YIELD PERFORMANCE OF SOYBEAN VARIETIES UNDER DIFFERENT FERTILIZER LEVEL

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CERTIFICATE

*This is to certify that thesis entitled **"YIELD PERFORMANCE OF SOYBEAN VARIETIES UNDER DIFFERENT FERTILIZER LEVEL"** submitted to the **Faculty of Agriculture,** Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) in AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **MD. LUTFOR RAHMAN** Registration No. 15-06658 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, received during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

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DEDICATED
TO
MY BELOVED
PARENTS

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ABSTRACT

A field experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University to find out the combination effect of variety and different fertilizer level on the yield of soybean, cultivated during December, 2021 to April, 2022. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The four varieties included in this study were BINAsoybean-5; BU soybean 2; BARI Soybean-5 and BARI Soybean-6. There were four fertilizer combinations. Such as F_0 = No fertilizer, F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF). Among all the varieties, BU soybean 2 (V_2) emerged as the superior performer, showcasing the tallest plant height at harvest (59.55 cm), highest dry weight plant^{-1} at harvest (6.94 g), maximum number of pod plant^{-1} (29.75), seed pod^{-1} (2.60), weight of 100 seeds (14.03 g) and leading seed and stover yield of 3.20 t ha^{-1} and 5.53 t ha^{-1}, respectively. On the other hand, among the fertilizer doses, F_3 (50% more than recommended dose of fertilizer), proved most effective, yielding the tallest plant at harvest (60.28 cm), highest dry weight plant^{-1} at harvest (6.76 g), maximum number of pod plant^{-1} (32.73), seed pod^{-1} (2.44), weight of 100 seeds (12.29 g), and the leading seed and stover yield of 3.21 t ha^{-1} and 5.75 t ha^{-1} respectively. But in the case of combination between varieties and different doses of fertilizer, V_2F_3 (BU soybean 2 with 50% more fertilizer than the recommended dose) treatment gave the best results. The tallest plant at harvest (67.55 cm), highest dry weight plant^{-1} at harvest (7.49 g), maximum number of pod plant^{-1} (35.61), seed pod^{-1} (3.00), weight of 100 seeds (15.52 g), leading seed and stover yield of 4.52 t ha^{-1} and 7.22 t ha^{-1} was recorded in V_2F_3 (BU soybean 2 with 50% more fertilizer than the recommended dose). It may be concluded that the BU soybean 2 (V_2) variety and the F_3 fertilizer dose individually exhibited notable results, but their combination in the V_2F_3 treatment yielded unparalleled performance, achieving the most impressive growth and highest seed and stover yields, highlighting the profound impact of optimizing both variety and fertilizer.

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Full meaning
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
BBS	Bangladesh Bureau of Statistics
Cm	Centi-meter
CV	Coefficient of variation
^{o}C	Degree Celsius
Df	Degrees of freedom
DAS	Days After Sowing
et al.	And others
FAO	Food and Agriculture Organization
g	Gram
Ha	Hectare
J.	Journal
kg	Kilogram
LSD	Least Significant Difference
mg	Milligram
MoP	Muriate of Potash
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
SPAD	Soil Plant Analysis Development
TSP	Triple Superphosphate

CHAPTER I

INTRODUCTION

The Soybean (*Glycine max* L. Merrill) is a species of legume native to East Asia, widely grown for its edible bean that has numerous uses. It is an annual plant of the family Fabaceae which is capable of adding nitrogen into the soil. The Food and Agriculture Organization (FAO) classified soybean as an oilseed rather than a pulse. Soybean cultivation is successful in climates with hot summers, with optimum growing conditions in mean temperatures of 20°C to 30°C. They can grow in a wide range of soils, with optimum growth in moist alluvial soils with good organic matter content. The crop is cultivated to 119 million ha worldwide, with a total annual production of 319 MMT (FAO, 2020). As a grain legume crop it is gaining an important position in the agriculture of tropical countries including India, Sri Lanka, Thailand and Bangladesh. The benefits of soybean are countless. It is considered as miracle crop of 20^{th} Century on account of having high protein and oil content. It contains lysine comparable with cow milk. Soybean oil is either directly used as edible oil or for manufacturing of vanaspati ghee. It is widely used in variety of foods and also in production of different antibiotics. Moreover, it contains minerals such as Fe, Cu, Mn, Ca, Mg, Zn, Co, P and K. Vitamins B_1, B_2 and B_6 are also available in soybean grains (Messina, 1997). Soybean oil is rich in polyunsaturated fatty acids, including the two essential fatty acids: linoleic and linolenic (Khan *et al.,* 2015). It serves as source of food and feed for human and animal, respectively. Tripsin inhibitor is a major anti– nutritional factor in soybean. The seeds of soybean contain 42-45% protein as well as 22% edible oil (Mondal *et al.,* 2002) and 24-26% carbohydrate (Gowda and Kaul, 1982), nutritional superiority on account of containing essential amino acids, unsaturated fatty acids and carbohydrates (Pawar *et al.,* 2011).

In Bangladesh, soybean is called the Golden bean. It is the most popular oil crops in Bangladesh, however, grown in scanty arable area. According to the April 2021 projection of the United States Department of Agriculture (USDA), Bangladesh's current yearly demand for soybean oil stands at 1.3 million tons and that of palm oil 1.6 million tons. Bangladesh is heavily dependent on import to meet its oils and fats requirements. With 0.8 million tons of yearly crude soybean oil imports, Bangladesh stands behind only India and China among top oil and oilseed importing countries. Each year, Bangladesh pays a whooping import bill of 2 billion dollars to meet its edible oil needs (Dhaka Tribune, 2021). Out of total oil copped area, Soybean occupied about 0.142 million acres land and production of soybean was around 0.092 million tons per year (BBS, 2020). 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).

Soil fertility reduction is one of the major challenges to crop production and productivity (Amsal and Tanner, 2001). Soil fertility depletion in smallholder farmers is the basic root cause for declining production and productivity of soybean (Mafongoya *et al.,* 2006). Use of blended or balanced fertilizers containing both macro and micronutrients is one of the key solutions suggested to resolve the soil fertility problems. Inorganic fertilizers are source of mineral elements, which plants required for effective growth and development. Nitrogen is a chlorophyll component and it promotes vegetative growth and green coloration of foliage (Joshi and Biliore, 1988). 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 are 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). Potassium (K) has also an important role in regulating the water loss of plants thus help to prevent plant from necrosis. It serves as an activator of enzymes used in photosynthesis and respiration, helps to build cellulose and aids in photosynthesis by the formation of a chlorophyll precursor and finally results in quality fruits (Nziguheba *et al.,* 1998). Application of sulphur improved nitrogenase activity, nitrogen fixation, plant dry matter and quality of soybean grain in sulphur deficient soil (Kandpal and Chandel, 1993). Sulphur is involved in the synthesis of fatty acids and also increases protein quality through the synthesis of certain amino acids such as cysteine, cysteine and methionine (Havlin *et al.,* 1999). World-wide, boron deficiency is more extensive than any other plant micronutrients (Gupta, 1979). Boron deficiency in soybean was first documented in some soybean producing areas in Arkansas (Slaton *et al.*, 2002). The possible roles of B include sugar transport, cell wall synthesis, lignifications, cell wall structure integrity, carbohydrate metabolism, ribose nucleic acid (RNA) metabolism, respiration, indole acetic acid (IAA) metabolism, phenol metabolism, and as part of the cell membranes (Ahmad *et al.*, 2009)

Keeping all the points in mind mentioned above, the present piece of research work was under taken with the following objectives:

- To observe the yield of different soybean varieties released under different organization,
- To find out the suitable fertilizer level for better yield of soybean, and
- To find out the suitable combination of variety and fertilizer level for high yield of soybean.

CHAPTER II

REVIEW OF LITERATURE

Soybean is one of the leading oil and protein containing crops of the world. The crop has conventional less attention by the researchers on various aspects because normally it grows with minimum care or management practices. However, researches are going on in home and abroad to maximize the yield of soybean with different management practices especially on NPK fertilizer, spacing, variety, weeding, biofertilizers etc. But research works related to variety and nutrient management are limited in Bangladesh context. However, some of the important and informative works and research findings related to the integrated nutrient management so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1 Effect of varieties on growth and yield of soybean

Saha and Islam (2022) carried out an experiment with ten soybean genotypes to assess of yield performance and related attributes of selected soybean genotypes in southwest coastal region of Bangladesh. The highest seed yield per plant was observed in BINA Soybean-5 (14.302 g) followed by BINA Soybean-2 (14.225 g) while BINA Soybean-6 produced the lowest seed yield (8.495 g) and showed inferior yield attributes. BD-4 was the early matured variety and required 101 days to attain maturity while BINA Soybean-2 and BINA Soybean-5 required 106 days to mature fully. Among the selected ten varieties, BINA Soybean-2 and BINA Soybean-5 showed superior performances than other varieties.

Chakma *et al.* (2015) conducted an experiment with four soybean genotype (BARI soybean 6, BD 2329, BD 2331 and BD 2340 to evaluate the effects of different levels of chemical fertilizers (nitrogen, phosphorus, potassium, sulpher and boron) on yield of soybean. The results indicated that the number of pods, seeds per pod, 100- seed weight and seed yield were high with recommended doses of fertilizers. The maximum number of pods er plant (47.8), maximum number of seeds per pod (2.63) and the highest 100-seed weight (26.6 g) were recorded in T_2 fertilizer treatment in the genotypes BD 2340 and BD 2329, respectively. The genotype BD 2329 produced the highest seed yield (2.15 t ha^{-1}) in T_2 treatment followed by BARI Soybean 6 (2.08 t ha^{-1}) in T_3 treatment.

Rahman (2005) reported from BAU-USDA soybean project that plant height of the soybean genotype PB-1 (Shohag) was 24.28 cm, CM3 was 72.11 cm, F85-l 1347 was Sl.70 cm, GC-840079-5-l was 75.40 cm and AGS-276 was 59.90 cm. The plant height of the genotype PB-l (Shohag) was 40.70 cm, CM-3 was 9l.20 cm, F85-H347 was 78.10 cm, GC840079-5-l was 62.20 cm and AGS-276 was 93.I0 cm (Rahrnan, 2004). The observation on the plant height of PB-l (Shohag) was 37.98 cm, CM3 was 55.46 cm, F85-l 1347 was 59.92 cm, GC-840079-5-l was 103.4 cm and AGS-276 was 85.08 cm (Rahman, 2003).

Pedersen and Lauer (2004) reported on two newer released cultivars (CX232 and Spansoy 250) and one older cultivar (Hardin). He reported on 100 seed weight that seed mass ranging from l0.5 to l6.5 g. In November planting the 100 seed weight was counted at the harvest stage of the following genotypes GPB-l was 13.3 g, GPB-2 was 9.24 g, AGS-332 was 24.4 g and AGS-l1-35 was 24.3 g (Uddin, 2004). He also reported that in December planting the 100 seed weight of the following genotypes GPB-l was l3.3 g, GPB-2 was 8.2 g, AGS-332 was 25.0 g and AGS-l l-35 was 30.3 g. Die researchers finding was that I00 seed weight followed a composite trend.

Uddin (2004) stated from his experiment that in November planting the pod weight plant^{-1} of the following soybean genotypes GPB-l was 3.5 g, GPB-2 was 7.1 g, AGS-332 was 3.0 g and AGS-l l-35 was 3.9 g. He also reported that in December planting the pod weight plant^{-1} of the same genotypes GPB-1 was ll.7 g, GPB-2 was 8.4 g, AGS-332 was 10.0 g and AGS-l 1-35 was 9.7 g. The final observation of the researcher was that the pod weight plant^{-1} increased in December planting compared to November one in all genotypes. He also found that in November planting the plant height was counted at the maturity of soybean of the following genotypes GPB-l was 33.9 cm, GPB-2 was 59.6 cm, AGS332 was 34.7 cm and AGS-l 1-35 was 37.0 cm. He also reported that in December planting the plant height of the following genotypes GPB-l was 6.l cm, GPB-2 was 66.9 cm. AGS332 was 58.0 cm and AGS-l l-35 was 52.5 cm. His finding was that plant height was increased in December planting compared to November planting in all genotypes. He also reported that in December planting the number of leaves plant-1 of the genotypes GPB-1 was 11.6, GPB-2 was 11.0, AGS-332 was 9.4 and AGS-11-35 was 5.5. The final observation was the number of leaves plant^{-1} was decreased in December planting compared to

November planting in all soybean genotypes. The final observation of the researcher was that the pod weight plant^{-1} increased in December planting compared to November one in all genotypes.

Rabbani (2001) stated from hid experiment that the number of filled pods plant^{-1} of the following soybean genotypes of BS-3 was 3l.l0, BS-16 was 27.26 and BS-60 was 28.22. The soybean genotype BS-3 has the superior performance than other genotypes.

2.2 Effect of inorganic fertilizer on seed quality and yield of soybean

Agegn *et al.* (2022) carried out a field experiment in 2020/2021 cropping season at Guangua district, North-western Ethiopia to determine the effect of blended NPSZnB (Nitrogen, Phosphorus, Sulfur, Zinc and Boron) fertilizer rates on seed yield and quality of soybean varieties. Five levels of blended NPSZnB fertilizer (0, 50, 100, 150 and 200 kg ha^{-1}) and three soybean varieties (Pawe-01, Pawe-02 and Pawe-03) were arranged in factorial and laid out in randomized complete block design with three replications. Results revealed most growth, yield, yield components and quality traits of soybean were significantly affected by varieties, blended fertilizer rates and by their interaction. Planting variety Pawe-03 with the application of 100 kg ha^{-1} NPSZnB gave the highest grain yield (2.88 t ha^{-1}) and protein content (41.50%). Maximum oil content (24.50%) was recorded when variety Pawe-01 was planted with the application of 100 kg ha^{-1} NPSZnB. Planting Variety Pawe-03 with application of 100 kg ha^{-1} NPSZnB gave the highest net benefit (74953.56 birr ha^{-1}). In conclusion, planting Pawe-03 soybean variety with the application of 100 kg ha^{-1} NPSZnB gave significantly highest seed yield, protein content and profitability and recommended for soybean production in Northwestern agro-ecologies of Ethiopia. It is suggested that this experiment should be repeated in various agro ecologies with various soybean varieties.

Sutharsan *et al.* (2016) conducted a pot experiment under a rain shelter in Agro Technology Park, Eastern University, Sri Lanka 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).

Khanam *et al.* (2016) carried out an experiment to evaluate the effect phosphorus and potassium and their combinations on growth and yield of soybean (*Glycine max*). The treatment of combined phosphorus @ 175 kg ha^{-1} and potassium @ 120 kg MoP ha^{-1} depicted the highest number of filled pods plant^{-1} (63.00), length of pod (3.16 cm), number of seeds pod^{-1} (3.11) vis a vis the highest (3.67 t ha^{-1}) seed yield. Thus, the combined application of 175 kg ha^{-1} TSP and 120 kg ha^{-1} MoP could be the optimum for getting maximum yield of soybean.

Begum *et al.* (2015) found that soybean was 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 (30.95 cm). 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}.

Kuntyastuti and Suryantini (2015) conducted a study 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 (PS1) 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.

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).

