Bangladesh J. Bot. **54**(1): 123-128, 2025 (March) DOI: https://doi.org/10.3329/bjb.v54i1.80306

EFFECTS OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF SOYBEAN

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Keywords: BINA Soybean-6, BINA SB-4, *Bradyrhizobium*, Vermicompost, Yield

Abstract

Soybean (*Glycine max* L.) is valued for its high protein content and versatile applications. This study evaluated the effects of integrated nutrient management on growth, yield and yield attributes of soybean. Six fertilizer treatments such as T_1 = Farmers' improved practice (N=25, P=12, K=15, S=2 kg/ha), T_2 = Recommended Dose (RD) (N = 25, P = 40, K = 45, S = 3, Zn = 1, B = 0.5 kg/ha), T_3 = 50% RD + 1.2 kg/ha BINA SB-4, T_4 = 100% RD + 1.2 kg/ha BINA SB-4, T_5 = 100% RD (N = 5 kg/ha) + 1.2 kg/ha BINA SB-4 and T_6 = 50% RD + 1.5 t/ha vermicompost, using BINA Soybean-6. The experiment was laid out in a Randomized Complete Block Design (RCBD). Results revealed that treatment T_5 (100% recommended dose with nitrogen and *Bradyrhizobium* inoculant) achieved the highest plant height, branching, leaf count, and pod formation, resulting in superior seed yield (2.54 t/ha), stover yield (3.64 t/ha), and biological yield (6.18 t/ha). Conversely, the absence of nitrogen in T_4 reduced growth and yield. The study highlighted the synergistic benefits of combining fertilizers and bio-inoculants, achieving the highest harvest index (41.08%) in T_5. These findings underscore the importance of integrated nutrient management strategies for optimizing soybean production in nutrient-deficient soils.

Introduction

Soybean (*Glycine max* L.) is an important leguminous crop, valued for its high protein content and versatile uses in food, animal feed, and industrial products (Wang and Komatsu 2016). Because of nutrient shortages and soil deterioration owing to intensive farming methods, soybean production is still below ideal in many areas, including Bangladesh (Raza *et al.* 2017). Fertilization is a key factor influencing soybean growth, yield, and quality. Many researchers observed that both organic and inorganic fertilizers are essential for increasing the growth and yield of soybean. Compost and vermicompost are examples of organic fertilizers that have drawn interest due to their capacity to enhance soil microbial diversity, nutrient retention, and structure- all of which support sustainable farming (Aritonang and Sidauruk 2020). The effects of inoculating soybean with *Bradyrhizobium* spp. have been investigated and recorded, demonstrating an enhancement in soybean yields (Thuita *et al*. 2012, Njira *et al.* 2013). The incorporation of biofertilizer into the soil enhances soil fertility and agricultural yield (Yadav and Sarkar 2019). Due to the low organic matter content in soils, the reaction to fertilizers has been limited because of the quick fixation of nutrients (Rabiul *et al*. 2020). Rhizobium inoculation may be advantageous in certain circumstances. However, there remains a gap in understanding the integrated effects of multiple fertilizer types, including starter nitrogen on soybean productivity, particularly in regions with nutrient-deficient soils like Bangladesh. Although previous studies have explored individual fertilizer types, the combined influence of fertilizers on both the yield and quality of soybean has been investigated recently (Haque *et al*. 2021, Islam *et al*. 2021). To

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make a practical recommendation on the application of integrated nutrient management on soybean productivity it is necessary to conduct more comprehensive relevant studies. This study was therefore undertaken to evaluate the effect of different fertilizers *i.e.*, chemical, organic, bio-fertilizers, and starter nitrogen on soybean growth, yield characteristics, and seed yield.

Materials and Methods

The experiment was carried out at the experimental field of Daffodil International University, Birulia, Savar, Dhaka, from December 2023 to March 2024. BINA Soybean-6 was used as the experimental material. Six nutrients treatments were employed in the experiment, namely T_1 = Farmers' improved practice (N=25, P=12, K=15, S=2 kg/ha), T_2 = Recommended Dose (RD) (N = 25, P = 40, K = 45, S = 3, Zn = 1, B = 0.5 kg/ha), T_3 = 50% RD + 1.2 kg/ha BINA SB-4, T_4 = 100% RD + 1.2 kg/ha BINA SB-4, T_5 = 100% RD (N = 5 kg/ha) + 1.2 kg/ha BINA SB-4, and T_6 = 50% RD + 1.5 t/ha vermicompost, using BINA Soybean-6. The experimental design used was a Randomized Complete Block Design (RCBD) with three replications. The dimensions of the unit plot were 10 m² (2.5 m × 4 m). Seeds were sowed at a rate of 40 kg/ha in the designated furrow on December 6, 2023, and the furrows were promptly covered with earth following seeding. All fertilizers were disseminated and properly incorporated into the soil. Biofertilizer (*Bradyrhizobium*, BINA SB-4) was applied at a dosage of 30 g per kilogram of seeds. Biofertilizer was combined with the seeds prior to seeding. Data were collected on plant height, branch count, leaf count at various days after sowing (DAS) (30, 40, 50, 60 DAS, and harvest), pods per plant, pod length, seeds per pod, weight of 100 seeds, grain yield, straw yield, biological yield, and harvest index (%). The collected data were assembled and statistically evaluated utilizing the analysis of variance (ANOVA) method, employing the MSTAT-C software, and the mean differences were adjusted using the Least Significant Difference (LSD) test at a 5% significance level.

