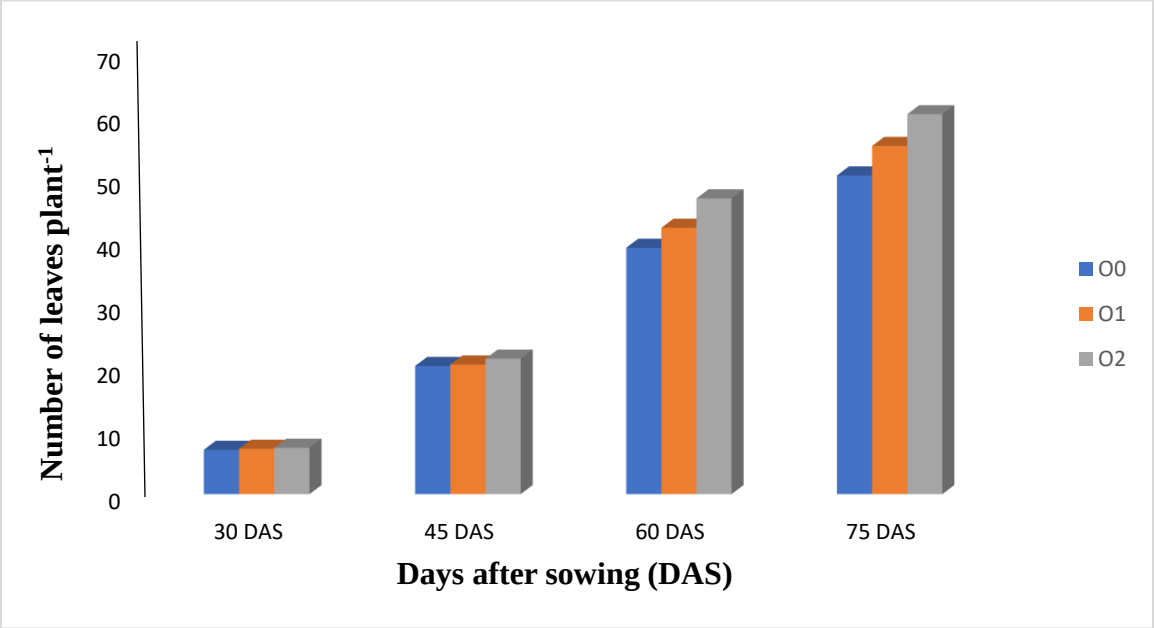
Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

4.3 Number of leaves plant^{-1}

Statistically significant variation was recorded in terms of number of leaves plant^{-1} of BARI soybean-5 due to different levels of organic manure application at 60 and 75 DAS (Figure 5 and Appendix V). Figure shows that number leaves plant^{-1} increased sharply with the advances of growth stages and the highest increase was found at 75 DAS. O_2 (poultry litter) treatment gave highest leaves plant^{-1} at 60 and 75 DAS and that of lowest was found O_0 (control) treatment. However, 60 and 75 DAS, the maximum number of leaves plant^{-1} (46.91 and 60.27, respectively) was

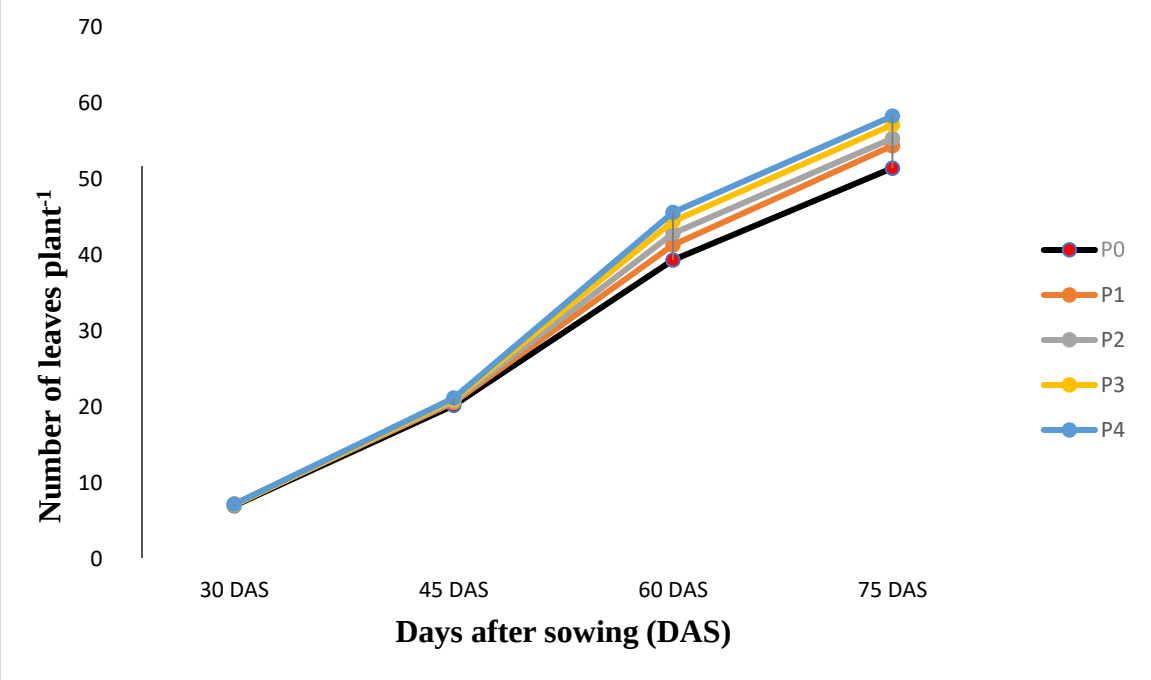
recorded from O_2 (poultry litter), which were statistically similar (42.25 and 55.23, respectively) with O_1 (cowdung), whereas the number of leaves plant^{-1} (39.08 and 50.55, respectively) was found from O_0 (control) treatment (Figure 5).



Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Figure 5. Effect of organic manure on number of leaves plant^{-1} of soybean at different days after sowing (LSD $_{(0.05\%)}$ = NS, NS, 0.72 and 2.44 at 30, 45, 60 and 75 DAS, respectively)

Different levels of phosphorous differed significantly in terms of number of leaves plant^{-1} of BARI soybean-5 at 60 and 75 DAS (Figure 6 and Appendix VI). At 60 and 75 DAS, the highest number of leaves plant^{-1} (45.64 and 58.31, respectively) was found from P_4 (50% higher than recommended dose of P) which were statistically similar (44.46 and 57.17, respectively) with P_2 (Recommended dose of P), while the lowest leaves plant^{-1} (39.39 and 51.48, respectively) was observed from P_0 (control) treatment (Figure 6).



Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

Figure 6. Effect of phosphorous on number of leaves plant^{-1} of soybean at different days after sowing (LSD $_{(0.05\%)}$ = NS, NS, 0.93 and 1.14 at 30, 45, 60 and 75 DAS, respectively)

Interaction effect of different levels of organic manure and phosphorous showed statistically significant variation on number of leaves plant^{-1} of BARI soybean 5 at 60 and 75 DAS (Table 3 and Appendix VI). At 60 and 75 DAS, the highest number of leaves plant^{-1} (50.06 and 63.73, respectively) was recorded from O_2P_4 (poultry litter and 50% higher than recommended dose of P) which were statistically similar (48.86 and 61.73, respectively) with O_2P_3 (poultry litter and 25% higher than recommended dose of P), and the minimum leaves plant^{-1} (36.53 and 48.33, respectively) was observed from O_0P_0 (control) treatment combination (Table 3).

Table 3. Interaction effect of organic manure and phosphorous fertilizer application on number of leaves plant^{-1} of soyabean at days after sowing (DAS)

Interaction (AXB)	Number of leaves plant^{-1} at			
	30 DAS	**45 DAS**	**60 DAS**	**75 DAS**
O_0P_0	7.00	19.90	36.53 i	48.33 i
O_0P_1	7.33	20.26	38.00 hi	50.00 hi
O_0P_2	7.00	20.46	39.13 gh	50.53 f-h
O_0P_3	6.93	20.46	40.10 fg	51.80 f-h
O_0P_4	6.93	20.56	41.66 ef	52.13 fg
O_1P_0	6.86	20.03	39.46 gh	50.20 g-i
O_1P_1	7.46	20.53	40.13 fg	53.40 ef
O_1P_2	7.46	20.73	42.03 e	55.53 e
O_1P_3	7.00	20.73	44.43 d	58.00 cd
O_1P_4	7.20	20.80	45.20 d	59.06 bc
O_2P_0	7.33	20.83	42.20 e	55.93 de
O_2P_1	7.06	21.13	46.00 cd	59.86 bc
O_2P_2	7.20	21.26	47.46 bc	60.13 bc
O_2P_3	7.53	21.83	48.86 ab	61.73 ab
O_2P_4	7.66	22.36	50.06 a	63.73 a
LSD (0.05)	**NS**	**NS**	**1.62**	**2.01**
CV %	**7.99**	**7.48**	**6.32**	**7.15**

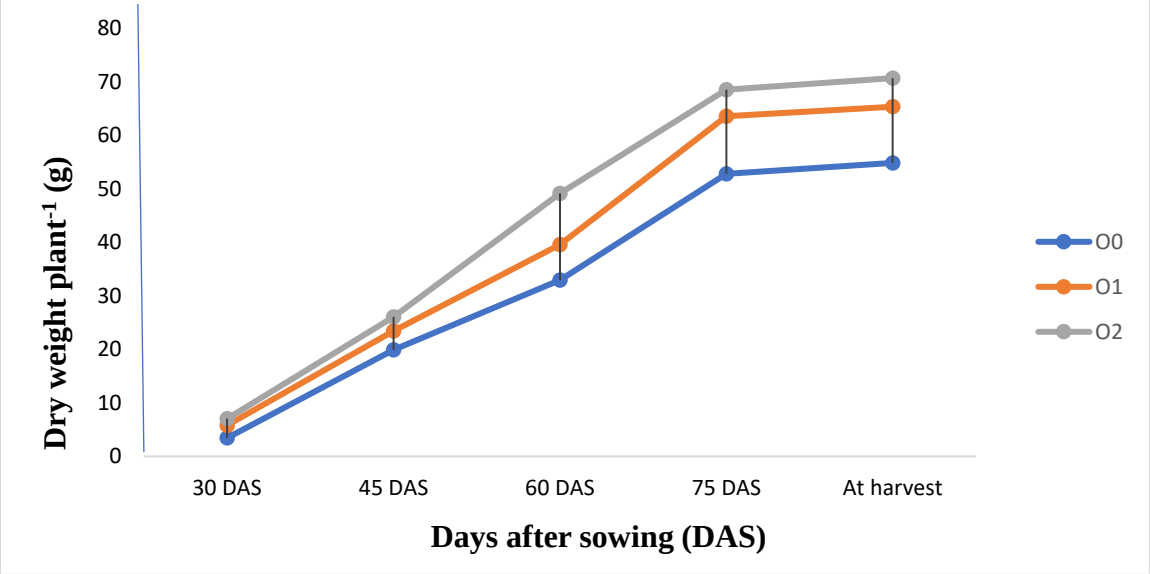
Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

4.4 Dry weight plant^{-1}

Different levels of organic manure showed significant variation for dry weight plant^{-1} at 30, 45, 60, 75 DAS and at harvest (Figure 7 and Appendix VII). The result revealed that dry weight plant^{-1} of soyabean increased sharply with the advances of growth stages and increasing rate was higher at early stages (upto 75 DAS) of growth, after that the rate of increase was minimum which may be due to defoliation leaves at later stages. The poultry litter, O_2 treatment showed the higher dry weight than other two treatments for all sampling dates and that of lower at O_0 (52.78). At 30 DAS, the highest dry weight plant^{-1} (7.03g) was recorded from O_2 (poultry litter) which was statistically similar with O_1 (cowdung), and the lowest from O_0 (control). At 45 DAS, the highest dry weight plant^{-1} (26.04 g) was observed from O_2 (poultry

litter), which was statistically similar with O_1 (cowdung), the lowest weight (19.887 g) was obtained from O_0 (control). At 60 DAS, the highest dry weight plant^{-1} (42.12 g) was obtained from O_2 (poultry litter), which was statistically similar with O_1 (cowdung), while the lowest 32.93 g) was obtained from O_0 (control). At 75 DAS, the highest dry weight plant^{-1} (68.53 g) was recorded from O_2 (poultry litter), which was closely followed by O_1 (cowdung) and that of lowest (52.78 g) from O_0 (control). At harvest, the highest dry weight plant^{-1} (70.67 g) was attained in O_2 (poultry litter), which was statistically similar with O_1 (cowdung) again the lowest (54.83g) was obtained from O_0 (control) treatment.