The soybean seed yield was significantly increased with the application of sulphur @ 20 kg ha^{-1} (2534 kg ha^{-1}) compared to sulphur levels; 30 kg ha^{-1} (2494 kg ha^{-1}), 40 kg ha^{-1} (2376 kg ha^{-1}) and 10 kg ha^{-1} (2226 kg ha^{-1}) (Hosmath *et al.*, 2014).

Application of different levels of sulphur showed significant effect on yield and yield attributes of soybean. In case of S, the positive response was observed only upto 20 kg S ha^{-1}. Application of sulphur @ 20 kg S ha^{-1} gave rise to the highest number of pods $plant^{-1}$ (30.07), number of seeds $plant^{-1}$ (84.94), thousand seed weight (94.61 g), and in turn produced highest seed yield (2.29 t ha^{-1}) (Akter *et al.*, 2013). The levels of sulphur @ 30 kg ha^{-1} showed significantly highest content and uptake in grain and stover (Yadav *et al.*, 2013).

Khaim *et al.* (2013) conducted a field experiment 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%, which was statistically different from other treatments but identical with RDCF75% + PM1 t ha^{-1}. The shortest plant (25.47 cm) was found in control, which was statistically identical with CD 10 t ha^{-1}.

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

Singh *et al.* (2012) observed that application of 2.0 kg ha^{-1} B recorded better yield attributes (branches plant^{-1}, pods plant^{-1}, seeds pod^{-1} and 100 seed weight and higher yield) than the other treatments.

Seidel and Basso (2012) observed that application of B did not influence soybean yield in any application stage and the yield components (pod number plant^{-1}, grain number pod^{-1}, grain weight) did not differ significantly with application to leaf spraying of B, probably due to their adequate content in soil and water availability during the growing season.

Chaturvedi *et al.* (2012) observed that soybean yield attributed viz., pods/plant, seeds/pod and hundred seed weight were increased significantly by the addition of boron and FYM at the fertility levels of 50% and 100% NPK.

Devi *et al.* (2012) found from an experiment that application of 1.5 kg B ha^{-1} were found to be the optimum levels of boron for obtaining maximum yield attributes.

Huang *et al.* (2012) reported from a field experiment that P and B treatments significantly affected soybean growth, and there were significant interactions between P and B. Among which, P availability was the primary factor on soybean growth and B uptake. At the same B level, increasing P availability could significantly increase soybean plant dry mass, grain yield and P, B uptake. At the normal P level, increasing B availability only increased plant dry mass and P, B uptake of the P efficient genotypes, but not the P inefficient genotypes, particularly at mature stage. Improving B status could significantly increase the yield of P efficient soybean genotypes.

El-Yazied and Mady (2012) Foliar application with boron and yeast extract either individually or in a mixture, significantly stimulate many growth aspects as number of leaves per plant, dry weights of both stems and leaves per plant, total leaf area and absolute growth rate as compared with the control treatment.

Arora *et al.* (2012) found that optimum concentration of boron needed to mitigate the harmful effect of salinity at early establishment of seedlings including seed germination.

Xiang et al. (2012) carried out a field experiment 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 pod^{-1} (1.20).

Singh *et al.* (2011) found that micronutrients boron has shown significant impact on plant metabolism absorption and translocation of materials synthesis of essential macro and micro molecule and enzyme synthesis and their activity regulation.

Pable and Patil (2011) reported from a field experiment that application of 30 kg S ha^{-1} and 2.5 kg Zn ha^{-1} with fertilizer dose of 30:75:0 kg NPK ha^{-1} recorded higher seed yield and straw yield. Total uptake of nutrients and micronutrients was recorded significantly highest in same treatment after harvest of crop.

Farhad *et al.* (2010) conducted a field experiment was at the Sher-e-Bangla Agricultural University Farm, Dhaka 1207 to study the role of potassium and sulphur on the growth, yield and oil content of soybean. The experimental soil was clay loam in texture having pH of 6.3. The experiment included four levels of potassium viz. 0, 20, 40 and 70 kg K ha^{-1} and four levels of sulphur viz. 0, 10, 20 and 40 kg S ha^{-1}. Application of of sulphur @ 20 kg ha^{-1} produced the highest plant height, seed yield, 1000-seed weight and straw yield.

Falodun and Osaigbovo (2010) carried out a field experiment to found out the effect of packaged organic and inorganic fertilizers on the growth and yield of soyabean (*Glycine max* (L) merr.) 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.

Boron is considered as an essential element for plant growth and development. Sexual reproduction in plant is more sensitive to low B, than vegetative growth (Ahmad *et al.,* 2009).

Manchanda *et al.* (2006) conducted a field experiment in Ludhiana, Punjab, India, on a loamy sand soil to study the effects of S fertilizer with 0, 7.5, 15.0 and 30 kg S/ha as gypsum on soybean cv. SL 295. The grain yield of soybean increased by 23.1 and 30.5% over the control with application of 7.5 and 15.0 kg S/ha, respectively. The availability of Zn, Cu, Fe and Mn in soil, and the concentrations of these nutrients increased significantly due to S application. He reported from the study that the grain yield of soybean increased by 23.1 and 30.5% over the control with application of 7.5 and 15.0 kg S/ha, respectively. The availability of Zn, Cu, Fe and Mn in soil, and the concentrations of these nutrients increased significantly due to S application.

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

Vijayapriya *et al.* (2005) mentioned that nutrient availability was significantly influenced by the addition of S compared to the control. The availability of N, P, K and S was the highest at 30 kg S ha^{-1}.

Arshad *et al.* (2005) conducted an experiment and found significant effects of sulphur and nitrogen, when applied together, on the growth characteristics, yield components, and seed and oil yield. Maximum response was observed with treatment with 40 kg S and 43.5 kg N ha^{-1}. The results obtained in these experiments clearly suggest that balanced and judicious application of nitrogen and sulphur can improve both seed and oil yield of soybean cultivars by enhancing their growth.

Gokhale *et al.* (2005) conducted a field experiment to study the effect of different S levels as 0, 10, 20, 30, 40 and 50 kg ha^{-1} on soybean in Maharashtra, India. Application of increasing S levels up to 30 kg ha^{-1} increased the seed yields over the control. Thus, the highest soybean yield of 25.1 q ha^{-1} was observed at 30 kg S ha^{-1}.

Treatments with 40 and 50 kg S ha^{-1} slightly reduced the yields as the soil under study was marginally low in S content (9.6 mg kg^{-1}) which showed responses to lower S levels. S application increased N and S availability in soil. Oil contents in soybean increased with increasing S levels up to 30 kg ha^{-1}. Thereafter, 40 and 50 kg S ha^{-1} showed a declining trend. Available N and S contents in the soil also increased with increasing S levels applied to soybean.

Sarkar and Saha (2005) conducted an experiment in West Bengal, India. found that sesame CV-13-67 produced 10.4% higher seed yield at the rate of 1 kg B ha^{-1} compared to the control.

Sharma *et al.* (2004) conducted an experiment to find out the effects of S rate (0, 10, 20 or 30 kg ha^{-1}) and source (50% through ammonium sulfate + 50% through elemental S or compound fertilizer 13-33-0-15S) on the performance of soyabean (cv. JS 335) grown on Typic Haplusterts and on soil properties were studied in Indore, Madhya Pradesh, India and observed that the values of the evaluated parameters increased as the S rate increased and when the compound fertilizer was applied. Thus, 30 kg S ha^{-1} supplied resulted in the highest number of pods plant^{-1} (50.0), number of seeds pod^{-1} (2.08), 100-grain weight (11.94 g), grain yield (1747 kg ha^{-1}), straw yield (2214 kg ha^{-1}) and oil content (20.19%).

Sangale *et al.* (2004) conducted a field experiment to investigate the effects of S fertilizer sources (single super phosphate, elemental S and gypsum) and levels (0,10 and 20 kg ha^{-1}) on the seed yield, quality and S uptake of soybean cv. JS 335 grown on deep black soil in the Marathwada region of Maharashtra, India. Gypsum and single super phosphate were given at the time of sowing whereas elemental S was applied 15 days before sowing. Application of S at 20 kg ha^{-1} gave highest yield.

Mohanti *et al.* (2004) conducted a field experiment at Raipur, Chhattisgarh, India to evaluate the effect of different levels of S as 0, 10, 20 and 30 kg ha^{-1} on soybean cv. JS-335. Data were recorded for plant height, number of branches plant^{-1} and seed yield. S at 30 kg ha^{-1} recorded the highest values for these parameters. Net realization per investment was highest with S at 20 kg ha^{-1}, followed by S at 30 kg ha^{-1}.

Rajni and Meitei (2004) conducted a field experiment and reported that combined application of boron (1.0 ppm) and zinc (0.10 ppm) after 20 and 40 days of sowing of the seeds was found to be beneficial for growth in terms of plant height, leaf number, branch number and shoot weight, earliness, yield in terms of number, length, fresh weight, dry weight and percent dry matter of pod and number of seeds pod^{-1}.

Reddy *et al.* (2004) conducted a field experiment on a Typic Haplustert from 1992 to 1995 where in the annual treatments included four rates of fertilizer P (0, 11, 22 and 44kg ha^{-1} applied to both soybean and wheat) in the absence and presence of 16 t ha of manure (applied to soybean only). They observed that with regular application of fertilizer P to each crop the level of Olsen P increased significantly and linearly through the years in both manured and unmanured plots. The mean P balance required to raise Olsen P by I mg kg^{-1} was 17.9 kg ha^{-1} of fertilizer P in unmanured plots and 5.6 kg hi' of manure plus fertilizer P in manured plots.

Liu *et al.* (2003) studied the effects of Mo and B, alone or in combination, on seed quality of pot growth soybean cultivars Zhechum 3, Zhccliun 2, and 3811. Application of Mo and/or B increased the content of protein, in dispensable amino acids, total amino-acids (excluding proline), N. P, K and decrease the content of Ca and oil.

Praharaj *et al.* (2003) conducted a pot culture experiment using a clay loam soil to investigate the effect of S application and *Bradyrhizobium japonicum* inoculation on nodulation, nitrogenase activity and yield of soyabean cv. CO1. Sulfur was applied as 0, 7.5, 15.0 and 30.0 kg ha^{-1} through gypsum with or without *B. japonicum* inoculation. With increasing levels of S, there was gradual increase in seed yield.

Deasarker *et al.* (2001) conducted an experiment with soybean, was given 2, 4 and 6 kg B ha^{-1} 2 kg B ha^{-1} was the best among the boron treatment for increasing seed yield.

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

P_2O_5 - K_2O kg ha^{-1}), T_8 = Compost + 30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}), T_9 = Inoculants + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}), T_{10} = Compost + 00-00-00 (N - P_2O_5 - K_2O kg ha^{-1}) and T_{11} = Compost + inoculants +30-60-30 (N - P_2O_5 - K_2O kg ha^{-1}). They reported that, the highest plant height (103.50 cm) obtained under T_7 (Compost + 60-60-30), then (102.50 cm) T_1 (100-60–30) at 56 DAS and the lowest plant height (83.30 cm) obtained under T_4.

Singh *et al.* (2001) conducted a field experiment in New Delhi, India to assess the growth characteristics, seed and oil yield of two cultivars of soybean, in relation to sulfur and nitrogen nutrition. Six combinations of two levels of sulfur (0 and 40 kg ha^{-1}) and two levels of nitrogen (23.5 and 43.5 kg ha^{-1}) were applied as nutrients. Results indicated significant effect of sulfur and nitrogen, when applied together, on the growth characteristics, yield components, and seed and oil yield. Maximum response was observed with 40 kg S and 43.5 kg N ha^{-1}.

Tomar *et al*. (2000) conducted a field experiment at College of Agriculture, Indore, Madhya Pradesh, India, to study the effect of various levels and sources of sulfur on yield and biochemical composition of soybean. The treatments comprised 5 levels of S as10, 20, 30, 40 and 50 kg ha^{-1} and 3 sources, sulfur, along with an absolute control. Findings revealed that the highest seed yield, protein and oil content of 2257 kg ha^{-1}, 41.29% and 20.51%, respectively, were recorded with the application of 50 kg S ha^{-1} regardless of sources.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the research field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2021 to April 2022 to find out the suitable combination of variety and fertilizer level for better yield of soybean. This chapter will deal with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and data analysis. The details are presented below under the following headings:

3.1 Experimental site

The study was conducted at central research field of Sher-e-Bangla Agricultural University, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. The location of the site is $23^{0}74$/N latitude and $90^{0}35$/E longitude with an elevation of 8.2 meter from sea level. The location of the experimental field was presented in Appendix I.

3.2 Climate

The experimental area is situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of April to September (Kharif Season) and scanty rainfall during the rest period of the year (Biswas, 2000). The Rabi season (October to March) is characterized by comparatively low temperature and plenty of sunshine from November to February (SRDI, 1991). The detailed meteorological data in respect of air temperature, relative humidity, total rainfall and soil temperature recorded by the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka during the period of study have been presented in Appendix II.

3.3 Soil

The soil belongs to “The Modhupur Tract”, AEZ – 28. Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish- brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix III.

3.4 Planting material

For fulfilling the objectives of the experiment four soybean varieties were selected as planning materials. They were:

- BINAsoybean-5
- BU soybean 2
- BARI Soybean-5
- BARI Soybean-6

3.5 Collection of the varieties

Variety	Source
BINAsoybean-5	Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh
BU soybean 2	BSMRAU (Bangabandhu Sheikh Mujibur Rahman Agricultural University), Gazipur
BARI Soybean-5	Bangladesh Agricultural Research Institute (BARI), Gazipur
BARI Soybean-6	Bangladesh Agricultural Research Institute (BARI), Gazipur

3.6 Experimental details

3.6.1 Treatments

The experiment consists of 2 factors, they were

Factor A: Variety-4

i) V_1 = BINAsoybean-5

ii) V_2 = BU soybean 2

iii) V_3 = BARI Soybean-5

iv) V_4 = BARI Soybean-6

Factor B: Different fertilizer doses-4

i) F_0 = Control (no fertilizer)

ii) F_1 = 50% less than RDF

iii) F_2 = Recommended dose of fertilizer (RDF) (Urea 50 kg ha^{-1}, TSP 150 kg ha^{-1}, MoP 100 kg ha^{-1}, Gypsum 80 kg ha^{-1}, Boron 8 kg ha^{-1}) (BARI, 2019)

iv) F_3 = 50% more than RDF

Treatment Combination

V_1F_0 = BINAsoybean-5 × Control
V_1F_1 = BINAsoybean-5 × 50% less than RDF
V_1F_2 = BINAsoybean-5 × Recommended dose of fertilizer (RDF)
V_1F_3= BINAsoybean-5 × 50% more than RDF
V_2F_0 = BU soybean 2 × Control
V_2F_1 = BU soybean 2 × 50% less than RDF
V_2F_2 = BU soybean 2 × Recommended dose of fertilizer (RDF)
V_2F_3 = BU soybean 2 × 50% more than RDF
V_3F_0 = BARI Soybean-5 × Control
V_3F_1 = BARI Soybean-5 × 50% less than RDF
V_3F_2 = BARI Soybean-5 × Recommended dose of fertilizer (RDF)
V_3F_3 = BARI Soybean-5 × 50% more than RDF
V_4F_0 = BARI Soybean-6 × Control
V_4F_1 = BARI Soybean-6 × 50% less than RDF
V_4F_2 = BARI Soybean-6 × Recommended dose of fertilizer (RDF)
V_4F_3 = BARI Soybean-6 × 50% less than RDF

3.7 Land preparation

The land was first opened by a tractor in November 2021 and prepared thoroughly by ploughing and cross ploughing with a power tiller followed by country plough. Laddering followed by ploughing was done to level the soil. The corners of the land were spaded and larger clods were broken into smaller pieces after ploughing and laddering all the stubbles and uprooted weeds were removed and the land was ready.

