

In Vitro Effects of Organic Versus Chemical Fertilizers on Glycine Max Plant Growth

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Abstract- Soybean (*Glycine max L.*) is a globally significant legume crop valued for its nutritional and economic importance. Early seedling growth plays a crucial role in determining final crop productivity and is highly influenced by nutrient availability. This study evaluated the *in vitro* effects of organic and chemical fertilizers on the early growth performance of *Glycine max* under controlled conditions. Five treatments including control were applied in sand-filled pots. Statistical analysis revealed significant differences among treatments ($p < 0.05$), with vermicompost outperforming all others by enhancing germination (93.67%), seedling vigor (2186.20), and chlorophyll content (2.76 mg/g FW). These results highlight the potential of vermicompost as a sustainable alternative to chemical fertilizers in promoting healthy seedling development in soybean cultivation.

Keywords- Glycine max, vermicompost, DAP, NPK, seedling vigor, sustainable agriculture.

I. INTRODUCTION

Soybean (*Glycine max L.*) is one of the most important legume crops worldwide, valued for its high protein content and diverse applications in food, feed, and industrial products. In India and other developing countries, increasing soybean productivity remains a major agricultural goal due to growing demand and limited arable land. Seedling establishment and early growth are critical phases that determine crop success, and these stages are heavily influenced by nutrient availability (Kumar et al., 2020). Fertilizers—both organic and inorganic—are widely used to enhance soil fertility and plant growth, yet their comparative effects on early seedling development remain an area of active research.

Chemical fertilizers such as di-ammonium phosphate (DAP) and NPK mixtures are known for their immediate availability and high nutrient content, but their long-term use has been associated with soil degradation, nutrient leaching, and environmental concerns (Sharma et al., 2020). In contrast, organic fertilizers like vermicompost and compost not only supply essential macro- and micronutrients but also improve soil structure, microbial activity, and water retention capacity (Meena and Singh, 2018). Vermicompost, in particular, is rich

in humic substances, enzymes, and beneficial microorganisms that stimulate plant growth through both nutritional and hormonal mechanisms (Yadav et al., 2019).

Several studies have compared organic and chemical fertilizers in field conditions; however, fewer have focused on controlled *in vitro* settings that eliminate soil variability and isolate fertilizer effects on early seedling traits. *In vitro* studies using sand as a neutral substrate allow for precise assessment of root-shoot development, biomass accumulation, and physiological responses such as chlorophyll content and seedling vigor (Singh and Dwivedi, 2017). These early-stage indicators are predictive of overall plant health and productivity, making them vital for evaluating input efficiency.

This study aims to assess and compare the effects of organic and chemical fertilizers on the germination and early growth of *Glycine max* under *in vitro* sand pot conditions. By measuring various parameters under study, this research seeks to provide insights into the relative effectiveness of different fertilizer types and contribute to sustainable nutrient management strategies.

II. MATERIALS AND METHODS

A. Plant Material

This study was conducted to assess the *invitro* effects of organic and chemical fertilizers on the early growth performance of *Glycinemax* (soybean). Healthy seeds of *Glycinemax* were procured from a agriculture store. Prior to sowing, the seeds were surface-sterilized using 0.1% sodium hypochlorite for 2 minutes and thoroughly rinsed with distilled water to eliminate potential microbial contaminants (Sharma et al., 2016).

B. Experimental Setup

The experiment was designed as a completely randomized design (CRD) with five treatments replicated three times, and was conducted under laboratory conditions using sterilized sand as a growth medium. Each treatment was applied in 500 g capacity plastic pots filled with washed and

autoclaved river sand, which served as an inert substrate to exclude soil-based microbial interactions (Singh and Dwivedi, 2017).

C. Fertilizers Treatment

The treatments included a control (T0, no fertilizer), two organic fertilizers—vermicompost (T1) and compost (T2), and two chemical fertilizers—di-ammonium phosphate (DAP, T3) and a balanced NPK fertilizer (20-20-20, T4). All fertilizers were administered in liquid form to ensure uniform application. Organic fertilizers were prepared by dissolving 50 g of vermicompost or compost in 100 ml of distilled water, and 20 ml of this solution was applied to each pot. For chemical treatments, 1 g of DAP or NPK was dissolved in 100 ml of distilled water, with 20 ml applied per pot at the time of sowing. These doses were scaled based on standard field recommendations to suit pot-scale experiments (Patel et al., 2020).

D. Parameters under Study

Each pot received five soybean seeds, and consistent moisture was maintained using distilled water throughout the study period. Observations were recorded 14 days after sowing, focusing on multiple growth and physiological parameters. Germination rate was calculated as the percentage of seeds germinated per pot. Root and shoot lengths were measured using a scale, and fresh biomass was recorded using an analytical balance. The seedling vigor index (SVI) was calculated by multiplying the germination percentage by the sum of root and shoot lengths, following the formula given by Abdul-Baki and Anderson (1973). Chlorophyll content in soybean seedlings was estimated using the 80% acetone extraction method as described by Arnon (1949). Fresh leaf samples (0.5 g) were homogenized in acetone and absorbance was measured at 645 nm and 663 nm.