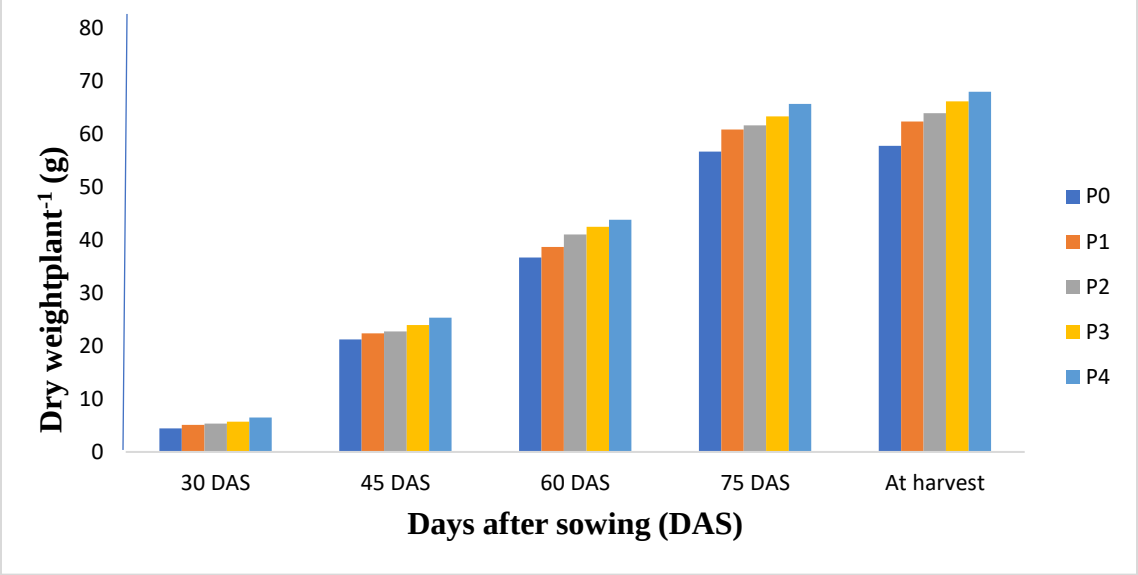


Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Figure 7. Effect of organic manure on dry weight plant^{-1} of soybean at different days after sowing (LSD (0.05) = 0.49, 0.61, 1.91, 0.80 and 0.97 at 30, 45, 60, 75 DAS and at harvest, respectively)

Different levels of phosphorous differed significantly in terms of dry weight of BARI soybean-5 at 30, 45, 60, 75 DAS and at harvest (Figure 8 and Appendix VII). At 30, 45, 60, 75 DAS and at harvest, the maximum dry weight (6.51, 25.33, 43.81, 65.66 and 67.95 g, respectively) was found from P_4 (50% higher than recommended dose of P), which were statistically similar (5.73, 23.94, 42.59, 63.23 and 66.13 g,

respectively) with P_2 (Recommended dose of P), while the shortest plant (4.45, 21.20, 36.69, 56.69 and 57.74 g, respectively) was observed from P_0 (control) treatment. 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 *et al.* (2004); Gopalkrishna and Palaniappan (1992).



Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

Figure 8. Effect of phosphorous on dry weight plant^{-1} of soybean at different days after sowing (LSD $_{(0.05)}$ = 0.27, 0.82, 0.85, 1.56 and 0.87 at 30, 45, 60, 75 DAS and at harvest, respectively)

Interaction effect of different levels of organic manure and phosphorous showed statistically significant variation on dry weight of BARI soybean-5 at 30, 45, 60, 75 DAS and at harvest (Table 4 and Appendix VII). At 30, 45, 60, 75 DAS and at harvest, the highest dry weight (8.11, 28.99, 51.72, 71.75 and 74.53 g, respectively)

was recorded from O_2P_4 (poultry litter and 50% higher than recommended dose of P) which were statistically similar (7.54, 26.87, 50.45, 70.47 and 73.32, respectively) with O_2P_3 (poultry litter and 25% higher than recommended dose of P), and the minimum dry weight (2.58, 18.53, 28.79, 48.76 and 50.42 g, respectively) was observed from O_0P_0 (control) treatment combination.

Table 4. Interaction effect of organic manure and phosphorous fertilizer application on dry weight plant^{-1} of soyabean at days after sowing (DAS)

Interaction (AXB)	Dry weight plant^{-1} (g) at				
	30 DS	**45 DAS**	**60 DAS**	**75 DAS**	**At harvest**
O_0P_0	2.58 j	18.53 i	28.79 i	48.76 h	50.42 i
O_0P_1	3.35 i	19.33 hi	32.80 h	52.16 g	54.61 h
O_0P_2	3.35 i	19.33 hi	33.01 h	52.91 g	55.10 h
O_0P_3	3.46 i	20.72 gh	34.86 gh	53.11 g	55.95 gh
O_0P_4	4.48 h	21.52 fg	35.19 g	56.97 f	58.11 f
O_1P_0	5.01 gh	21.63 fg	35.03 gh	56.70 f	57.17 fg
O_1P_1	5.34 fg	22.83 ef	35.81 g	62.64 e	63.67 e
O_1P_2	5.57 f	22.95 ef	40.37 f	63.74 de	65.47 d
O_1P_3	6.21 de	24.25 de	42.18 e	66.33 cd	69.12 c
O_1P_4	6.95 bc	25.49 b-d	44.53 d	68.28 bc	71.21 b
O_2P_0	5.77 ef	23.45 e	46.27 cd	64.61 de	65.63 d
O_2P_1	6.57 cd	25.01 cd	47.50 c	67.64 c	68.73 c
O_2P_2	7.17 b	25.93 bc	49.69 b	68.17 bc	71.15 b
O_2P_3	7.54 b	26.87 b	50.45 ab	70.47 ab	73.32 a
O_2P_4	8.11 a	28.99 a	51.72 a	71.75 a	74.53 a
LSD (0.05)	**0.46**	**1.45**	**1.43**	**2.64**	**1.51**
CV %	**5.03**	**10.34**	**5.14**	**6.62**	**5.40**

Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

4.5 Pod length

Statistically significant variation was recorded due to different levels of phosphorous in terms of pod length of BARI soybean-5 (Table 5 and Appendix VIII). The longest pod (3.72 cm) was observed from O_2 (poultry litter), which was followed by (3.60 cm) with O_1 (cowdung), while the shortest pod (3.44 cm) was

found from O_0 (control) treatment.

Different levels of phosphorous fertilizer varied significantly in terms of pod length of BARI soybean-5 (Table 5 and Appendix VIII). The longest pod (4.05 cm) was recorded from O_2 which were statistically similar (3.94 cm) with P_3 (25% higher recommended doses of P) and the shortest pod (2.95 cm) from P_0 (0 kg P ha^{-1}) treatment. 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.

Table 5. Effect of organic manure and phosphorous fertilizer application on yield attributes of soyabean

Organic manure	**Pod length (cm)**	**No. of pods $plant^{-1}$**	**No. of seeds pod^{-1}**	**100 seed weight (g)**
O_0	3.44 c	25.91 c	2.49 c	9.19 c
O_1	3.60 b	31.96 b	2.85 b	10.23 b
O_2	3.72 a	34.83 a	3.22 a	10.99 a
LSD (0.05)	**0.07**	**0.81**	**0.09**	**0.49**
CV %	**9.53**	**13.39**	**7.57**	**6.88**
Phosphorous fertilizer				
P_0	2.95 d	23.59 d	2.41 d	9.60 c
P_1	3.20 c	27.79 c	2.74 c	9.89 bc
P_2	3.80 b	31.46 b	2.90 b	10.21 ab
P_3	3.94 a	35.25 a	3.02 a	10.42 a
P_4	4.05 a	36.41 a	3.19 a	10.56 a
LSD (0.05)	**0.09**	**0.90**	**0.08**	**0.49**
CV %	**6.85**	**12.34**	**5.88**	**7.35**

Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

Pod length of BARI soybean 5 showed statistically significant variation due to the interaction effect of different levels of organic manure and phosphorous application (Table 6 and Appendix VIII). The longest pod (4.19 cm) was recorded from O_2P_4 (poultry litter with 50% higher than recommended doses of P) which were

statistically similar (4.05 cm) with O_2P_3 (25% higher recommended doses of P) and O_1P_4 (4.08 cm), whereas the shortest pod (2.81 cm) was found from O_0P_0 (control) treatment combination.