3.8 Experimental design and layout

The experimental land was carried out with Randomized Complete Block Design (RCBD) plot design with three replications. An area of 10.5 m × 25.0 m was divided into three rows. The total number of plots was 16. The size of each unit plot was 3 m × 1.0 m. The space between two adjacent replications was 0.50 m. The space between two adjacent rows was 0.5 m. The layout was done at 27 November, 2020.

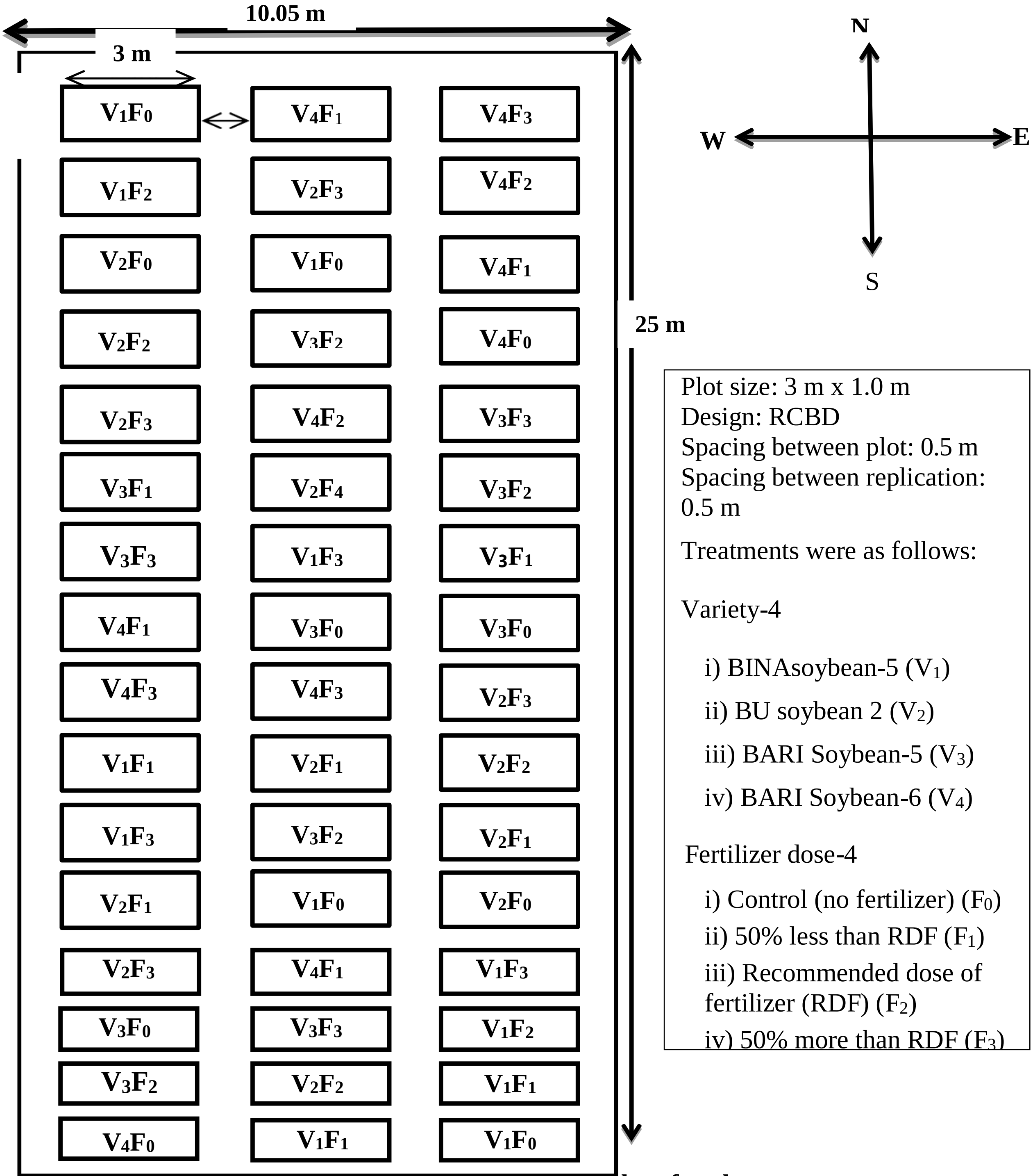


Figure 1: Layout of the experimental plot of soybean

3.9 Fertilizer application

N, P, K, S and B fertilizers were applied in the form of urea, TSP, MoP, Gypsum and Boron according the Bangladesh Agricultural Research Institute (BARI) recommendation (BARI, 2019). All of the fertilizers were applied in broadcast during final land preparation as per treatment.

3.10 Growing of crops

3.10.1 Sowing of seeds

Seeds were sown at the rate of 40 kg ha^{-1} in the furrow on 20^{th} December, 2021 and the furrows were covered with the soils soon after seeding. The line to line (furrow to furrow) distance was maintained 30cm as per treatment arrangements with continuous sowing of seeds in the line.

3.10.2 Germination of seeds

Seed germination occurred from 5^{th} day of sowing. On the 8^{th} day the percentage of germination was more than 85% and on the 10^{th} day nearly all baby plants (seedlings) came out of the soil.

3.11 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done.

3.11.1 Thinning

Emergence of seedlings was completed within 10 days after sowing. Overcrowded seedlings were thinned out for two times. First thinning was done after 20 days of sowing which was done to remove unhealthy and lineless seedlings. The second thinning was done 10 days after first thinning.

3.11.2 Weeding

First weeding was done at 15 DAS and second one at 35 DAS to keep the plots free from weeds and to keep the soil loose and aerated with optimum plant population.

3.11.3 Irrigation

The first irrigation was done at 20 DAS. Second irrigation was provided at 55 DAS. Proper drainage facility was also provided for draining out excess water.

3.11.4 Insect and pest control

The experimental crop was infested by hairy caterpillars (*Diacrisia oblique*) and cutworms at the early growth stage, which were controlled by applying Sumithion 50 EC @ 1.0 L ha^{-1}. Hand-picking of infested leaves was also done as a control measure. Autostine 50 WDG @ 2.0 L ha^{-1} was used to control the fungal disease from the field. Diseased or off-type plants were uprooted as and when required but these were not recorded.

3.12 General observations of the experimental field

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

3.13 Sampling

Five plants were collected randomly from each plot. These 5 plants were used for recording yield component data.

3.14 Harvesting

Maturity of crop was determined when 95 % of the pods become brown in colour. Five sample selected 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 quadrate for recording yield data. Harvesting was completed on April 9, 2022. 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.

3.15 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.

3.15 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.

3.16 Cleaning and weighing

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

3.17 Yield components

The following data was recorded-

A. Growth characteristics data

i. Plant height (cm)
ii. Number of leaves $plant^{-1}$ (no.)
iii. Number of primary branches $plant^{-1}$ (no.)
iv. Dry weight $plant^{-1}$ (g)
v. SPAD value
vi. Leaf area (cm^2)

B. **Yield attributes data**

i. Number of pods $plant^{-1}$ (no.)
ii. Number of seeds pod^{-1} (no.)
iii. Weight of 100 seeds (g)

C. Yield data

i. Grain yield (t ha^{-1})
ii. Stover yield (t ha^{-1})
iii. Harvest index (%)

3.18 Procedure of recording growth data

3.18.1 Plant height

The height of the soybean plants was recorded from 25 days after sowing (DAS) at 25 days interval up to 75 DAS and at harvest. The plant height was counted as beginning from the ground level up to tip of the top leaf. The average height of five plants randomly selected was considered as the height of the plant for each plot.

3.18.2 Number of leaves plant^{-1}

Total number of leaves plant^{-1} was taken from 25 DAS at 25 days interval up to 75 DAS and at harvest. The average number of leaves plant^{-1} of five plants was considered as the number of leaves plant^{-1} for each plot.

3.18.3 Number of primary branches plant^{-1}

Total number of branches plant^{-1} was taken from 25 DAS at 25 days interval up to 75 DAS. The average number of branches plant^{-1} of five plants was considered as the number of branches plant^{-1} for each plot.

3.18.4 Dry weight plant^{-1}

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 4 times at 30, 60, 90 and at harvest.

3.18.5 SPAD value

Chlorophyll content of leaf was measured by SPAD meter (SPAD 502 chlorophyll meter). Data was recorded from 3 leaves of each sampling plant and at four stages i.e 25, 50, 75 and 90 DAS.

3.18.6 Leaf area

The length and width of five selected leaves from each of the five tag plants were measured by a scale during the harvest. Leaf area was calculated by using the following formula:

Leaf area (cm^2) = Leaf length (cm) x leaf breadth (cm)

3.18.7 Number of pods plant^{-1}

Numbers of total pods of selected plants from each plot were counted and the mean numbers were expressed as plant^{-1} basis. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.18.8 Number of seeds pod^{-1}

The number of seeds pods^{-1} was recorded from randomly selected 20 pods at the time of harvest. Data were recorded as the average of 20 pods from each plot.

3.18.9 Weight of 100 seeds

One thousand cleaned dried seeds were randomly collected from the seed stock of each plot and were sun dried properly. These dried seeds were weighed using an electric balance and the weight was expressed in gram.

3.18.10 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.

3.18.11 Stover yield

After separation of seeds from plants, the straw and shell of harvested 1 m^2 area was sun dried and the weight was recorded and then converted to t ha^{-1}.

3.18.12 Biological yield

Biological yield was calculated by using the following formula:

Biological yield = Seed yield + Stover yield

3.18.13 Harvest index (%)

Harvest index was calculated from the grain and straw yield of soybean for each plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.19 Data analysis

The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program. The mean values for all the parameters were calculated and analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Least Significant Different (LSD) at 5% levels of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to determine the effect of different fertilizer level on the yield performance of soybean varieties. Data on different growth parameter, yield attributes and yield parameters were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix IV-XXX. The results have been presented and possible interpretations given under the following headings:

4.1 Plant height

4.1.1 Effect of variety

The plant height of soybean was significantly influenced by varieties at different days after sowing (DAS) (Figure 2). The figure shows that plant height increased gradually with the advances of growth stages irrespective of varieties. The highest increase was found at harvest stage. However, at 25 DAS, the variety BU soybean 2 produced (V_2) the tallest plant (20.24 cm) which was statistically at par with V_1 (BINAsoybean-5) (19.47 cm) and the variety BARI Soybean-5 gave the shortest plant (17.89 cm) which was statistically similar with V_4 (BARI Soybean-6) (18.58 cm). At 50 DAS, 75 DAS and at harvest, BU soybean 2 gave the tallest plant (45.82, 56.99 and 59.55 cm, respectively) and BARI Soybean-5 produce the shortest plant (35.19, 46.45 and 49.62 cm, respectively). The dissimilarity in plant tallness might be attributed due to variations in genotypic constituents. The results of the experiment are in agreement with Saha and Islam (2022), who observed the tallest plant at harvest (53.44 cm) in case of BINAsoybean-5 and the lowest plant highest at harvest (42.43 cm) in case of BINAsoybean-2. Khan *et al.* (2015) and Sultana *et al.* (2015) have reported high variability in plant height of different soybean varieties. Haque (2018) also found the similar result, who observed the tallest plant at harvest (53.40 cm) in the case of BINAsoybean-5 and the shortest plant at harvest (40.59 cm) in case of Shohag (PB-1).

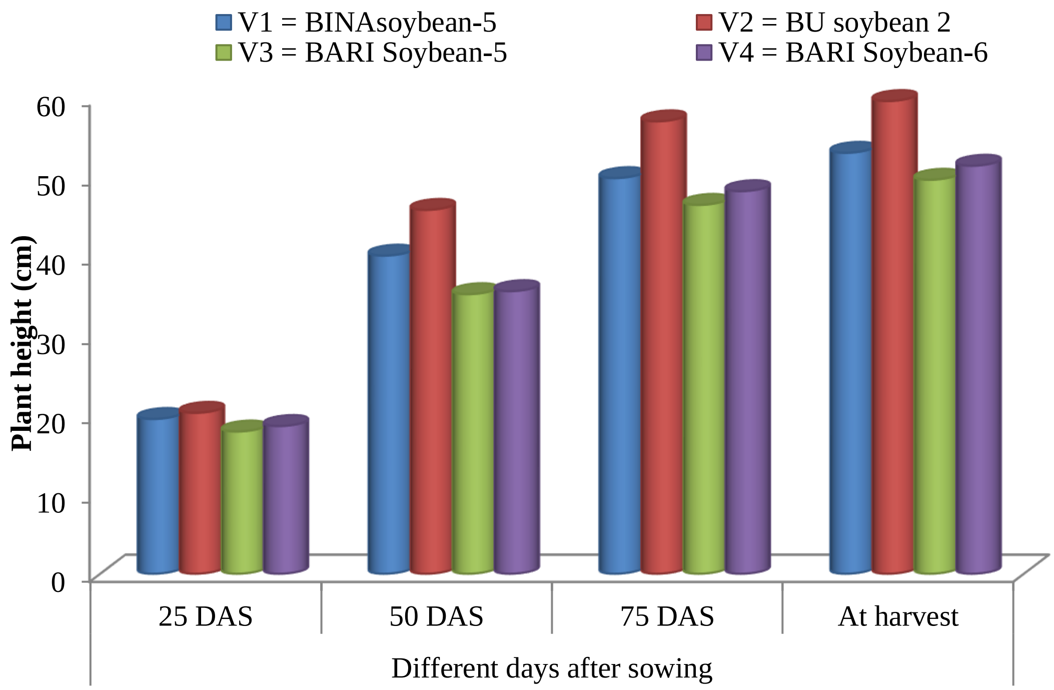


Figure 2. Effect of variety on plant height of soybean at different days after sowing ($LSD_{0.05}$ = 1.12, 2.84, 4.47 and 4.80 at 25, 50, 75 DAS and at harvest, respectively)

4.1.2 Effect of fertilizer level

Statistically significant variation was recorded for plant height of soybean due to the application of different doses of fertilizers at 25, 50, 75 DAS and at harvest (Figure 3). The figure indicates that irrespective of inorganic fertilizers doses, plant height increased progressively with the advance of growth stages and the highest increase was found at harvest stage. At the different days after sowing (DAS) the tallest plant (21.01 cm, 45.26 cm, 57.29 cm and 60.28 cm) was recorded from F_3 (50% more than recommended dose of fertilizer (RDF) at 25, 50, 75 DAS and at harvest, respectively. On the other hand, at the same DAS the shortest plant (16.07 cm, 32.76 cm, 41.82 cm and 44.85 cm) was observed from F_0 as fertilizer control condition. From the data it was revealed that all doses of fertilizer treatments produced significantly taller plants compared to the control treatment. The significant increase in plant height observed by plants treated with fertilizer may be attributed to internodes elongation and other nutrients received by the plant from both organic and inorganic sources. This observation confirms the findings of Espinoza (2001), Khaim *et al.* (2013) and Falodun *et al.* (2015). Falodun and Osaigbovo (2010) reported that nutrients in inorganic are readily available for plant up take upon application while the organic forms of nutrients are slowly available. So, there is a continuous supply of nutrient to the plant up to maturity. Babalad (1999) had observed increased plant height in soybean due to the application of different doses of organic manure and inorganic fertilizers. Arslan *et al.* (1993) reported that different doses of potassium and sulphur fertilizers from organic and inorganic sources had significant effect on the plant height of soybean. Nitrogen fertilization increased the plant height (Akbari *et al.*, 2001). Myint *et al.* (2009) added that chemical fertilizer application provided better plant growth due to its higher nutrient availability and rapid nitrogen mineralization power.