E. Data Analysis

All data were statistically analyzed using analysis of variance (ANOVA).

III. RESULTS AND DISCUSSION

The application of organic and chemical fertilizers significantly influenced the early growth performance of *Glycinemax* under *in vitro* conditions. Among the treatments, vermicompost (T1) showed the most pronounced positive effect on nearly all measured parameters.

Germination rate was highest in the vermicompost treatment ($93.67 \pm 2.04\%$), followed by NPK ($90.80 \pm 1.85\%$), compost ($87.30 \pm 2.00\%$), and DAP ($85.37 \pm 1.66\%$), while the control group showed the lowest germination ($59.87 \pm 1.00\%$). The differences were statistically significant ($p < 0.05$), indicating the superiority of both organic and chemical fertilizers over the control in promoting seed germination (Table 1). This aligns with findings by Yadav et al. (2019), who reported enhanced germination in legumes with organic amendments due to improved microbial activity and moisture retention.

Root and shoot lengths followed a similar trend. Vermicompost-treated plants had the longest roots (11.16 ± 0.15 cm) and shoots (12.17 ± 0.05 cm), significantly outperforming all other treatments ($p < 0.05$). Compost and NPK treatments also showed substantial improvements over the control. The increase in seedling length may be attributed to better nutrient availability and aeration offered by the organic matter (Kumar et al., 2020).

Biomass accumulation was highest in the vermicompost group (0.93 ± 0.01 g), followed by NPK (0.89 ± 0.04 g), compost (0.79 ± 0.02 g), and DAP (0.80 ± 0.00 g). These increases are indicative of improved plant vigor under fertilized conditions. According to Meena and Singh (2018), the presence of humic substances in compost and vermicompost enhances root development and nutrient uptake, resulting in higher biomass production.

Seedling Vigor Index (SVI), a comprehensive indicator of seedling health, was significantly higher in the vermicompost treatment (2186.20 ± 56.98) compared to the control (835.90 ± 27.24). The values for compost, NPK, and DAP ranged from 1735.73 to 1990.73, reflecting a clear growth advantage due to fertilization (Table 1). This supports previous research suggesting that organic inputs not only provide nutrients but also stimulate enzymatic and microbial processes beneficial for seedling development (Patel et al., 2021).

Chlorophyll content, measured as an indicator of photosynthetic efficiency, was also enhanced by fertilizer application. Vermicompost again led with the highest chlorophyll content (2.76 ± 0.06 mg/g FW), followed by NPK (2.61 ± 0.17 mg/g FW), DAP (2.46 ± 0.16 mg/g FW), and compost (2.34 ± 0.12 mg/g FW), while the control exhibited the lowest value (1.07 ± 0.11 mg/g FW). The increased chlorophyll content under organic treatments may be due to improved micronutrient availability and hormonal stimulation (Ling et al., 2011).

Overall, statistical analysis using one-way ANOVA confirmed that all measured parameters were significantly influenced by fertilizer treatment ($p < 0.05$). The superiority of vermicompost suggests that organic amendments can effectively substitute chemical fertilizers in early growth stages, offering a sustainable and eco-friendly alternative. These findings are consistent with current trends advocating organic farming to reduce chemical input load on the environment while maintaining crop productivity (Sharma et al., 2020).

IV. CONCLUSIONS

The present study concludes that both organic and chemical fertilizers significantly enhance early growth parameters of *Glycinemax* under *invitro* conditions. Among the treatments, the superior performance of vermicompost may be attributed to its balanced nutrient profile and positive influence on seedling physiology. These findings support the integration of organic fertilizers into crop production systems, especially during early growth stages, to promote plant health while reducing chemical dependency.

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Table 1: Influence of various fertilizers on *Glycine max* based on studied growth parameters.

Treatment	Germination Rate (%)	Root Length (cm)	Shoot Length (cm)	Biomass (g)	SVI	Chlorophyll (mg/g FW)
T0 (Control)	59.87 ± 1.00	6.60 ± 0.33	7.36 ± 0.08	0.47 ± 0.05	835.90 ± 27.24	1.07 ± 0.11
T1 (Vermicompost)	93.67 ± 2.04	11.16 ± 0.15	12.17 ± 0.05	0.93 ± 0.01	2186.20 ± 56.98	2.76 ± 0.06
T2 (Compost)	87.30 ± 2.00	10.32 ± 0.29	11.09 ± 0.33	0.79 ± 0.02	1869.20 ± 72.26	2.34 ± 0.12
T3 (DAP)	85.37 ± 1.66	9.53 ± 0.07	10.81 ± 0.27	0.80 ± 0.00	1735.73 ± 13.05	2.46 ± 0.16
T4 (NPK)	90.80 ± 1.85	10.43 ± 0.29	11.49 ± 0.32	0.89 ± 0.04	1990.73 ± 74.23	2.61 ± 0.17