Table 6. Interaction effect of organic manure and phosphorous fertilizer application on yield attributes of soyabean

Interaction (AXB)	Pod length (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	100 seed weight (g)
O_0P_0	2.81 i	21.26 i	1.94 j	8.80 g
O_0P_1	3.05 gh	22.77 hi	2.43 i	8.99 g
O_0P_2	3.68 e	25.60 g	2.57 h	9.20 fg
O_0P_3	3.79 de	29.75 ef	2.62 gh	9.43 fg
O_0P_4	3.90 cd	30.16 e	2.92 de	9.54 e-g
O_1P_0	2.99 h	25.46 g	2.47 hi	9.62 e-g
O_1P_1	3.17 h	28.37 f	2.73 fg	9.95 d-f
O_1P_2	3.78 de	32.16 d	2.88 e	10.38 c-e
O_1P_3	3.98 bc	36.33 c	3.02 cd	10.55 b-d
O_1P_4	4.08 ab	37.52 c	3.15 bc	10.67 a-c
O_2P_0	3.07 gh	24.05 gh	2.84 ef	10.40 c-e
O_2P_1	3.38 f	32.24 d	3.08 c	10.73 a-d
O_2P_2	3.94 b-d	36.62 c	3.26 b	11.04 a-c
O_2P_3	4.05 a-c	39.68 b	3.43 a	11.30 ab
O_2P_4	4.19 a	41.57 a	3.52 a	11.48 a
LSD (0.05)	**0.17**	**1.55**	**0.14**	**0.85**
CV %	**6.85**	**12.34**	**5.88**	**7.35**

Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

4.6 Number of pods plant^{-1}

Different levels of organic manure showed statistically significant variation on number of pods plant^{-1} of BARI soybean-5 (Table 5 and Appendix V). The maximum number of pods plant^{-1} (34.83) was recorded from O_2 (poultry litter), which was followed by (31.96) with O_1 (cowdung), whereas the minimum number (25.91) from O_0 (control) treatment.

Number of pods plant^{-1} BARI soybean-5 varied significantly due to different levels of phosphorous (Appendix VIII). The maximum number of pods plant^{-1} (36.41) was recorded from P_4 (poultry litter) which were statistically similar (35.25) with P_3 (cowdung), while the minimum number (23.59) from P_0 (control) treatment (Table 5). Begum *et al.* (2015) and Singh and Bajpai (1990) observed that increasing phosphorus rate increased the number of pods plant^{-1} which corroborates the present findings.

Interaction effect of different levels of organic manure and phosphorous varied significantly in terms of number of pods plant^{-1} of BARI soybean-5 (Appendix VIII). The maximum number of pods plant^{-1} (41.57) was found from O_2P_4 (poultry litter and 50% higher than recommended doses of P) which was followed by (39.68) with O_2P_3 (poultry litter and 25% higher recommended doses of P), and the minimum number (21.26) was found from O_0P_0 (control) treatment combination (Table 6).

4.7 Number of seeds pod^{-1}

Different levels of organic manure showed statistically significant variation on number of seeds pod^{-1} of BARI soybean-5 (Table Appendix VIII). The maximum number of seeds pod^{-1} (3.22) was found from O_2 (poultry litter), which was followed by (2.85) with O_1 (cowdung), while the minimum number (2.49) was recorded from O_0 (control) treatment (Table 5).

Number of seeds pod^{-1} BARI soybean-5 varied significantly due to different levels of phosphorous (Appendix VIII). The maximum number of seeds pod$_{-1}$ (3.19) was recorded from P_4 (50% higher than recommended doses of P) which were statistically similar (3.02) with P_3 (25% higher than recommended doses of P), while the minimum number (2.41) from P_0 (control) treatment (Table 5). Begum *et al.* (2015), Tomar and *Khajanji* (2009) and Islam *et al.* (2004) observed that number of

seeds pod^{-1} increased with the increase of phosphorus application.

Statistically significant variation was recorded due to the interaction effect of different levels of organic manure and phosphorous on number of seeds pod^{-1} of BARI soybean-5 (Appendix VIII). The maximum number of seeds pod^{-1} (3.52) was observed from O_2P_4 (poultry litter with 50% higher than recommended doses of P) which were statistically similar (3.43) with O_2P_3 (25% higher than recommended doses of P), and the minimum number (1.94) was found from O_0P_0 (control) treatment combination (Table 6).

4.8 Weight of 100 seeds

Weight of 100 seeds of BARI soybean-5 varied significantly due to different levels of organic manure under the present trial (Appendix VII). The highest weight of 100 seeds (10.99 g) was observed from O_2 (poultry litter), which was followed by (10.23 g) with O_1 (cowdung), while the lowest weight (9.19 g) was attained from O_0 (control) treatment (Table 5).

Statistically significant variation was recorded in terms of weight of 100 seeds of BARI soybean-5 due to different levels of phosphorous (Appendix VIII). The highest weight of 100 seeds (10.56 g) was found from P_4 (50% higher than recommended dose of P) which was followed by P_3 (10.42) and P_2 (10.21) respectively. Again, the lowest weight (9.60 g) from P_0 (control) treatment (Table 5). 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).

Interaction effect of different levels of organic manure and phosphorous showed statistically significant variation in terms of weight of 100 seeds of BARI soybean-

5 (Appendix VIII). The highest weight of 100 seeds (11.48 g) was observed from O_2P_4 (poultry litter and 50% higher than recommended dose of P), whereas the lowest weight (8.80 g) was attained from O_0P_0 (control) treatment combination (Table 6).

4.9 Grain yield

Grain yield t $ha^{-1}$of soybean was significantly influenced by different levels of organic manure treatments (Table 7 and Appendix IX). The results revealed O_2 (poultry litter) treatment out yielded over O_1 (cowdung) and O_0 (control) by producing 12.69 and 37.89% higher yield However, the result also showed that the highest grain yield (2.22 t ha^{-1}) was obtained from O_2 (poultry litter) followed by O_1 (cowdung). Similarly, the lowest grain yield (1.61 t ha^{-1}) was recorded from control treatment, O_0.