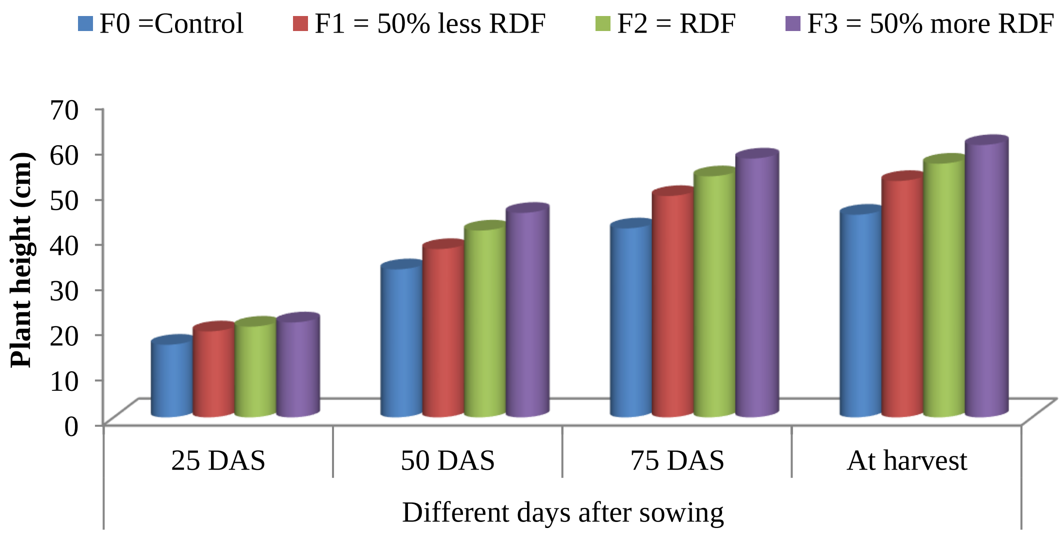


Figure 3. Effect of different fertilizer level on plant height of soybean at different days after sowing ($LSD_{0.05}$ = 1.12, 2.84, 4.47 and 4.80 at 25, 50, 75 DAS and at harvest, respectively)

4.1.3 Combine effect of variety and fertilizer level

Combine effect of variety and different fertilizer level showed significant variation on plant height of soybean at 25, 50, 75 DAS and at harvest (Table 1). At 25 DAS, the longest plant (22.10 cm) was observed from the V_2F_3 (BU soybean 2 with 50% more than recommended dose of fertilizer (RDF) treatment and the shortest plant (14.79 cm) was observed from V_4F_0 treatment. Similarly, at 50 DAS, 75 DAS and at harvest, the height plant height (52.60 cm, 64.51 cm and 67.55 cm, respectively) was observed from the V_2F_3 (BU soybean 2 with 50% more than recommended dose of fertilizer (RDF) treatment and the lowest plant height (29.79 cm, 40.53 cm and 43.53 cm, respectively) was observed from V_4F_0 (BARI Soybean-6 with fertilizer control condition) treatment.

Table 1. Combine effect of variety and different fertilizer level on plant height of soybean at different days after sowing

Treatment	Plant height (cm) at			
	25 DAS	50 DAS	75 DAS	At harvest
V_1F_0	17.03 d-f	34.27 h-k	41.41 ef	44.42 de
V_1F_1	18.82 b-d	37.45 f-g	48.11 c-f	51.72 c-e
V_1F_2	20.19 ab	42.54 c-e	52.52 b-d	55.66 bc
V_1F_3	21.82 a	45.93 bc	57.28 a-c	60.30 a-c
V_2F_0	17.17 d-f	36.82 g-i	46.89 d-f	49.77 c-e
V_2F_1	20.63 ab	44.82 b-d	55.75 a-d	58.03 a-c
V_2F_2	21.06 ab	49.22 ab	60.82 ab	62.86 ab
V_2F_3	22.10 a	52.60 a	64.51 a	67.55 a
V_3F_0	15.29 ef	30.35 jk	38.44 f	41.74 e
V_3F_1	17.53 c-e	34.60 h-k	46.28 d-f	49.66 c-e
V_3F_2	19.21 b-d	35.17 h-i	48.54 c-f	51.42 c-e
V_3F_3	19.54 a-d	40.65 d-g	52.55 b-d	55.66 bc
V_4F_0	14.79 f	29.79 k	40.53 f	43.45 e
V_4F_1	19.14 b-d	32.15 i-k	45.83 d-f	49.85 c-e
V_4F_2	19.82 a-c	38.45 e-h	51.52 b-e	54.65 b-d
V_4F_3	20.57 ab	41.87 c-f	54.83 a-d	57.61 a-c
LSD $_{(0.05)}$	**2.24**	**4.57**	**8.94**	**9.60**
CV (%)	**7.05**	**7.00**	**10.64**	**10.78**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6; F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

4.2 Number of leaves plant^{-1}

4.2.1 Effect of variety

The number of leaves per plant was significantly influenced by different varieties of soybean at 25, 50 and 75 DAS (Table 2). The result revealed that at 25 DAS, the variety BU soybean 2 (V_2) produced the highest number of leaves plant^{-1} (5.69) which was statistically similar with V_1 (5.55) and V_3 (5.40) and the variety BARI Soybean-6 (V_4) gave the lowest number of leaves plant^{-1} (5.08). At 50 DAS, the variety BU soybean 2 (V_2) produced the highest number of leaves plant^{-1} (33.98) which was statistically different from all other varieties and the variety BARI Soybean-6 gave the lowest number of leaves plant^{-1} (27.05) which was statistically similar with V_3 variety (28.00) and the same trend was observed for those varieties at 75 DAS, where the maximum leaves plant^{-1} (42.29) was recorded from V_2 (BU soybean 2) variety and the lowest leaves plant^{-1} (34.52) was recorded from V_4 (BARI Soybean-6). Number of leaves plant^{-1} can be different in different varieties due to genetical build-up of the varieties. Genotypic variation in total number of leaves plant^{-1} during different growth stages was also reported by (Amin *et al.*, 2009). Khan *et al*. (2015) and Sultana *et al.* (2015) have reported that variation in leaf number among soybean varieties was responsible for the dissimilarity in leaf area index (LAI) at different growth stages. The results of the experiment are in agreement with Saha and Islam (2022), who counted the highest number of leaves plant^{-1} in BINAsoybean-3 and the lowest number of leaves plant^{-1} in BARI Soybean-6.

4.2.1 Effect of fertilizer level

Statistically significant variation was recorded for number of leaves plant^{-1} of soybean due to the application of different doses of fertilizers at 25, 50 and 75 DAS (Table 2). At the different days after sowing, the maximum number of leaves per plant (6.06, 36.18 and 46.10, respectively) at 25, 50 and 75 DAS was observed from F_3 (50% more than recommended dose of fertilizer (RDF) which was followed by F_2 (recommended dose of fertilizer (RDF) (5.76, 33.98 and 41.23, respectively). Again, at the same DAS, the minimum number of leaves per plant (4.57, 21.32 and 29.33, respectively) was observed from F_0 as fertilizer control condition. It was revealed that all the fertilizer treatments produced significantly higher number of leaves compared to the control treatment.

Table 2. Effect of variety, different fertilizer level and their interaction on leaf number per soybean plant at different days after sowing (DAS)

Treatment	Number of leaves plant^{-1} at		
	25 DAS	**50 DAS**	**75 DAS**
Different soybean variety			
V_1	5.55 ab	30.59 b	39.11 b
V_2	5.69 a	33.98 a	42.29 a
V_3	5.40 ab	28.00 c	36.92 b
V_4	5.08 b	27.05 c	34.52 c
LSD (0.05)	**0.48**	**2.00**	**2.22**
Different doses of fertilizer			
F_0	4.57 c	21.32 d	29.33 d
F_1	5.33 b	28.14 c	36.19 c
F_2	5.76 ab	33.98 b	41.23 b
F_3	6.06 a	36.18 a	46.10 a
LSD (0.05)	**0.47**	**2.00**	**2.22**
Combine effect of variety and fertilizer			
V_1F_0	4.92 b-d	21.64 gh	30.35 fg
V_1F_1	5.42 ab	27.33 ef	37.48 cd
V_1F_2	5.75 ab	35.85 a-c	42.25 bc
V_1F_3	6.10 a	37.55 ab	46.37 b
V_2F_0	5.12 a-c	24.80 fg	32.66 ef
V_2F_1	5.61 ab	33.69 b-d	39.29 cd
V_2F_2	5.82 ab	37.27 ab	46.12 b
V_2F_3	6.21 a	40.15 a	51.11 a
V_3F_0	4.26 cd	19.33 h	27.88 fg
V_3F_1	5.34 ab	26.19 f	35.82 de
V_3F_2	5.88 ab	32.15 cd	39.22 cd
V_3F_3	6.12 a	34.32 b-d	44.78 b
V_4F_0	3.97 d	19.52 h	26.42 g
V_4F_1	4.94 b-d	25.34 fg	32.18 ef
V_4F_2	5.59 ab	30.67 de	37.33 cd
V_4F_3	5.82 ab	32.68 cd	42.15 bc
LSD (0.05)	**0.95**	**4.0**	**4.44**
CV%	**10.48**	**7.98**	**6.97**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6; F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

4.2.1 Combine effect of variety and fertilizer level

Combine effect of varieties and different fertilizer level showed significant variation on number of leaves plant^{-1} of soybean at 25, 50 and 75 DAS (Table 2). At 25 DAS, the highest number of leaves plant^{-1} (6.21) was observed from the V_2F_3 treatment which was statistically at par with all interaction except V_1F_0, V_3F_0, V_4F_0 and V_4F_1. Whereas, the lowest (3.97) was observed from V_4F_0 (BARI Soybean-6 with fertilizer control condition) treatment. At 50 DAS, the highest number of leaves plant^{-1} (40.15) was observed from the V_2F_3 and the lowest (19.52) was observed from V_4F_0. At 75 DAS, the highest number of leaves plant^{-1} (51.11) was observed from the V_2F_3 treatment whereas, the lowest (26.42) was observed from V_4F_0.

4.3 Soil Plant Analysis Development (SPAD) value

4.3.1 Effect of variety

The SPAD value of soybean was significantly influenced by varieties at different days after sowing (DAS) (Table 3). At 25 DAS, higher chlorophyll 43.99 (SPAD unit) was found in the variety BU soybean 2 and lower amount of chlorophyll (40.16) was contained in variety BARI Soybean-6 which was statistically similar with V_3 (BARI Soybean-5) (40.55) and BINAsoybean-5 (41.88). Similarly at 50 DAS, 75 DAS and 90 DAS, BU soybean 2 contained the highest SPAD value (42.41, 44.67 and 43.98, respectively) and BARI Soybean-6 contained the lowest SPAD value (39.41, 39.80 and 38.05 respectively). The dissimilarity in plant tallness might be attributed due to variations in genotypic constituents.

4.3.2 Effect of fertilizer level

In the experiment, effect of different fertilizer level on SPAD value of soybean at different days after sowing was found statistically significant (Table 3). SPAD value was increased due to application of fertilizer. The highest SPAD value (43.49, 41.92, 45.22 and 43.35) was recorded in F_3 (50% more than recommended dose of fertilizer (RDF) at 25, 50, 75 and 90 DAS, respectively. On the other hand, at the same DAS the lowest SPAD value (39.65, 39.21, 39.49 and 38.33) was observed from F_0 as fertilizer control condition. Muthulakshmi and Pandiyarajan (2015) reported that application of fertilizer led to significant increase photosynthetic pigment, non-photosynthetic pigment composition leaf nitrate, chlorophyll content.

Table 3. Effect of variety, different fertilizer level and their combine effect on SPAD value of soybean at different days after sowing (DAS)

Treatment	**SPAD value at**			
	25 DAS	**50 DAS**	**75 DAS**	**90 DAS**
Different soybean variety				
V_1	41.88 b	41.13 a	42.21 b	41.97 ab
V_2	43.99 a	42.41 a	44.67 a	43.98 a
V_3	40.55 b	39.45 b	43.03 ab	39.58 bc
V_4	40.16 b	39.41 b	39.80 c	38.05 c
LSD $_{(0.05)}$	**1.87**	**1.42**	**2.00**	**2.90**
Different doses of fertilizer				
F_0	39.65 c	39.21 c	39.49 c	38.33 c
F_1	41.24 bc	40.33 bc	41.94 b	40.22 bc
F_2	42.21 ab	40.95 ab	43.06 b	41.67 ab
F_3	43.49 a	41.92 a	45.22 a	43.35 a
LSD $_{(0.05)}$	**1.87**	**1.42**	**2.00**	**2.90**
Combine effect of variety and fertilizer				
V_1F_0	40.07 b-e	39.43 c-e	38.24 ef	39.51 b-d
V_1F_1	41.27 b-e	41.06 b-e	41.77 b-e	41.61 a-d
V_1F_2	42.30 a-d	41.88 a-e	42.90 b-d	42.71 a-d
V_1F_3	43.86 a-c	42.14 a-c	45.92 ab	44.04 ab
V_2F_0	42.06 a-d	40.00 b-e	42.54 b-e	41.06 a-d
V_2F_1	43.34 a-c	42.05 a-d	43.48 a-d	43.46 a-c
V_2F_2	44.29 ab	42.99 ab	45.12 a-c	44.95 ab
V_2F_3	46.29 a	44.59 a	47.56 a	46.45 a
V_3F_0	38.83 de	38.74 de	41.11 c-e	36.89 cd
V_3F_1	39.79 c-e	38.95 c-e	42.25 b-e	39.06 b-d
V_3F_2	41.16 b-e	39.45 c-e	43.05 b-d	40.15 a-d
V_3F_3	42.44 a-d	40.66 b-e	45.72 a-c	42.21 a-d
V_4F_0	37.64 e	38.65 e	36.07 f	35.87 d
V_4F_1	40.54 b-e	39.26 c-e	40.27 de	36.75 cd
V_4F_2	41.08 b-e	39.48 c-e	41.18 c-e	38.88 b-d
V_4F_3	41.39 b-e	40.26 b-e	41.66 b-e	40.71 a-d
LSD $_{(0.05)}$	**3.73**	**2.84**	**4.00**	**5.80**
CV%	**5.37**	**4.21**	**5.65**	**8.51**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6; F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

4.3.3 Combine effect of variety and fertilizer level

Combine effect of variety and different fertilizer level showed significant variation on SPAD value of soybean at 25, 50, 75 DAS and at harvest (Table 3). At 25 DAS, the maximum SPAD value (46.29) was recorded from the V_2F_3 (BU soybean 2 with 50% more than recommended dose of fertilizer (RDF) treatment and the minimum SPAD value (37.64) was observed from V_4F_0 treatment. Similarly, at 50 DAS, 75 DAS and 90 DAS, the maximum SPAD value (44.59, 47.56 and 46.45, respectively) was recorded from the V_2F_3 (BU soybean 2 with 50% more than recommended dose of fertilizer (RDF) treatment and the minimum SPAD value (38.65, 36.07 and 35.87 respectively) was recorded from V_4F_0 (BARI Soybean-6 with fertilizer control condition) treatment.