Results and Discussion

Different fertilizer treatments had a significant effect on plant height, number of leaves and branches at all growth stages of soybeans. At 30, 40, 50, 60 DAS and at harvest, the highest plant height was 17.37, 28.97, 47.34, 58.53, and 61.15 cm, respectively was recorded in T_5 followed by T_6. On the other hand, the lowest plant height was recorded in T_4 (Fig. 1). The increase in plant height was likely to attributed due to an adequate supply of essential nutrients to the plant, which ultimately enhanced photosynthesis and soybean development. The highest number of branches in plant was recorded in treatment T_5 whereas the lowest number was in T_4 (Fig. 2). The slow release of nitrogen by the nitrogen stabilizer appears to have enhanced the number of branches/plants in T_5 and T_4 treatments. The highest number of leaves/plant was recorded in T_5 whereas the lowest in T_4 (Fig. 3). It is well known that leaf area quantifies the dimensions of a plant's assimilatory system and is derived from the product of leaf length and width, which depends on the number of leaves per plant. It significantly affects plant productivity and a crucial determinant of dry matter production and grain yield. Effective symbiosis between rhizobia and legume strains may be the cause of the increased growth characters of soybean like plant height, branch number and leaves. This study aligns with the findings of Haque *et al.* (2021). Sultana *et al.* (2014) demonstrated a similar result stating that soybean inoculation considerably raised the nodulation and growth characteristics that impacted yield.

Different fertilizer treatments significantly influenced all the studied yield contributing characters. The highest days to first flowering (45.22 days) was recorded in T_5 followed by T_6 and T_4 which was statistically similar with T_3 (Table 1). Treatment T_5 showed the highest number of

pods and seeds/plant (42.06 and 3.81), which was statistically similar to treatment T_6. On the other hand, the lowest number of pods/plant (24.78 and 2.01) was found in T_4, which may be attributed to the reduced number of branches/plants, as no nitrogen fertilizer was used in the treatment. Haque *et al*. (2021) observed that the highest pods/plant, pod length, seeds/pod, and 100 seed weight was recorded in BINA Binasoybean-5 with *Rhizobium* (Soybean Laxmipur) application. The highest pod length (5.17 cm) was observed in T_5, while the lowest (3.21 cm) in T_4 (Table 1). Treatment T_5 revealed significantly the highest weight of 100 seeds (13.14 g) whereas the lowest (10.89 g) was measured in T_4 (Table 1).

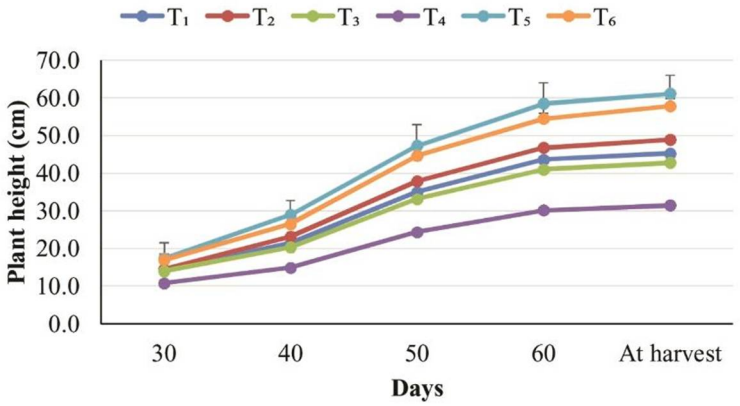

Fig. 1. Effect of fertilizer treatments on plant height of soybean at different days. Vertical bar represented LSD at 0.05% level.

T_1 = Farmers improved practice, **T_2** = Recommended Doses (RD), **T_3** = 50% RD + 1.2 kg/ha BINA SB-4, **T_4** = 100% RD + 1.2 kg/ha BINA SB-4, **T_5** = 100% RD (additional N =5 kg/ha) + 1.2 kg/ha BINA SB-4 and **T_6** = 50% RD + 1.5 t/ha vermicompost

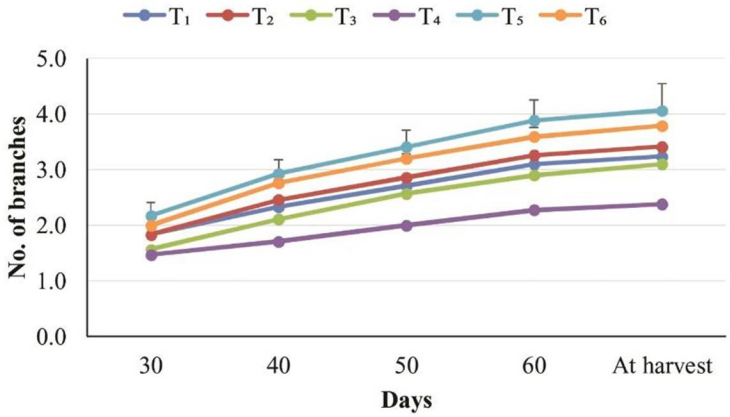

Fig. 2. Effect of fertilizer treatments on number of branch/plants of soybean at different day. Vertical bar represented LSD at 0.05% level.