Significant influence was also found by different levels of phosphorous treatments for grain yield of soybean (Table 7 and Appendix IX). Results showed that the highest grain yield (2.37 t ha^{-1}) was obtained from P_4 (50% higher than recommended doses of P) followed by P_3 (25% higher than recommended doses of P) and P_2 (recommended doses of P). Likewise, the lowest grain yield (1.31 t ha^{-1}) was recorded from control treatment, P_0 (0 kg P ha^{-1}).

Interaction effect of different levels of organic manure and phosphorous application had significantly influence on grain yield of soybean (Table 8 and Appendix IX). Results signified that the highest grain yield (2.70 t ha^{-1}) was recorded from O_2P_4 treatment combination where the 2nd and 3rd highest seed yield 2.65 t ha^{-1} and 2.42 t ha^{-1} respectively were achieved from O_2P_3 and O_2P_2. Accordingly, the lowest grain yield (1.13 t ha^{-1}) was recorded from O_0P_0 treatment combination followed by 2nd and 3rd lowest grain yield (1.35 t ha^{-1} and 1.38 t ha^{-1}, respectively) were obtained from O_1P_0 and O_0P_1 interaction.

4.10 Stover yield t ha^{-1}

Different levels of organic manure varied significantly on stover yield t ha^{-1} of BARI soybean-5 (Table 7 and Appendix IX). The highest stover yield (3.47 t ha^{-1}) was found from O_2 (poultry litter), which were statistically similar (3.19 t ha^{-1}) with O_1 (cowdung), whereas the lowest stover yield (2.86 t ha^{-1}) from O_0 (control) treatment.

Stover yield t ha^{-1} of BARI soybean-5 varied significantly due to different levels of phosphorous (Table 7 and Appendix IX). The highest stover yield (3.59 t ha^{-1}) was observed from P_4 (50% higher than recommended dose of P) which were statistically similar (3.57 t ha^{-1}) with P_3 (25% higher than recommended dose of P), while the lowest stover yield (2.43 t ha^{-1}) was recorded from P_0 (control) treatment. Forhad and Malik (2010) also reported that application of P and K also increased the stover yield.

Interaction effect of different levels of organic manure and phosphorous showed statistically significant variation in terms of stover yield t ha^{-1} of BARI soybean-5 (Table 8 and Appendix IX). The highest stover yield (3.93 t ha^{-1}) was observed from O_2P_4 (poultry litter and 50% higher than recommended dose of P ha^{-1}) and the lowest stover yield (2.21 t ha^{-1}) from O_0P_0 (control) treatment combination. 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.

4.11 Biological yield

Biological yield t ha^{-1} of BARI soybean-5 varied significantly due to different levels of organic manure (Table 7 and Appendix IX). The highest biological yield (5.70 t ha^{-1}) was observed from O_2 (poultry litter), which were statistically identical (5.16 t ha^{-1}) with O_1 (cowdung). On the other hand, the lowest biological yield (4.52 t ha^{-1}) was observed from O^0 (control) treatment.

Different levels of phosphorous varied significantly in terms of biological yield hectare^{-1} of BARI soybean-5 (Table 7 and Appendix IX). The highest biological yield (5.77 t ha^{-1}) was recorded from P_4 (50% higher than recommended dose of P) which were statistically similar (5.91 t ha^{-1}) with P_3 (recommended dose of P) followed by P_2 (5.55 t ha^{-1}), whereas the lowest seed yield (3.73 t ha^{-1}) from P_0 (control).

Statistically significant variation was recorded due to the interaction effect of different levels of organic manure and phosphorous on biological yield of BARI soybean 5 (Appendix IX). The highest biological yield (6.63 t ha^{-1}) was found from O_2P_4 (poultry litter and 50% higher than recommended dose of P) which was statistically similar with O_2P_3 (poultry litter and 25% higher than recommended dose of P), while the lowest biological yield (3.41 t ha^{-1}) was found from O_0P_0 (control) treatment combination (Table 8). The result revealed that combination of organic and 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 of Khaim *et al.* (2013), who reported that biological yield was also increased in the RDCF 75%+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 was significantly influenced by different organic manure treatments (Table 7 and Appendix IX). Results revealed that the highest harvest index (38.16%) was obtained from O_2 (poultry litter) where the lowest harvest index (36.32%) was recorded from control treatment, (O_0).

Significant influence was found by different levels of phosphorous treatments for harvest index of soybean (Table 7 and Appendix IX). Results showed that the

highest harvest index (39.66%) was obtained from P_4 (50% higher than recommended dose of P) where the lowest harvest index (34.47%) was recorded from control treatment, P_0.

Interaction effect of different levels of organic manure and phosphorous application had significant influence on harvest index of soybean (Table 8 and Appendix IX). Results signified that the highest harvest index (40.47%) was recorded from O_2P_4 treatment combination which was statistically similar with O_2P_3 followed by O_2P_2. Accordingly, the lowest harvest index (33.10%) was recorded from O_0P_0 treatment combination followed by O_0P_1. These findings are contradictory with the results of Khaim *et al.* (2013), who reported that harvest index was influenced by the application of organic and inorganic fertilizer with other fertilizers.

Table 7. Effect of organic manure and phosphorous fertilizer application on yield of soyabean

Organic manure	**Grain yield (t ha^{-1})**	**Stover yield (t ha^{-1})**	**Biological yield (t ha^{-1})**	**Harvest index (%)**
O_0	1.61 c	2.86 c	4.52 c	36.32 b
O_1	1.97 b	3.19 b	5.16 b	37.82 a
O_2	2.22 a	3.47 a	5.70 a	38.16 a
LSD (0.05)	**0.15**	**0.08**	**0.13**	**1.22**
CV %	**9.40**	**9.42**	**12.94**	**9.17**
Phosphorous fertilizer				
P_0	1.31 d	2.43 d	3.73 d	34.47 e
P_1	1.65 c	2.82 c	4.48 c	36.59 d
P_2	2.01 b	3.44 b	5.55 b	37.75 c
P_3	2.33 a	3.57 a	5.91 a	38.71 b
P_4	2.37 a	3.59 a	5.97 a	39.66 a
LSD (0.05)	**0.21**	**0.07**	**0.21**	**0.81**
CV %	**11.61**	**7.20**	**11.53**	**6.24**

Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

Table 8. Interaction effect of organic manure and phosphorous fertilizer application on yield contributing parameters of soyabean