4.4. Dry weight plant^{-1}

4.4.1 Effect of variety

The dry weight plant^{-1} of soybean was significantly influenced by varieties at different days after sowing (DAS) (Figure 4). The figure shows that dry weight plant^{-1} increased gradually with advances of growth stages irrespective of varieties. The highest increase was found at harvest stage. However, statistically at 30 DAS, the highest dry weight plant^{-1} was recorded from V_2 (0.61 g) variety which was statistically at par with V_1 (BINAsoybean-5) (0.59 g) and the lowest dry weight plant^{-1} (0.51 g) was recorded in V_4 (BARI Soybean-6 variety) followed by V_3 (BARI Soybean-4) (0.54 g). At 60 DAS, 90 DAS and at harvest, the highest dry weight plant^{-1} (2.90 g, 5.98 g and 6.94 g, respectively) was also recorded from BU soybean 2 and at the same DAS, the lowest dry weight plant^{-1} (2.06 g, 4.82 g and 5.47 g, respectively) was also found in BARI Soybean-6 (V_4).

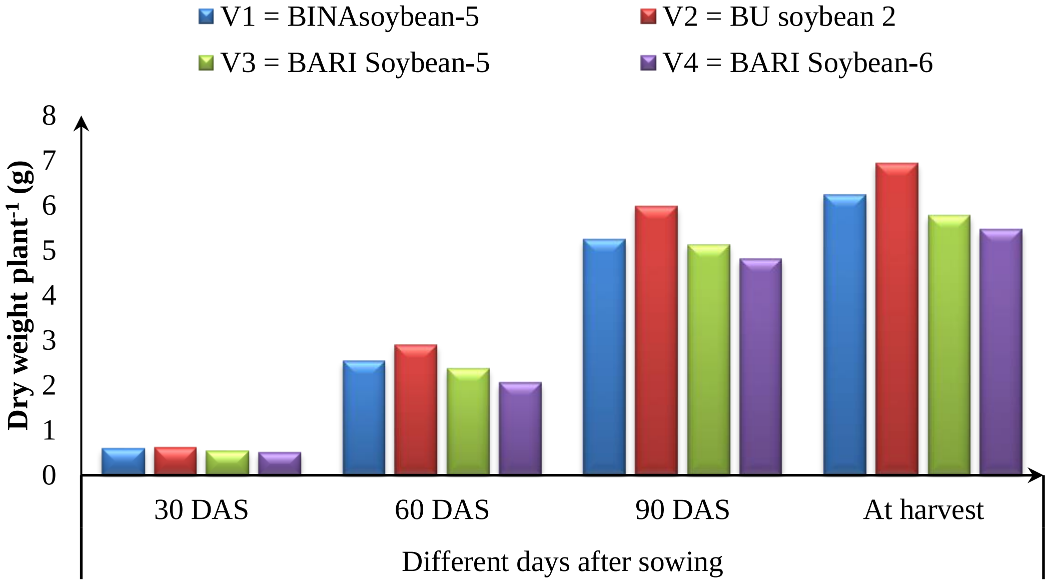


Figure 4. Effect of variety on dry weight plant^{-1} of soybean at different days after sowing ($LSD_{0.05}$ = 0.02, 0.23, 0.31 and 0.51 at 30, 60, 90 DAS and at harvest, respectively)

4.4.2 Effect of fertilize level

Statistically significant variation was recorded for dry weight plant^{-1} of soybean due to the application of different doses of fertilizers at 25, 50, 75 DAS and at harvest (Figure 5). The figure indicates that irrespective of fertilizers level, dry weight plant^{-1} increased progressively with the advance of growth stages and the highest increase was found at harvest stage. At 30, 60, 90 DAS and at harvest, the highest dry weight plant^{-1} (0.67 g, 2.83 g, 5.99 g and 6.76 g, respectively) was recorded from F_3 (50% more than recommended dose of fertilizer (RDF). On the other hand, at the same DAS the lowest dry weight plant^{-1} (0.48 g, 2.12 g, 4.29 g and 5.37 g, respectively) was observed from F_0 as fertilizer control condition. Application of 50% more fertilizer than the recommended doses gave the highest dry matter accumulation followed by the recommended doses. This might be due to optimum supply 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 Akter (2016), Patil and Udmale (2016) and Gopalkrishna and Palaniappan (1992). Akter (2016) found that application of fertilizer at recommended dose gave the highest dry weight plant^{-1} of soybean than other combination of fertilizers.

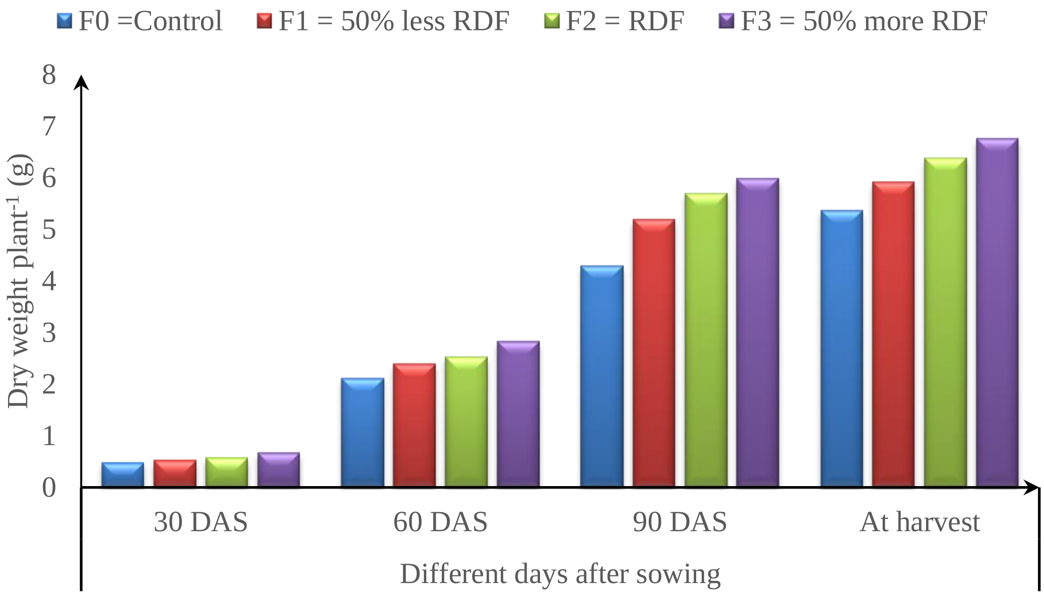


Figure 5. Effect of different fertilizer level on dry weight plant^{-1} of soybean at different days after sowing ($LSD_{0.05}$ = 0.02, 0.23, 0.31 and 0.51 at 30, 60, 90 DAS and at harvest, respectively)

4.4.3 Combine effect of variety and fertilizer level

Combine of variety and different fertilizer level showed significant variation on dry weight of soybean at 30, 60, 90 DAS and at harvest (Table 4). At 30 DAS, the maximum dry weight plant^{-1} (0.71 g) was observed from the V_2F_3 (BU soybean 2 with 50% more than recommended dose of fertilizer (RDF) treatment which was statistically at par with V_1F_3 (0.70 g) and V_3F_3 (0.66 g), while the minimum dry weight plant^{-1} (0.41 g) was observed from V_4F_0 treatment. Similarly at 60 DAS, 90 DAS and 90 DAS, maximum dry weight plant^{-1} (3.44 g, 6.69 g, and 7.49 g, respectively) was observed from the V_2F_3 (BU soybean 2 with 50% more than recommended dose of fertilizer (RDF) treatment and the minimum dry weight plant^{-1} (1.85 g, 3.79 g and 4.66 g, respectively) was observed from V_4F_0 (BARI Soybean-6 with fertilizer control condition) treatment.

Table 4. Combine effect of variety and different fertilizer level on dry weight plant^{-1} of soybean at different days after sowing

Treatment	Dry weight plant^{-1} (g) at			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
V_1F_0	0.55 de	2.17 fg	4.15 f	5.37 d-f
V_1F_1	0.52 d-f	2.46 b-f	4.98 e	5.99 b-e
V_1F_2	0.58 cd	2.74 b-e	5.83 b-d	6.56 a-d
V_1F_3	0.70 a	2.80 b-d	6.02 a-c	7.04 ab
V_2F_0	0.49 ef	2.39 c-f	5.16 de	6.39 a-d
V_2F_1	0.58 cd	2.84 bc	5.74 b-d	6.72 a-c
V_2F_2	0.65 ab	2.92 b	6.32 ab	7.17 ab
V_2F_3	0.71 a	3.44 a	6.69 a	7.49 a
V_3F_0	0.46 fg	2.06 fg	4.09 f	5.05 ef
V_3F_1	0.50 ef	2.27 e-g	5.16 de	5.59 c-f
V_3F_2	0.55 de	2.37 c-f	5.46 c-e	6.06 b-e
V_3F_3	0.66 ab	2.78 b-d	5.83 b-d	6.40 a-d
V_4F_0	0.41 g	1.85 g	3.79 f	4.66 f
V_4F_1	0.48 f	1.99 fg	4.88 e	5.37 d-f
V_4F_2	0.54 de	2.12 fg	5.19 de	5.73 c-f
V_4F_3	0.62 bc	2.29 b-g	5.40 c-e	6.12 b-e
LSD $_{(0.05)}$	**0.05**	**0.45**	**0.63**	**1.02**
CV (%)	**6.80**	**10.94**	**7.20**	**10.09**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6; F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

4.5 Number of primary branches plant^{-1}

4.5.1 Effect of variety

The number of primary branches plant^{-1} was significantly influenced by different varieties of soybean at 50 and 75 DAS (Table 5). The result revealed that at 50 DAS, the variety BU soybean 2 (V_2) produced the highest number of primary branches plant^{-1} (4.32) which was statistically different from all other varieties and the variety BARI Soybean-6 (V_4) gave the lowest number of primary branches plant^{-1} (3.21). At 75 DAS, the variety BU soybean 2 (V_2) also produced the highest number of primary branches plant^{-1} (5.36) which was statistically at par with V_1 varieties and the variety BARI Soybean-6 gave the lowest number of primary branches plant^{-1} (4.11). Number of primary branches plant^{-1} can be different in different varieties due to genetical build-up of the varieties. The similar findings about number of branches per plant were also observed by Malek *et al.* (2013) and Pankaj (2013). The results of the experiment are in agreement with Saha and Islam (2022), who counted the highest no. of primary branches plant^{-1} in BINAsoybean-3 and the lowest no. of primary branches plant^{-1} in BARI Soybean-6.

4.5.2 Effect of fertilizer level

Statistically significant variation was recorded for number of primary branches per plant of soybean due to the application of different doses of fertilizers at 50 and 75 DAS (Table 5). At the different days after sowing, the maximum number of primary branches plant^{-1} (4.97 and 5.83, respectively) at 50 and 75 DAS was observed from F_3 (50% more than recommended dose of fertilizer (RDF) which was followed by F_2 (recommended dose of fertilizer (RDF) (4.57 and 5.26, respectively) at the same DAS. At the same DAS, the minimum number of primary branches per plant (1.86 and 3.04 respectively) was observed from F_0 as fertilizer control condition. It was revealed that all the fertilizer treatments produced significantly higher number of primary branches plant^{-1} compared to the control treatment. Khaim *et al.* (2013) and Falodun and Osaigbovo (2010) stated that total number of branches plant^{-1} was enhanced by inorganic fertilizers.

4.5.3 Combine effect of variety and fertilizer level

Combine effect of varieties and different fertilizer level showed significant variation on number of primary branches plant^{-1} of soybean at 50 and 75 DAS (Table 5). At 50 DAS, the highest number of primary branches plant^{-1} (5.58) was observed from the V_2F_3 treatment which was statistically at par with V_1F_3 (5.40), V_2F_2 (5.26) and V_3F_3 (4.96). Whereas, the lowest (1.49) was observed from V_3F_0 (BARI Soybean-5 with fertilizer control condition) treatment which was statistically at par with V_4F_0 (1.71), V_1F_0 (1.76). At 75 DAS, the highest number of primary branches plant^{-1} (6.89) was observed from the V_2F_3 and the lowest (2.44) was observed from V_4F_0.

Table 5. Effect of variety, different fertilizer level and their combine effect on primary branches number per soybean plant at different days after sowing (DAS)

Treatment	Number of primary branches plant^{-1} at	
	50 DAS	**75 DAS**
Different soybean variety		
V_1	4.00 b	4.80 ab
V_2	4.32 a	5.36 a
V_3	3.64 c	4.59 b
V_4	3.21 d	4.11 c
LSD $_{(0.05)}$	**0.29**	**0.27**
Different doses of fertilizer		
F_0	1.86 d	3.04 d
F_1	3.76 c	4.73 c
F_2	4.57 b	5.26 b
F_3	4.97 a	5.83 a
LSD $_{(0.05)}$	**0.29**	**0.27**
Combine effect of variety and fertilizer		
V_1F_0	1.76 g	3.07 g
V_1F_1	3.98 de	4.17 de
V_1F_2	4.86 bc	5.56 bc
V_1F_3	5.40 ab	5.86 b
V_2F_0	2.49 f	3.70 f
V_2F_1	3.95 de	5.08 cd
V_2F_2	5.26 ab	5.77 b
V_2F_3	5.58 a	6.89 a
V_3F_0	1.49 g	2.97 gh
V_3F_1	3.60 e	4.83 de
V_3F_2	4.50 cd	4.95 d
V_3F_3	4.96 a-c	5.60 bc
V_4F_0	1.71 g	2.44 h
V_4F_1	3.50 e	4.28 e
V_4F_2	3.68 e	4.76 de
V_4F_3	3.94 de	4.96 d
LSD $_{(0.05)}$	**0.59**	**0.54**
CV%	**9.28**	**6.84**

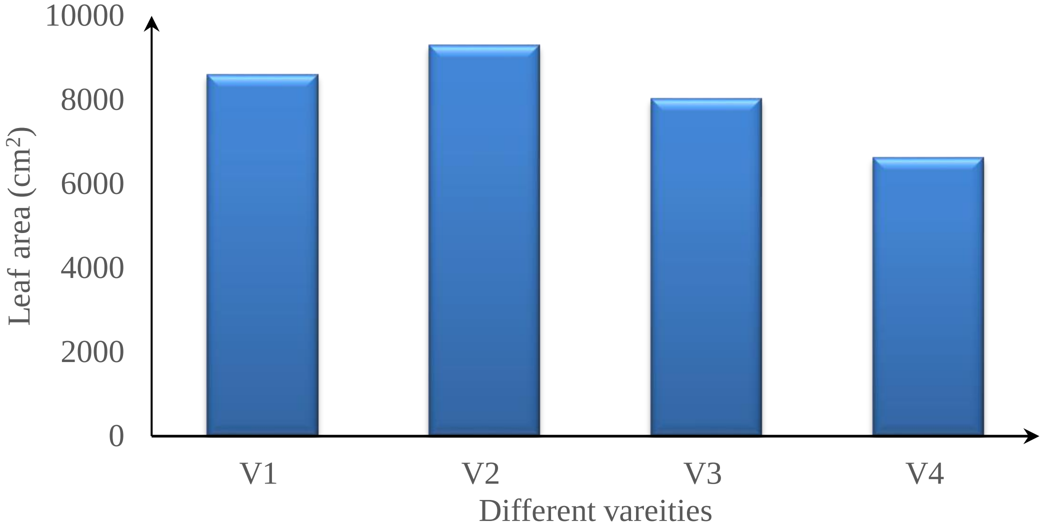
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6; F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

4.6 Leaf area (cm^2)

4.6.1 Effect of variety

The leaf area (cm^2) of soybean was statistically different among the four varieties under the present trial (Figure 6). Statistically largest leaf area (9306 cm^2) was found in the V_2 (BU soybean 2) and the shortest leaf area (6629 cm^2) was obtained from the variety V_4 (BARI Soybean-6).