According to Hossain *et al.* (2023) applying 50% of the recommended doses and biofertilizer (BARI RGm-901) at a rate of 1.2 kg/ha significantly increased the highest number of lateral branches/plant, number of pods plant-1, weight of 100 seeds, and seed yield (t/ha) of soybean.

Sultana *et al.* (2014) and Islam *et al.* (2021) also found the positive effect of biofertilizers on growth and yield attributes of soybeans.

The highest seed, stover and biological yield (2.54, 3.64, and 6.18 t/ha) was recorded in T5 whereas the lowest in T_4 (Table 2). *Bradyrhizobium* bacteria-inoculated soybeans have been shown to boost agricultural seed yields (Jat and Ahlawat 2006, Haque *et al.* 2021, Hossain *et al.* 2023).

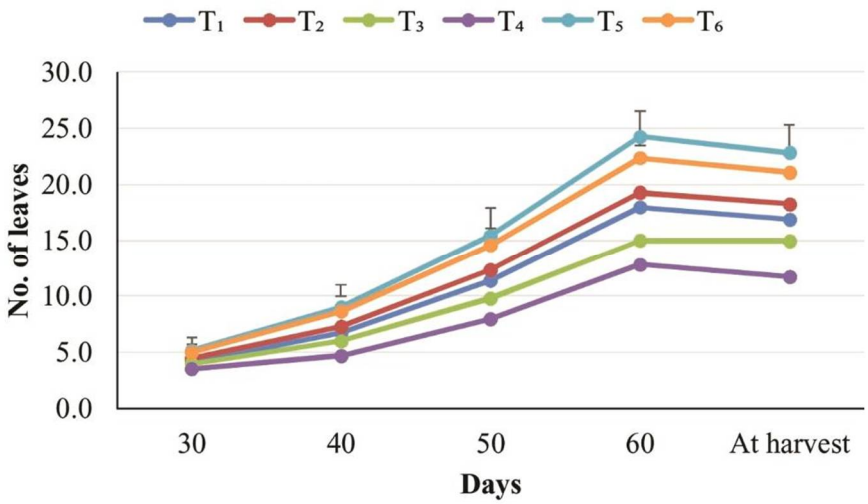

Fig. 3. Effect of fertilizer treatments on number of leaves/plant of soybean at different days. Vertical bar represented LSD at 0.05% level.

Table 1. Effects of different fertilizer treatments on yield contributing characters of soybean.

Treatments	Days to 1st flowering	Pods/plant (No.)	Pod length (cm)	Seeds/pod (No.)	Weight of 100 seeds (g)
T_1	41.38b	35.02b	4.47cd	2.96bc	11.74cd
T_2	42.58ab	37.05b	4.72bc	3.18b	12.06bc
T_3	37.25c	30.54c	4.17d	2.90c	11.41cd
T_4	35.57c	24.78d	3.21e	2.01d	10.89d
T_5	45.22a	42.06a	5.17a	3.81a	13.14a
T_6	43.83ab	40.65a	4.98ab	3.56a	12.73ab
$LSD_{(0.05)}$	3.062	2.705	0.340	0.276	0.901
CV (%)	4.11	4.25	4.20	4.95	4.17

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05% level.

Treatment T_5 had the highest harvest index (41.08 %) whereas the lowest was in T_4 (Table 2). The role that nitrogen-fixing bacteria play in secreting chelating substances-organic acids that are crucial for the solubilization of macro and microelements from organic manure sources which may

be the cause of these beneficial effects of biofertilization as reported by El-Sayed *et al*. (2015), Rahmayani *et al.* (2017) and Sánchez-Navarro (2020).

Table 2. Effects of different fertilizer treatments on yields and harvest index of soybean.

Treatments	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
T_1	1.80d	3.51ab	5.31cd	33.93d
T_2	2.04c	3.30b	5.34bc	38.22c
T_3	1.58e	3.34b	4.92d	32.10e
T_4	1.01f	2.96c	3.97e	25.44f
T_5	2.54a	3.64a	6.18a	41.08a
T_6	2.24b	3.48ab	5.72b	39.17b
$LSD_{(0.05)}$	0.154	0.248	0.397	0.724
CV (%)	4.55	4.04	4.16	1.14

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05% level.

The current study concludes that a mix fertilizer dose of 5 kg N/ha + 1.2 kg/ha of BINA SB-4 biofertilizer is more effective than other fertilizer management strategies regarding the yield of soybean. However, more studies are required to make a recommendation on the best mix of biofertilizer with synthetic fertilizer on soybean farming in Bangladesh.

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(Manuscript received on 30 November, 2024; revised on 20 February, 2025)