Interaction	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
O_0P_0	1.13 g	2.28 i	3.41 h	33.10 g
O_0P_1	1.38 fg	2.48 h	3.86 g	35.49 ef
O_0P_2	1.53 f	3.10 f	4.92 e	36.56 d-f
O_0P_3	1.98 de	3.20 ef	5.18 de	37.87 cd
O_0P_4	2.02 c-e	3.24 e	5.26 de	38.59 bc
O_1P_0	1.35 fg	2.47 h	3.82 g	35.01 f
O_1P_1	1.66 ef	2.82 g	4.48 f	36.68 de
O_1P_2	2.10 c-e	3.43 d	5.53 d	37.88 cd
O_1P_3	2.38 b-e	3.61 c	5.99 c	39.61 ab
O_1P_4	2.40 b-d	3.62 c	6.02 c	39.93 ab
O_2P_0	1.44 fg	2.54 h	3.98 g	35.31 ef
O_2P_1	1.93 de	3.18 ef	5.11 e	37.60 cd
O_2P_2	2.42 bc	3.79 b	6.21 bc	38.80 bc
O_2P_3	2.65 ab	3.92 a	6.57 ab	38.64 bc
O_2P_4	2.70 a	3.93 a	6.63 a	40.47 a
LSD (0.05)	**0.38**	**0.11**	**0.37**	**1.40**
CV %	**11.61**	**7.20**	**11.53**	**6.24**

Here, O_0 = Control, O_1 = Cowdung, O_2 = Poultry litter

Here, P_o = Control (without P), P_1 = 25% less then recommended dose of P, P_2 = Recommended dose of P, P_3 = 25% higher than recommended dose of P, and P_4 = 50% higher than recommended dose of P

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from February, 2019 to May, 2019 to study the "Influence of organic manure and phosphorous level on the performance of soybean". The variety BARI soybean-5 was used as the test crops. The experiment comprised of two factors; Factor A: Levels of organic manure (3 levels)- O_0 = Control (without organic manure); O_1 = Cowdung, O_2 = Poultry litter and Factors B: Levels of phosphorous (4 levels)- P_0 = 0 kg P ha^{-1} (control), P_1 = 25% less then recommended dose of P ha^{-1}, P_2 = Recommended dose of P ha^{-1}, P_3 = 25% higher than recommended dose of P ha^{-1} and P_4 = 50% higher than recommended dose of P. The two factors experiment was laid out in Split Plot Design (SPD) with three replications. Data on different growth parameter and yield parameter were recorded and significant variation was observed for different treatment.

For organic manure application, at 30, 45, 60, 75 DAS and at harvest, the tallest plant (27.23, 42.68, 60.66, 68.46 and 69.93 cm, respectively) was recorded from O_2, whereas the shortest plant (21.22, 35.43, 52.54, 60.30 and 64.41 cm, respectively) was found from O_0. At 30, 45, 60 and 75 DAS, the maximum number of leaves plant-1 (7.35, 21.48, 46.91 and 60.27, respectively) was observed from O_2, while the minimum (7.03, 20.33, 39.08 and 50.55, respectively) from O_0. At 45, 60 and 75 DAS, the maximum number of branches $plant^{-1}$ (3.24, 9.31 and 11.55, respectively) was observed from O_2, while the minimum (2.76, 7.52 and 9.08, respectively) from O_0. At 30, 45, 60, 75 DAS and at harvest, oven dry weight (7.023, 26.04, 49.12, 68.53 and 70.67 g, respectively) was recorded from O_2, whereas the lowest dry weight (3.44, 19.88, 32.93, 52.78 and 54.83 g, respectively) was found from O_0. The longest pod (3.72 cm) was observed from O_2 (poultry litter), while

the shortest pod length (3.44 cm) was found from O_0. The maximum number of seeds pod^{-1} (3.22) was recorded from O_2, whereas the minimum number (2.49) was attained from O_0. The maximum number of pod plant^{-1} (34.83) was found from O_2, while the minimum number (25.91) was recorded from O_0. The highest weight of 100 seeds (10.99 g) was observed from O_2, while the lowest weight (9.19 g) was attained from O_0. The highest grain yield (2.22 t ha^{-1}) was observed from O_2 and the lowest grain yield (1.61 t ha-^{1}) was observed from O_0. The highest stover yield (3.47 t ha^{-1}) was found from O_2, whereas the lowest stover yield (2.86 t ha^{-1}) from O_0. The highest biological yield (t ha^{-1}) (5.70) was observed from O_2 (poultry litter) and the lowest biological yield (4.52 t ha-1) from O0. The highest harvest index (38.16%) was observed from O_2 (poultry litter) and the lowest harvest index (36.32%) from O_0.

In case of phosphorous fertilizer application, at 30, 45, 60, 75 DAS and at harvest, the tallest plant (28.27, 41.63, 61.54, 69.92 and 72.02 cm, respectively) was recorded from P_4, whereas the shortest plant (19.14, 34.93, 50.12, 57.06 and 58.63 cm, respectively) was found from P_0. At 60 and 75 DAS, the maximum number of leaves plant^{-1} (45.64 and 58.31, respectively) was observed from P_4, while the minimum (39.39 and 51.48, respectively) from P_0. At 45, 60 and 75 DAS, the maximum number of branches plant^{-1} (3.04, 9.01 and 11.63, respectively) was observed from P_4, while the minimum (2.85, 7.44 and 8.64, respectively) from P_0. At 30, 45, 60, 75 DAS and at harvest, oven dry weight (6.51, 25.33, 43.81, 65.66 and 67.95 g, respectively) was recorded from P_4, whereas the lowest oven dry weight (4.45, 21.20, 36.69, 56.69 and 57.74 g, respectively) was found from P_0. The longest pod (4.05 cm) was observed from P_4 (50% higher than recommended dose of P), while the shortest pod (2.95 cm) was found from P_0. The maximum number of seeds pod^{-1} (3.19) was recorded from P_4, whereas the minimum number (2.41) was attained from P_0. The maximum number of pods plant^{-1} (36.41) was found from P_4, while the minimum number (23.59) was recorded from P_0. The highest weight of 100 seeds (10.56 g)

was observed from P_4, while the lowest weight (9.60 g) was attained from P_0. The highest grain yield (2.37 t ha^{-1}) was observed from P_4 and the lowest grain yield (1.31 t ha^{-1}) was observed from P_0. The highest stover yield (3.59 t ha^{-1}) was found from P_4, whereas the lowest stover yield (2.43 t ha^{-1}) from P_0. The highest biological yield (5.97 t ha^{-1}) was observed from P_4 (50% higher than recommended dose of P) and the lowest biological yield (3.73 t ha^{-1}) from P_0. The highest harvest index (39.66%) was observed from P_4 (50% higher than recommended dose of P) and the lowest harvest index (34.47%) from P_0.