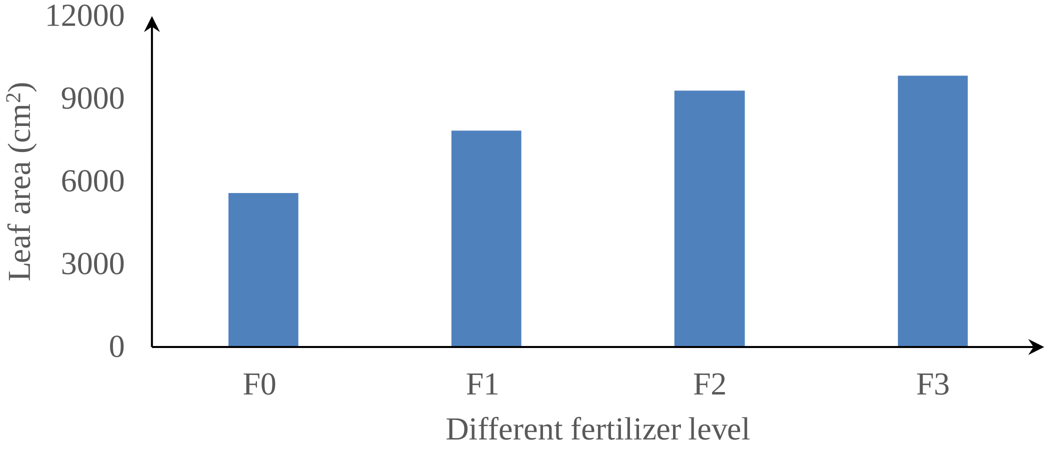


[Here, V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6]

Figure 6. Effect of variety on leaf area of soybean ($LSD_{0.05}$ = 7.28)

4.6.2 Effect of fertilizer level

The leaf area of soybean was statistically significant due to application of different fertilizer level (Figure 7). Statistically longest leaf area (9840 cm^2) was observed in the F_3 (50% more than recommended dose of fertilizer (RDF) and the shortest leaf area was obtained from F_0 (5582 cm^2) treatment. These findings are in accordance with the results of Jadhav *et al*. (1994). From his experiment it was revealed that application of 30 kg N ha^{-1} also produced significantly more leaf area $plant^{-1}$ than control.

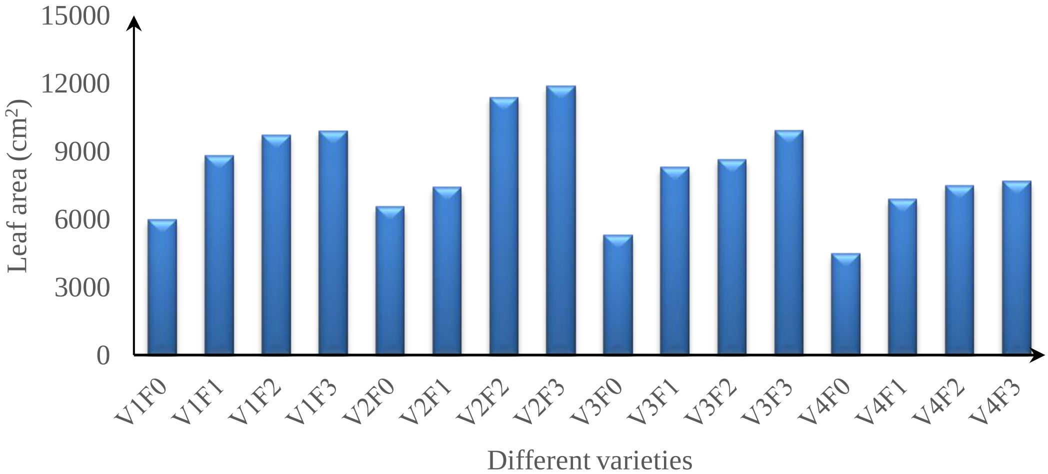


[Here, F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

Figure 7. Effect of different fertilizer level on leaf area of soybean ($LSD_{0.05}$ = 7.28)

4.6.3 Combine effect of variety and fertilizer level

Significant influence was observed on leaf area (cm$^{2)}$ due to combine effect of variety and different fertilizer level of soybean (Figure 8). Statistically, the maximum leaf area (11880 cm^2) was observed from V_2F_3 (BU soybean 2 with 50% more than recommended dose of fertilizer (RDF) treatment combination and lowest leaf area (4480 cm^2) was observed from V_4F_0 treatment.



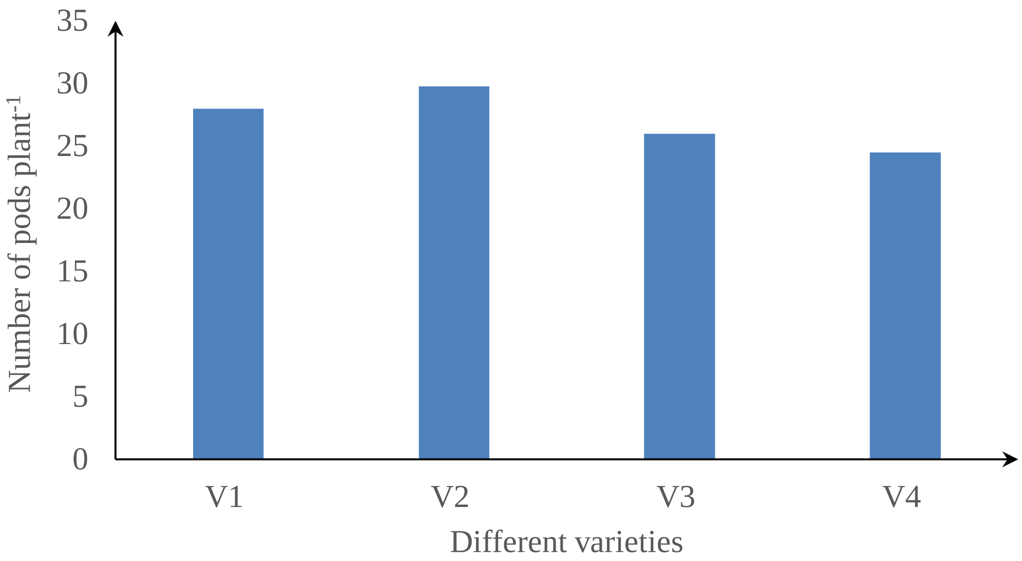
[Here, V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6; F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

Figure 8. Interaction effect of variety and different fertilizer levels on leaf area (cm^2) of soybean ($LSD_{0.05}$ = 14.56)

4.7 Number of pods plant^{-1}

4.7.1 Effect of variety

The number of pods per plant was significantly influenced by different varieties of soybean (Figure 9). The result revealed that the variety BU soybean 2 (V_2) produced the highest number of pods plant^{-1} (29.75) which was statistically similar with V_1 (27.96) and the variety BARI Soybean-6 (V_4) gave the lowest number of pods plant^{-1} (24.49) which was statistically at par with the variety V_3. Wide variation in number of pods plant^{-1} among varieties was also reported by Khanam *et al.* (2016), Malek and Rahman (2013) and Sultana *et al.* (2015). The similar findings on number of pods plant^{-1} were also supported by Ali *et al.* (2008). The results of the experiment are in agreement with Saha and Islam (2022), who counted the highest no. of pods plant^{-1} in BINAsoybean-5 and the lowest number of pods plant^{-1} in BARI Soybean-6.

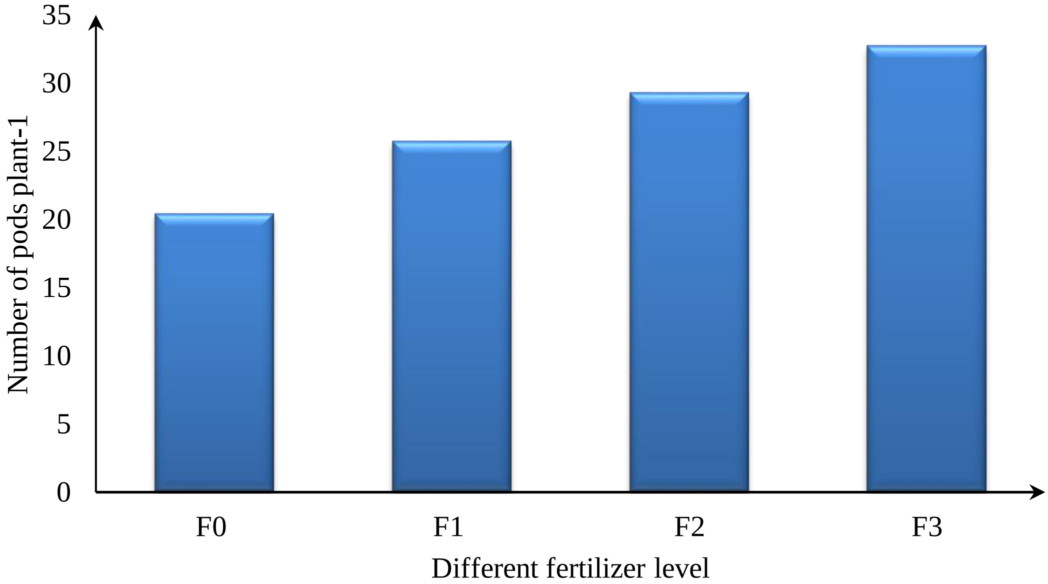


[Here, V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6]

Figure 9. Effect of variety on number of pods plant^{-1} of soybean ($LSD_{0.05}$ = 1.79)

4.7.2 Effect of fertilizer level

Statistically significant variation was recorded for number of pods plant^{-1} of soybean due to the application of different doses of fertilizers (Figure 10). From the figure it was revealed that the maximum number of pods plant^{-1} (32.73) was observed from F_3 (50% more than recommended dose of fertilizer (RDF) which was followed by F_2 (recommended dose of fertilizer (RDF) (29.30). On the other hand, the minimum number of pods per plant (20.41) was observed from F_0 as fertilizer control condition. It was revealed that all the fertilizer treatments produced significantly higher number of pods compared to the control treatment. There seemed to be less nutrient ability in the control plots resulting in low pod numbers. Begum *et al.* (2015) and Singh and Bajpai (1990) observed that increasing phosphorus rate increased the number of pods plant^{-1}. Chaubey *et al.* (2000) obtained significantly the highest number of pods plant^{-1} by applying S @ 45 kg ha^{-1} through gypsum in groundnut. This result was supported by Manalo *et al*. (1998), Myint *et al*. (2009) and Moghadam *et al.* (2014) who considered that fertilizer significantly increased the number of pods plant^{-1}.



[Here, F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

Figure 10. Effect of different fertilizer level on number of pods plant^{-1} of soybean ($LSD_{0.05}$ = 1.79)

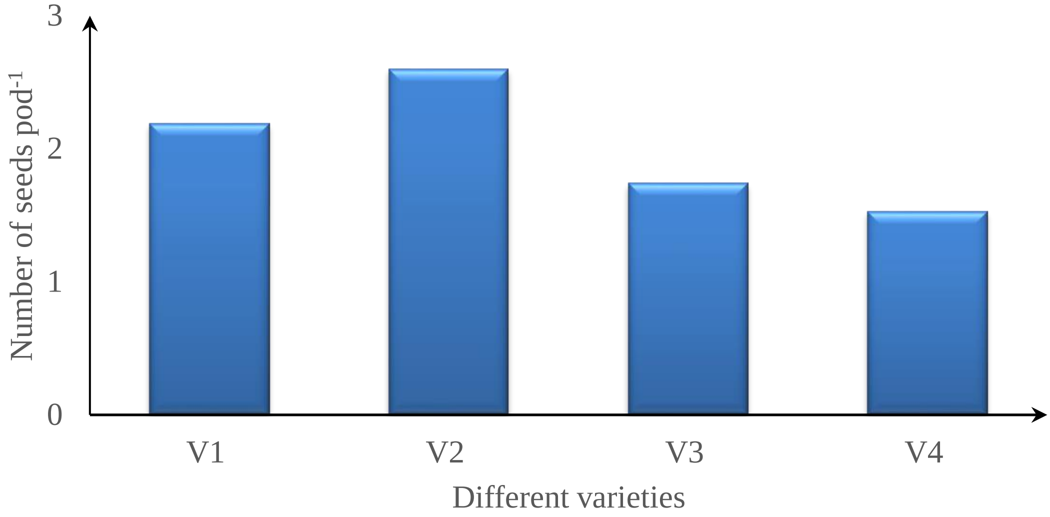
4.7.3 Combine effect of variety and fertilizer level

Combine of varieties and different fertilizer level showed significant variation on number of pods plant^{-1} of soybean (Table 6). The highest number of pods plant^{-1} (35.61) was observed from the V_2F_3 treatment which was statistically at par with V_1F_3 (33.46). Whereas, the lowest (17.46) was observed from V_4F_0 (BARI Soybean-6 with fertilizer control condition) treatment which was statistically similar with V_3F_0 (19.29).

4.8 Number of seeds pod^{-1}

4.8.1 Effect of variety

The number of seeds pod^{-1} was significantly influenced by different varieties of soybean (Figure 11). The result revealed that the variety BU soybean 2 (V_2) produced the highest number of seeds pod^{-1} (2.60) followed by V_1 (2.19) and the variety BARI Soybean-6 (V_4) gave the lowest number of seeds pod^{-1} (1.53) followed by V_3 (1.74). The results of the experiment are in agreement with Haque (2018), who counted the highest no. of seeds pod^{-1} in BINAsoybean-5 and the lowest no. of pods plant^{-1} in Shohag (PB-1).