Due to the interaction effect of different levels of organic manure and phosphorous at 30, 45, 60, 75 DAS and at harvest, the tallest plant (30.53, 45.22, 64.99, 72.90 and 74.56 cm, respectively) was recorded from O_2P_4 and the shortest plant (14.56, 31.28, 45.57, 53.10 and 57.31 cm, respectively) was observed from O_0P_0. At 30, 45, 60 and 75 DAS, the maximum number of leaves $plant^{-1}$ (7.66, 22.36, 50.06 and 63.73, respectively) was found from O_2P_4, while the minimum number (7.00, 19.90, 36.53 and 48.33, respectively) from O_0P_0. At 45, 60 and 75 DAS, the maximum number of branches $plant^{-1}$ (3.73, 10.26 and 13.27, respectively) was observed from O_2P_4, while the minimum (2.61, 7.06 and 7.53, respectively) from O_0P_0. At 30, 45, 60, 75 DAS and at harvest, the highest oven dry weight (8.11, 28.99, 51.72, 71.75 and 74.53 g, respectively) was recorded from O_2P_4, whereas the lowest oven dry weight (2.58, 18.53, 28.79, 48.76 and 50.42 g, respectively) was found from O_0P_0. The longest pod length (4.19 cm) was observed from O_2P_4 (50% higher than recommended dose of P), while the shortest pod length (2.81 cm) was found from O_0P_0. The maximum number of seeds pod^{-1} (3.52) was recorded from O_2P_4, whereas the minimum number (1.91) was attained from O_0P_0. The maximum number of pod $plant^{-1}$ (41.52) was found from O_2P_4, while the minimum number (21.26) was recorded from O_0P_0. The highest weight of 100 seeds (11.48 g) was observed from O_2P_4, while the lowest weight (8.80 g) was attained from O_0P_0. The highest grain yield (2.70 t ha^{-1}) was observed from O_2P_4 and the lowest grain yield (1.13 t ha^{-1})

was observed from O_0P_0. The highest stover yield (3.93 t ha^{-1}) was found from O_2P_4, whereas the lowest stover yield (2.28 t ha^{-1}) from O_0P_0. The highest biological yield (6.63 t ha^{-1}) was observed from O_2P_4 (50% higher than recommended dose of P) and the lowest biological yield (3.41 t ha^{-1}) from O_0P_0. The highest harvest index (40.47%) was observed from O_2P_4 (50% higher than recommended dose of P) and the lowest harvest index (33.10%) from O_0P_0.

Conclusion

Although O_2P_4 gave the highest yield but O_2P_3 gave similar result with O_2P_4. So, it may be concluded that application of poultry litter with 25% higher than recommended dose of P (O_2P_3) can be more beneficial for the farmers to get maximum yield of BARI soybean-5.

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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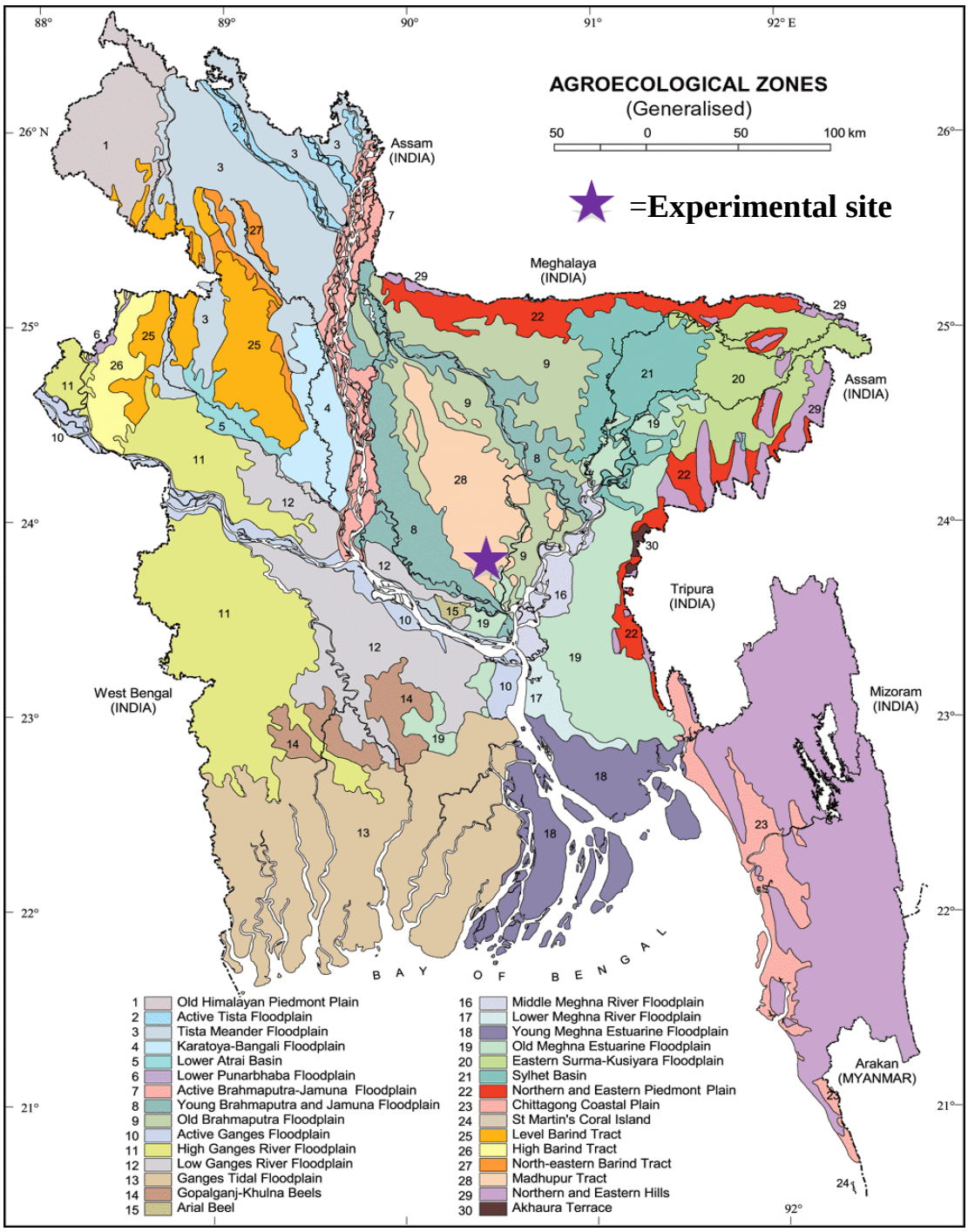
APPENDICES

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



Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from February, 2019 to May, 2019

Month	*Air temperature (°C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
February, 2019	27.7	17.0	78	00
March, 2019	28.4	18.5	74	00
April, 2019	25.2	18.8	69	00
May, 2019	26.7	1 6.9	66	39

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix III. 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 IV. Mean sum square (MSS) values for plant height of soybean at different days after sowing as influenced by organic manure, P level and their interaction

Sources of variation	Degrees of freedom	MSS				
		30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Replication	2	66.15	145.83	130.41	271.65	182.47
Factor A	2	143.81*	202.71*	254.09*	252.36*	115.70*
Error	4	1.947	0.38	4.45	1.32	0.96
Factor B	4	98.76*	63.72*	211.77*	203.64*	258.68*
AXB	8	2.58*	0.71 ^{NS}	6.21*	2.73*	2.87*
Error	24	0.95	0.68	2.00	0.52	0.79