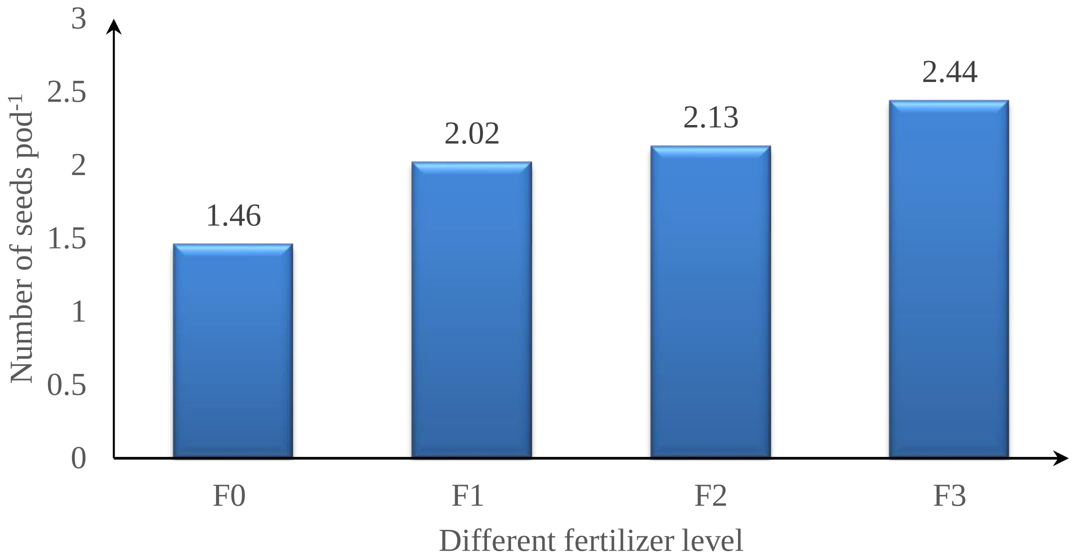


[Here, V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6]

Figure 11. Effect of variety on number of seeds plant^{-1} of soybean ($LSD_{0.05}$ = 0.10)

4.8.2 Effect of fertilizer level

Statistically significant variation was recorded for number of seeds pod^{-1} of soybean due to the application of different doses of fertilizers (Figure 12). From the table it was revealed that the maximum number of seeds pod^{-1} (2.44) was observed from F_3 (50% more than recommended dose of fertilizer (RDF) which was followed by F_2 (recommended dose of fertilizer (RDF) (2.13). On the other hand, the minimum number of seeds pod^{-1} (1.46) was observed from F_0 as fertilizer control condition. It was revealed that all the fertilizer treatments produced significantly higher number of seeds compared to the control treatment. There seemed to be less nutrient ability in the control plots resulting in low seed numbers. This finding is consistence with the finding of Patwary (2003), Khaim *et al.* (2013) and Patil and Udmale (2016) found highest seed $plant^{-1}$ of soybean in S and P treated plant. Begum *et al*. (2015), Tomar *et al*. (2004) and Islam *et al.* (2004) observed that number of seeds pod^{-1} increased with the increase of phosphorus application.



[Here, F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

Figure 12. Effect of different fertilizer level on number of seeds pod^{-1} of soybean ($LSD_{0.05}$ = 0.10)

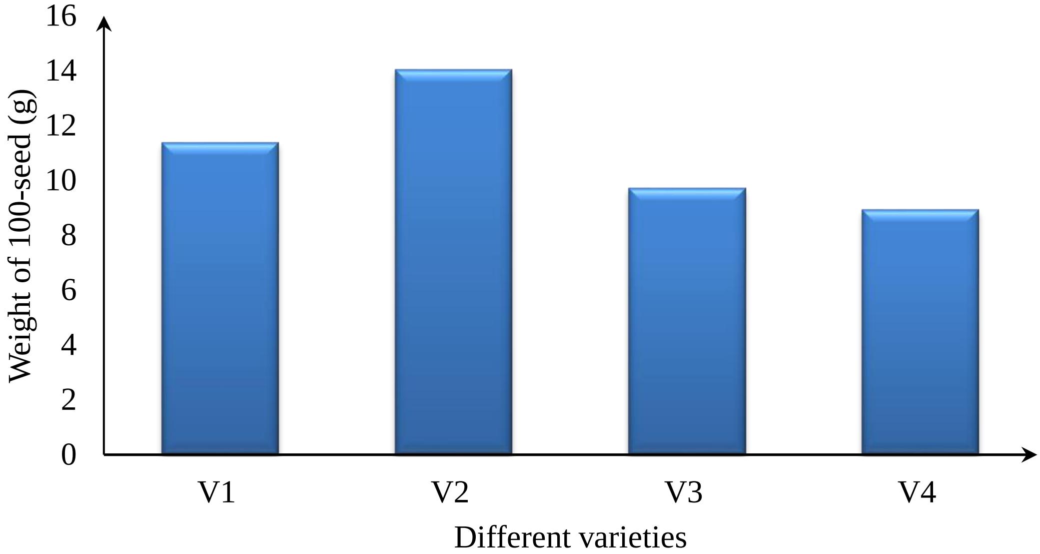
4.8.3 Interaction effect of variety and fertilizer level

Interaction of varieties and different fertilizer level showed significant variation on number of seeds pod^{-1} of soybean (Table 6). The highest number of seeds pod^{-1} (3.00) was observed from the V_2F_3 treatment which was statistically at par with V_2F_2 (2.86). Whereas, the lowest (1.03) was observed from V_4F_0 (BARI Soybean-6 with fertilizer control condition) treatment which was statistically different from other treatments and followed by V_3F_0 (BARI Soybean-5 with fertilizer control condition).

4.9 Weight of 100 grain (g)

4.9.1 Effect of variety

Considerable genotypic variation in 100-seed weight was found in this study. The 100-seed weight of four soybean varieties varied from 8.93 g to 14.03 g (Figure 13). The highest 100- seed weight was recorded in BU soybean 2 (V_2) (14.03 g) [i.e., the seed size is the highest among the 4 varieties], followed by V_1 (11.38 g). The lowest 100 seed weight was found in BARI Soybean-6 (V_4) (8.93 g) which was statistically similar with BARI Soybean-5 (V_3) (9.71 g). These findings have close conformity with the findings of Pankaj, 2013 who stated that 100 seed weight among varieties ranged from 10.55 g to 16.34 g. Ali *et al.* (2008) also found significant variation for 100 seed weight among soybean genotypes.

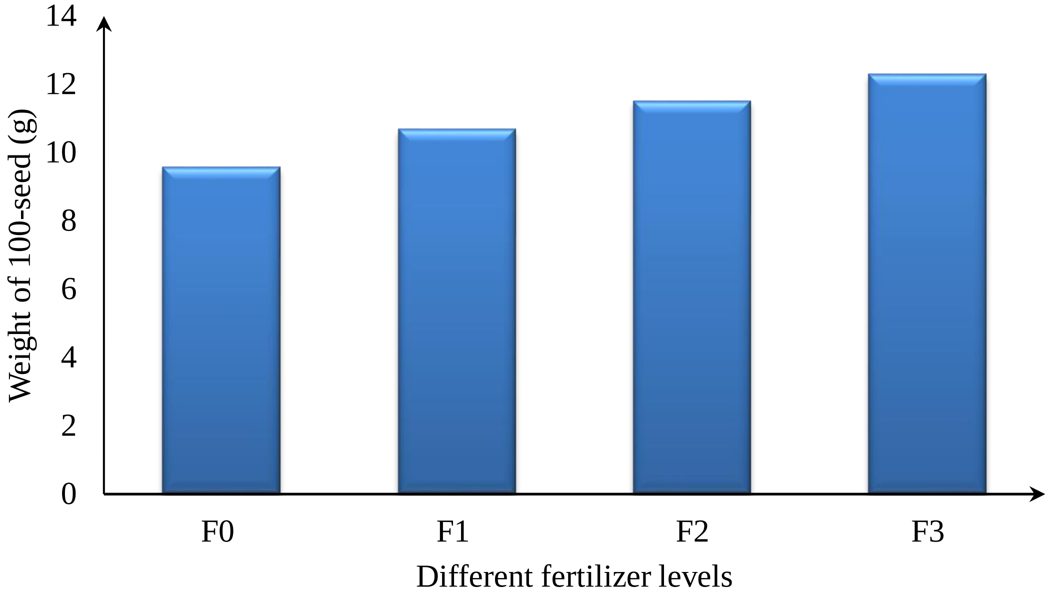


[Here, V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6]

Figure 13. Effect of variety on weight of 100 seeds of soybean ($LSD_{0.05}$ = 0.96)

4.9.2 Effect of fertilizer level

A significant variation was found on weight of 100 grains of soybean due to the application of different doses of fertilizers (Figure 14). The heaviest 100 grains weight (12.29 g) was recorded from F_3 (50% more than recommended dose of fertilizer (RDF), which was statistically similar with F_2 (recommended dose of fertilizer (RDF) (11.51 g) and the lightest weight was recorded from F_0 as fertilizer control condition (9.57 g). Better 100 grain weight depends on optimum dry matter partitioning during reproductive stage of plant. Nutrient elements from organic and inorganic sources ensure long term and optimum nutrient supply from the source to sink which ensure maximum accumulation of photosynthates to the pod; consequently, increase the 100-grain weight. Better growth and development of crop plants due to phosphorus supply and nitrogen uptake might have increased the supply of assimilates to seed, which ultimately gained more weight. Similar achievements on hundred seed weight with phosphorus were observed by Begum *et al.* (2015).



[Here, F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

Figure 14. Effect of different fertilizer level on weight of 100 seeds of soybean ($LSD_{0.05}$ = 0.96)

4.9.3 Combine effect of variety and fertilizer level

Combine effect of variety and different fertilizer level showed significant variation on 100 seed weight of soybean (Table 6). The maximum 100 seed weight (15.52 g) was observed from the V_2F_3 (BU soybean 2 with 50% more than recommended dose of fertilizer (RDF) treatment which was statistically at par with V_2F_2 (14.45 g), while the minimum 100 seed weight (7.52 g) was observed from V_4F_0 treatment.

Table 6. Combine effect of variety and different fertilizer level on number of pods plant^{-1}, number of seeds pod^{-1} and weight of 100 seed (g) of soybean

Treatment	Number of pods plant^{-1}	Number of seeds pod^{-1}	Weight of 100 seed (g)
V_1F_0	21.81 hi	1.80 fg	9.98 f-i
V_1F_1	26.60 e-g	2.14 de	11.27 d-g
V_1F_2	29.96 b-e	2.23 d	11.87 c-f
V_1F_3	33.46 ab	2.58 c	12.41 b-e
V_2F_0	23.09 g-i	1.76 fg	12.62 b-d
V_2F_1	29.00 c-e	2.78 bc	13.51 bc
V_2F_2	31.28 b-d	2.86 ab	14.45 ab
V_2F_3	35.61 a	3.00 a	15.52 a
V_3F_0	19.29 ij	1.26 i	8.15 ij
V_3F_1	24.54 f-h	1.69 gh	9.64 g-i
V_3F_2	28.32 c-f	1.77 fg	10.16 f-i
V_3F_3	31.75 bc	2.22 d	10.89 d-g
V_4F_0	17.46 j	1.03 j	7.52 j
V_4F_1	22.72 g-i	1.49 h	8.30 h-i
V_4F_2	27.66 d-f	1.67 gh	9.56 g-j
V_4F_3	30.11 b-e	1.94 ef	10.34 e-h
LSD (0.05)	**3.59**	**0.20**	**1.91**
CV (%)	**7.96**	**5.97**	**10.42**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6; F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

4.10 Seed yield

4.10.1 Effect of variety

Seed yield (t ha^{-1}**)** of soybean was significantly influenced by different varieties (Table 7). The result revealed that the variety BU soybean 2 (V_2) produced the highest seed yield (3.20 t ha^{-1}) and the variety BARI Soybean-6 (V_4) gave lowest seed yield (1.45 t ha^{-1}). This finding was supported by (Awal, 2014) who stated that seed yield of soybean varied among varieties for their difference in genetic makeup. (Sultana *et al.*, 2015) also reported significant differences on seed yield among soybean varieties.

4.10.2 Effect of fertilizer level

Statistically significant variation was recorded for seed yield (t ha^{-1}) of soybean due to the application of different doses of fertilizers (Table 7). From the table it was revealed that the maximum seed yield (3.21 t ha^{-1}) was observed from F_3 (50% more than recommended dose of fertilizer (RDF) which was followed by F_2 (recommended dose of fertilizer (RDF) (2.44 t ha^{-1}). On the other hand, the minimum seed yield (1.19 t ha^{-1}) was observed from F_0 as fertilizer control condition. Similar results also found by Falodun *et al.* (2015) who reported that the increase in the number of pods, pod weight and yield with the application rate of 150 kg ha^{-1} NPK could be due to the rate of release of nutrients which were much higher in the inorganic fertilizers since they provided major elements at the early stage of plant growth and development. The control plot produced the lowest values for grain yield of soybean, due to the absence of adequate nutrient level which an important factor is needed for proper growth and development of every plant including soybean and so the plants had to depend on the inherent soil nutrient which was low. Similar finding was reported by Begum *et al.* (2015) who mentioned that moderate application of nitrogen and phosphorous increase the number of pods per plant, seeds per pod, seed weight and seed yield of soya bean. Yamika and Ikawati (2012) found that the combination of inorganic with organic fertilizers (0, 0.5 and 1 t ha^{-1}) increased the seed yield up to 3.5 t ha^{-1}. Mahesbabu *et al.* (2008) also observed that application of recommended dose of N: K: S with CD 5 t ha^{-1} produced grain yield (2235 kg ha^{-1}).

4.10.3 Combine effect of variety and fertilizer level

Interaction of varieties and different fertilizer doses have significant effect on seed yield of soybean (Table 7). The highest seed yield (4.52 t ha^{-1}) was obtained from V_2F_3 treatment which was statistically different from all other treatments. On the other hand, V_4F_0 (BARI Soybean-6 with fertilizer control condition) showed the lowest result (0.91t ha^{-1}) which was statistically similar with V_3F_0 (0.94 t ha^{-1}), V_4F_1 (1.20 t ha^{-1}), V_3F_1 (1.25 t ha^{-1}) and V_1F_0 (1.37 t ha^{-1}).

4.11 Stover yield

4.11.1 Effect of variety

Stover yield (t ha^{-1}**)** of soybean was significantly influenced by different varieties (Table 7). The result revealed that the variety BU soybean 2 (V_2) produced the highest stover yield (5.53 t ha^{-1}) and the variety BARI Soybean-6 (V_4) gave the lowest stover yield (2.72t ha^{-1}). This finding was supported by Haque (2018) who reported significant differences on stover yield among soybean varieties.

4.11.2 Effect of fertilizer level

Statistically significant variation was recorded for stover yield (t ha^{-1}) of soybean due to the application of different doses of fertilizers (Table 7). From the table it was revealed that the maximum stover yield (5.75 t ha^{-1}) was observed from F_3 (50% more than recommended dose of fertilizer (RDF) which was followed by F_2 (recommended dose of fertilizer (RDF) (4.50 ha^{-1}). On the other hand, the minimum stover yield (2.08 t ha^{-1}) was observed from F_0 as fertilizer control condition. Similar results also found by Dikshit and Khatik (2008) who observed that application of organic and inorganic fertilizers increased the stover yield of soybean. Forhad and Malik (2010) also reported that application of P and K also increased the stover yield. Stover yield increased over control was the highest in RDCF100%. Devi *et al.* (2013) reported that, significantly higher stover yield (2.04 t ha^{-1}) was produced by the integration of 75% RDF with vermicompost at the rate of 1 t ha^{-1} and the lowest (0.97 t ha^{-1}) from control. Begum *et al*. (2015) obtained the similar findings in case of stover yield.

4.11.3 Combine effect of variety and fertilizer level

Combine effect of varieties and different fertilizer doses have significant effect on stover yield of soybean (Table 7). The highest stover yield (7.22 t ha^{-1}) was obtained from V_2F_3 treatment which was statistically different from all other treatments. On the other hand, V_4F_0 (BARI Soybean-6 with fertilizer control condition) showed the lowest result (1.55 t ha^{-1}) which was statistically similar with V_3F_0 (1.75 t ha^{-1}).

4.12 Harvest index

4.12.1 Effect of variety

Non-significant variation was found regarding harvest index values among the soybean varieties (Table 7). Numerically, the highest harvest index (36.80%) was found in BU soybean 2 (V_2). The lowest harvest index value (34.64%) was found in BARI Soybean-5 (V_3).

4.12.2 Effect of fertilizer level

Harvest index of soybean showed statistically non-significant variation due to the application of different fertilizer level (Table 7). The highest harvest index (36.45%) was found from F_0. On the other hand, the lowest harvest index (34.57%) was observed from F_1.

4.12.3 Interaction effect of variety and fertilizer level

Interaction of varieties and different fertilizer doses have no-significant effect on harvest index (HI) of soybean (Table 7). Numerically the highest HI value (38.52%) was observed in the treatment V_2F_3. On the other hand, V_3F_1 treatment showed the lowest result (32.86%).

Table 7. Interaction effect of variety and different fertilizer level on seed yield, stover yield and harvest index of soybean

Treatment	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Harvest Index (%)
Different soybean variety			
V_1	2.25 b	4.16 b	35.23
V_2	3.20 a	5.53 a	36.80
V_3	1.79 c	3.44 c	34.64
V_4	1.45 d	2.72 d	35.38
LSD $_{(0.05)}$	**0.21**	**0.26**	**NS**
Different doses of fertilizer			
F_0	1.19 d	2.08 d	36.45
F_1	1.85 c	3.44 c	34.57
F_2	2.44 b	4.50 b	35.21
F_3	3.21 a	5.75 a	35.83
LSD $_{(0.05)}$	**0.21**	**0.26**	**NS**
Interaction effect of variety and fertilizer			
V_1F_0	1.37 gh	2.27 hi	37.75
V_1F_1	1.99 de	3.74 f	33.90
V_1F_2	2.42 d	4.72 e	33.93
V_1F_3	3.23 c	5.92 c	35.33
V_2F_0	1.53 fg	2.75 g-i	35.68
V_2F_1	2.96 c	5.19 de	36.48
V_2F_2	3.80 b	6.61 b	36.54
V_2F_3	4.52 a	7.22 a	38.52
V_3F_0	0.94 h	1.75 ij	35.06
V_3F_1	1.25 gh	2.57 gh	32.86
V_3F_2	1.94 ef	3.73 f	34.50
V_3F_3	3.28 c	5.71 cd	36.13
V_4F_0	0.91 h	1.55 j	37.31
V_4F_1	1.20 gh	2.25 hi	35.04
V_4F_2	1.61 e-g	2.92 g	35.86
V_4F_3	2.06 de	4.15 f	33.32
LSD $_{(0.05)}$	**0.42**	**0.52**	**NS**
CV%	**11.66**	**7.98**	**10.16**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[V_1 = BINAsoybean-5; V_2 = BU soybean 2; V_3 = BARI Soybean-5; V_4 = BARI Soybean-6; F_0 =Control; F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF)]

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2021 to April, 2022 to study the influence of different level of fertilizer on yield of soybean. The four varieties included in this study were BINAsoybean-5; BU soybean 2; BARI Soybean-5 and V_4 = BARI Soybean-6. There were four levels of fertilizer. Such as F_0 = Control condition (No fertilizer); F_1 = 50% less than recommended dose of fertilizer (RDF); F_2 = Recommended dose of fertilizer (RDF); F_3 = 50% more than recommended dose of fertilizer (RDF). The experiment was laid out in a Randomized Complete Block Design with three replications. Data on growth, yield attribute, yield was recorded.

At 25, 50, 75 DAS and at harvest the tallest plant (20.24 cm, 45.82 cm, 56.99 cm and 59.55 cm) was found in BU soybean 2. At 25, 50 and 75 DAS maximum number of leaves plant^{-1} (5.69, 33.98 and 42.29) was recorded from V_2 and again the minimum (5.08, 11.58, 27.05 and 34.52) was observed from V_4. At 25, 50, 75 DAS and at harvest the maximum SPAD value (43.99, 42.41, 44.67 and 43.98) was found in BU soybean 2 and the minimum SPAD value (40.16, 39.41, 39.80 and 38.05) was recorded from V_4 variety. At 30 DAS, 60 DAS, 90 DAS and at harvest, the highest dry weight plant^{-1} (0.61 g, 2.90 g, 5.98 g and 6.94 g, respectively) was also recorded from BU soybean 2 and the lowest dry weight plant^{-1} (0.51 g, 2.06 g, 4.82 g and 5.47 g, respectively) was also found in V_4. At 50 and 75 DAS the maximum number of primary branches plant^{-1} (4.32 and 5.36) was found in BU soybean 2 and the minimum branches plant^{-1} (3.21 and 4.11) was recorded from V_4 variety. Number of pods plant^{-1}, seeds pod^{-1}, weight of 100 seeds, seed yield, stover yield and harvest indes was greatly influenced by different varieties. The maximum number of pod plant^{-1} (29.75), seed pod^{-1} (2.60), weight of 100 seeds (14.03 g), highest seed yield (3.20 t ha^{-1}) and stover yield (5.53 t ha^{-1}) was observed in the BU soybean 2.

At 25, 50, 75 DAS and at harvest the tallest plant (21.01 cm, 45.26 cm, 57.29 cm and 60.28 cm) was found from F_3 (50% more than recommended dose of fertilizer (RDF)). At 25, 50 and 75 DAS maximum number of leaves plant^{-1} (6.06, 36.18 and 46.10) was recorded from F_3 and again the minimum (4.57, 21.32 and 29.33) was recorded from F_0 (fertilizer control condition). At 25, 50, 75 DAS and at harvest the maximum SPAD value (43.49, 41.92, 45.22 and 43.35) was found in F_3 and the minimum SPAD value (39.65, 39.21, 39.49 and 38.33) was recorded from F_0. At 30 DAS, 60 DAS, 90 DAS and at harvest, the highest dry weight plant^{-1} (0.67 g, 2.83 g, 5.99 g and 6.76 g, respectively) was also recorded from F_3 and the lowest dry weight plant^{-1} (0.48 g, 2.12g, 4.29 g and 5.37 g, respectively) was also found in F_0. At 50 and 75 DAS the maximum number of primary branches plant^{-1} (4.97 and 5.83) was found in F_3 and the minimum branches plant^{-1} (1.86 and 3.04) was recorded from F_0. The maximum number of pod plant^{-1} (32.73), seed pod^{-1} (2.44), weight of 100 seeds (12.29 g), highest seed yield (3.21 t ha^{-1}) and stover yield (5.75 t ha^{-1}) was observed in the F_3 and minimum value was recorded from fertilizer control condition.

All the parameters were significantly influenced by the interaction of varieties and different fertilizer level. At 25, 50, 75 DAS and at harvest the tallest plant (22.10 cm, 52.60 cm, 64.51 cm and 67.55cm) was found from V_2F_3 treatment combination. At 25, 50 and 75 DAS maximum number of leaves plant^{-1} (6.21, 40.15 and 51.11) was also recorded from V_2F_3 and again the minimum (3.97, 19.52 and 26.42) was recorded from V_4F_0. At 25, 50, 75 DAS and at harvest the maximum SPAD value (44.29, 44.59, 47.56 and 46.45) was found in V_2F_3 and the minimum SPAD value (37.64, 38.65, 36.07 and 35.87) was recorded from V_4F_0. At 30 DAS, 60 DAS, 90 DAS and at harvest, the highest dry weight plant^{-1} (0.71 g, 3.44 g, 6.69 g and 7.49 g, respectively) was also recorded from V_2F_3 and the lowest dry weight plant^{-1} (0.41 g, 1.85 g, 3.79 g and 4.66 g, respectively) was also found in V_4F_0. At 50 and 75 DAS the maximum number of primary branches plant^{-1} (5.58 and 6.89) was found in V_2F_3 and the minimum branches plant^{-1} (1.71 and 2.44) was recorded from V_4F_0. The maximum number of pod plant^{-1} (35.61), seed pod^{-1} (3.00), weight of 100 seeds (15.52 g), highest seed yield (4.52 t ha^{-1}) and stover yield (7.22 t ha^{-1}) was observed in the V_2F_3 and minimum value was recorded from V_4F_0 treatment combination,

The result of present study generated some information which may help to increase the yield of soybean. Hence, the present study may be summerized as follows:

Among the soybean varieties, BU soybean 2 produced the tallest plant, longest leaf, maximum branches plant^{-1}, highest dry weight plant^{-1}, highest SPAD value, maximum number of pods plant^{-1}, maximum seeds pod^{-1}, highest seed and stover yield.

Application of 50% more fertilizer than the recommended dose gave the tallest plant, longest leaf, maximum branches plant^{-1}, highest dry weight plant^{-1}, highest SPAD value, maximum number of pods plant^{-1}, maximum seeds pod^{-1}, highest seed and stover yield.

In combination with BU soybean 2 with 50% more fertilizer than the recommended dose gave the tallest plant, longest leaf, maximum branches plant^{-1}, highest dry weight plant^{-1}, highest SPAD value, maximum number of pods plant^{-1}, maximum seeds pod^{-1}, highest seed and stover yield.

Considering the above result of this experiment the following conclusions can be drawn:

- Among the soybean varieties, BU soybean gave higher yield as well as other yield parameter.
- Among the different fertilizer level, 50% more fertilizers than recommended played an important role in maximum seed production.
- BU soybean, 50% more fertilizers than recommended and their combination seems for higher yield.

Further study should be needed in different locations of Bangladesh for accuracy of the results obtained from the present experiment.

CHAPTER VI

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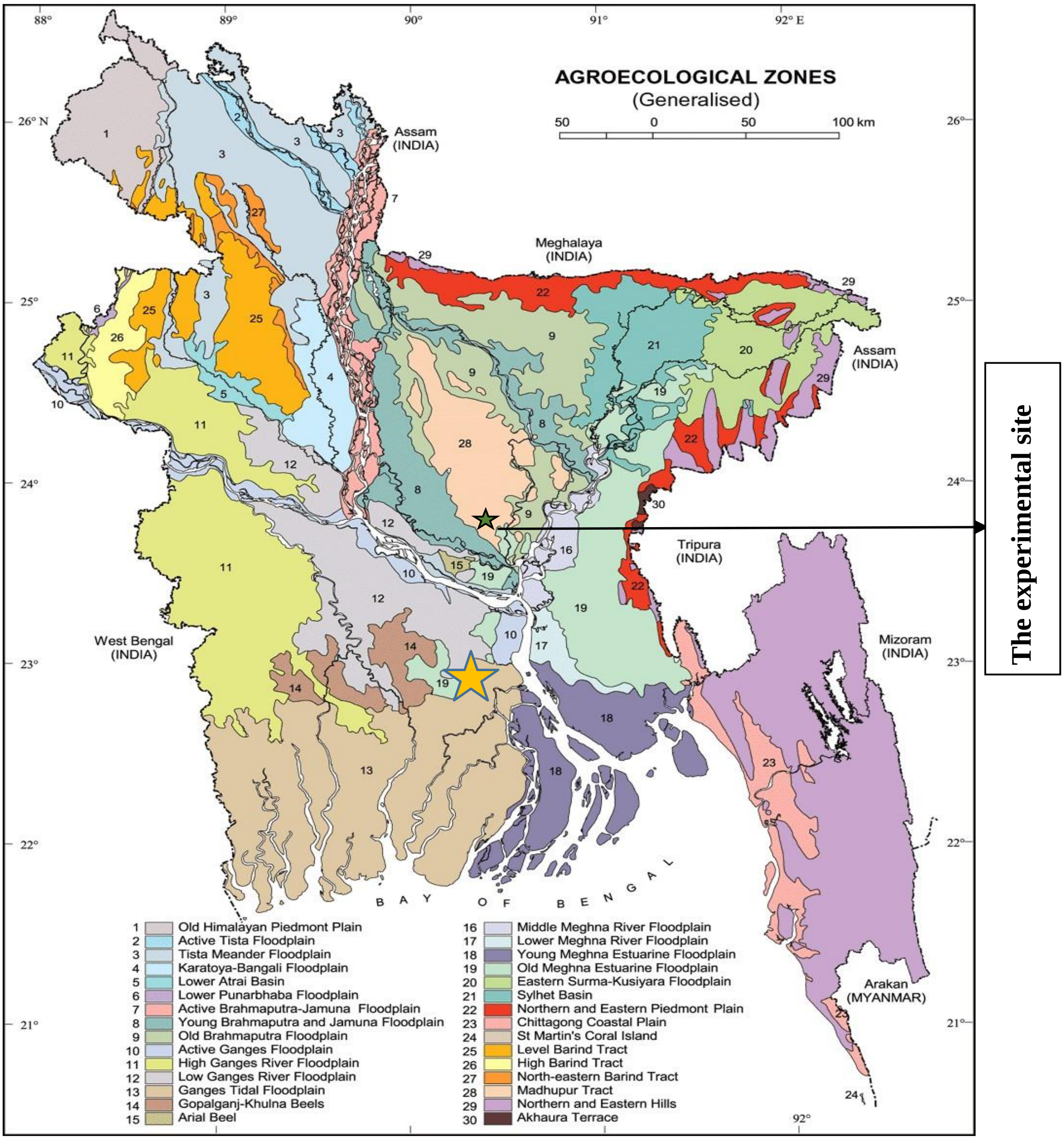
CHAPTER VII

APPENDICES

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



Appendix II. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from December 2021 to April 2022.

Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
December, 2021	26.9	15.3	69	14.3	5.8
January, 2022	26.4	14.1	69	12.8	5.5
February, 2022	25.4	12.7	68	7.7	5.6
March, 2022	28.1	15.5	68	28.9	5.5
April, 2022	28.5	16.2	67	29.3	5.6

Source: Sher-e-Bangla Agricultural University Weather Station and Bangladesh Meteorological Department.

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

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

Source: Soil Resources Development Institute (SRDI)

Chemical composition:

Soil characters	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.54
Total nitrogen (%)	0.027
Phosphorus	6.3 µg/g soil
Sulphur	8.42 µg/g soil
Magnesium	1.17 meq/100 g soil
Boron	0.88 µg/g soil
Copper	1.64 µg/g soil
Zinc	1.54 µg/g soil
Potassium	0.10 meg/100g soil

Source: Soil Resources Development Institute (SRDI)

Morphological Characteristics of the Experimental Field

Morphology	Characteristics
Location	SAU farm, Dhaka
Agro-ecological zone	Madhupur Tract (AEZ-28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Clay
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

Appendix IV. Some pictorial view of the experiment

Plate 1: Seed sowing in the main field

Plate 2: Seedling just after germination in main field

Plate 3: Growing seedling in the main field

Plate 4: Crop protection by using pesticide

Plate 5: Pesticide application in the main field

Plate 6: Signboard of the experiment

Plate 7: Pod formation stage of the crop

Plate 8: Harvesting stage of the crop

Plate 8: Harvested seed