NS = Non-significant * = Significant at 5% level

Appendix V. Mean sum square (MSS) values for number of soybean at different days after sowing as influenced by organic manure, P level and their interaction

Sources of variation	Degrees of freedom	MSS		
		45 DAS	60 DAS	75 DAS
Replication	2	1.46	4.65	18.11
Factor A	2	1.63*	12.75*	2.89*
Error	4	0.05	0.15	0.30
Factor B	4	0.44*	3.50*	12.01*
AXB	8	0.02 ^{NS}	0.30*	0.29 ^{NS}
Error	24	0.02	0.06	0.25

NS = Non-significant * = Significant at 5% level

Appendix VI. Mean sum square (MSS) values for number of leaves plant^{-1} of soybean at different days after sowing as influenced by organic manure, P level and their interaction

Sources of variation	Degrees of freedom	MSS			
		30 DAS	45 DAS	60 DAS	75 DAS
Replication	2	26.16	35.85	157.35	319.51
Factor A	2	0.37 ^{NS}	5.57 NS	232.83*	354.30*
Error	4	0.50	0.96	0.53	6.06
Factor B	4	0.07 ^{NS}	1.25 ^{NS}	54.97*	62.70*
AXB	8	0.20 ^{NS}	0.18 ^{NS}	1.83 ^{NS}	3.70*
Error	24	0.33	2.42	0.98	1.44

NS = Non-significant * = Significant at 5% level

Appendix VII. Mean sum square (MSS) values for dry weight plant^{-1} of soybean at different days after sowing as influenced by organic manure, P level and their interaction

Sources of variation	Degrees of freedom	MSS				
		25 DAS	45 DAS	65 DAS	85 DAS	At harvest
Replication	2	3.48	140.65	141.89	79.05	309.12
Factor A	2	49.94*	143.39*	993.97*	971.57*	973.31*
Error	4	0.23	0.38	3.63	0.64	0.92
Factor B	4	5.26*	22.35*	74.09*	99.39*	137.98*
AXB	8	0.16 ^{NS}	0.72 ^{NS}	5.12*	3.75 ^{NS}	6.41*
Error	24	0.07	0.78	0.77	2.56	0.79

NS = Non-significant * = Significant at 5% level

Appendix VIII. Mean sum square (MSS) values for yield contributing of soybean at different days after sowing as influenced by organic manure, P level and their interaction

Sources of variation	Degrees of freedom	MSS			
		Pod length (cm)	Number of pods plant^{-1}	Number of seeds pod^{-1}	100 seed weight (g)
Replication	2	0.64	184.50	0.89	24.75
Factor A	2	0.29*	311.41*	1.99*	12.22*
Error	4	0.005	0.68	0.008	0.23
Factor B	4	2.10*	253.76*	0.79*	1.37*
AXB	8	0.003 ^{NS}	9.85*	0.01 ^{NS}	0.02 ^{NS}
Error	24	0.01	0.89	0.006	0.25

NS = Non-significant * = Significant at 5% level

Appendix IX. Mean sum square (MSS) values for yield of soybean at different days after sowing as influenced by organic manure, P level and their interaction

Sources of variation	Degrees of freedom	MSS			
		Yield ((t/ha))	Stover yield ((t/ha))	Biological yield (t/ha)	Harvest index (%)
Replication	2	1.67	1.19	4.45	410.36
Factor A	2	1.45*	1.40*	5.18*	14.40*
Error	4	0.03	0.005	0.02	1.40
Factor B	4	1.87*	2.44*	8.68*	36.37*
AXB	8	0.03 ^{NS}	0.03*	0.09 ^{NS}	0.54 ^{NS}
Error	24	0.05	0.004	0.04	0.70

NS = Non-significant * = Significant at 5% level

PLATES

Plate 1. Growth stage of soybean

Plate 2. Growth stage of soybean

Plate 3. Maturity stage of soybean plant

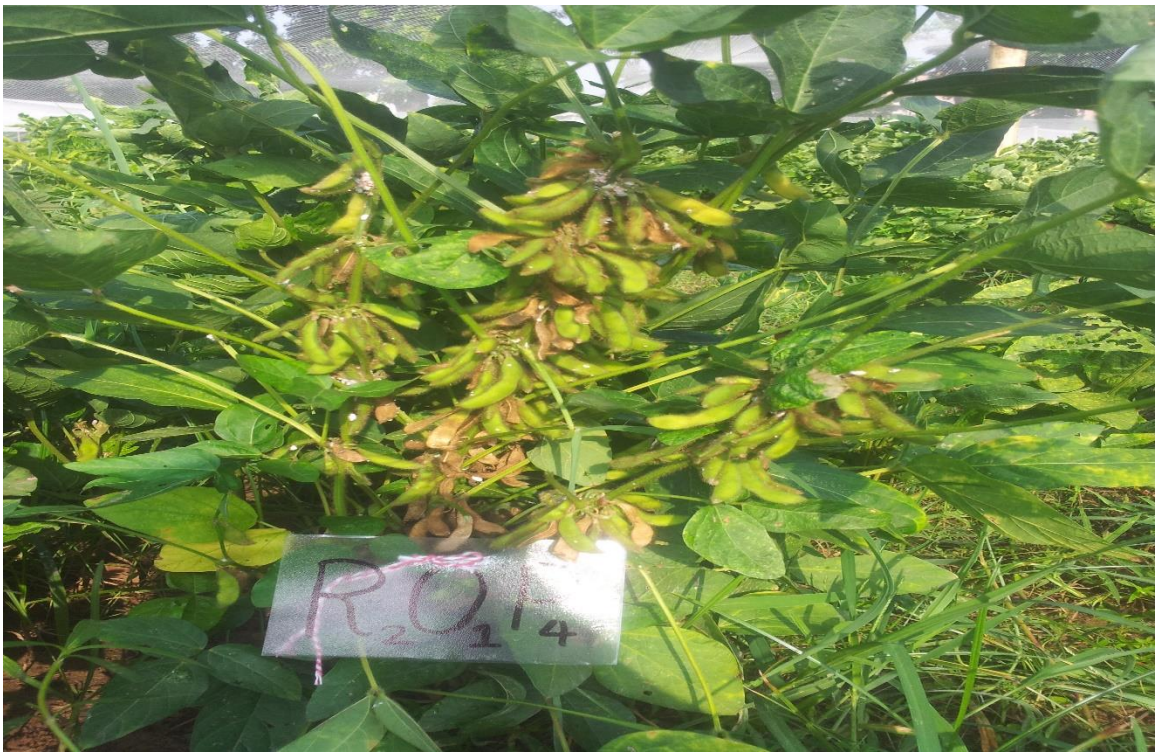


Plate 4. Ripening stage of soybean