Influence of nutrient sources on growth and yield of soybean (*Glycine max* l.)

ABSTRACT

The investigation was carried out at experimental cum demonstration fieldShri Vaishnav Institute of Agriculture, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore during *rabi* 2023. The soil of experimental field was medium black clay in texture. It was low in available nitrogen (210.65 kg ha-$^{-1}$), medium in phosphorus (15.22 kg ha^{-1}) and high in potassium (450.27 kg ha^{-1}). The soil organic carbon content, pH, and EC was 0.50 %, 7.30 %, and 0.75 dSm^{-1}, respectively. The field experiment was carried out in randomized block design with eight treatments consisted of T_1: absolute control, T_2: 100 % RDF, T_3: 100 % RDN through FYM, T_4: 100 % RDN through vermicompost, T_5: 50 % RDF + 50 % RDN through FYM, T_6: 50 % RDF + 50 % RDN through vermicompost, T_7: 75 % RDF + 25 % RDN through FYM, and T_8: 75 % RDF + 25 % RDN through vermicompost, and each experimental unit was replicated thrice having the gross plot size of 3.60 x 4.50 m^2 and net plot 2.70 x 4.30 m^2.

Application of 75 % RDF + 25 % RDN through vermicompost recorded significantly maximum growth characters *viz*., plant height (42.33 cm), number of branches plant^{-1} (9.90), number of leaves (23.33) plant^{-1} at 60 DAS, number of root nodules plant^{-1} (47.27) at 60 DAS , dry matter accumulation plant^{-1} (22.78 g) at harvest, and leaf area plant^{-1} (13.17 dm^2) as compare to all other treatments and was at par with treatment RDF. In a similar vein, noticeably higher yield contributing character such as number of pods (29.33) plant^{-1}, pod yield plant^{-1} (21.33 g), and seed yield plant^{-1} (10.83 g), was recorded in treatment 75 % RDF + 25 % RDN through vermicompost than rest of the treatments and was on par with treatment RDF. Significantly higher grain yield (15.30 q ha^{-1}), straw yield (23.69 q ha^{-1}) and biological yield (38.99 q ha^{-1}) of soybean was recorded in treatment 75 % RDF + 25 % RDN through vermicompost, over rest of the treatments and was on par with treatment RDF. The higher protein content (43.40 %), oil yield (314.03 kg ha^{-1}) and protein yield (665.22 kg ha^{-1}) was found in treatment 75 % RDF + 25 % RDN through vermicompost than any other treatment.

Keywords: organic, inorganic, soybean, nutrient source.

INTRODUCTION

Soybean [*Glycine max* L.] is an important oil-yielding crop having worldwide adaptation. It belongs to the legume family and is native to East Asia. Soybean is known as the “Golden Bean” of the twentieth century and is one of the most important oil seed crops in the world. Oil and protein-rich soybean have now been recognized all over the world as a potential supplementary source of edible oil and nutrition (Kaul and Das, 1986). “The oil of soybean contains 85 % unsaturated fatty acid and is cholesterol-free. Soybean seeds contain 43.2 % protein, 19.5 % fat, 20.9 % carbohydrate, and a good amount of other nutrients like calcium, phosphorus, iron, and vitamins” (Gopalan *et al.*, 1971). Soybean has 3 % lecithin which is helpful for brain development. Soybean oil is cholesterol-free and is an easily acceptable diet. Soybean accounts for approximately 50 % of the total production of oilseed crops in the world.

It occupies the third place among oilseeds in India covering about 60,000 km^2. The leading soybean-growing countries are USA, Brazil, China, Argentina, and India. Madhya Pradesh with average productivity of 1125 kg ha^{-1} and Maharashtra with average productivity of 946 kg ha^{-1} , contribute 88 % of the country`s total soybean production. Andhra Pradesh has an average productivity of 1280 kg ha$^{-1}$, which is 20 % more than country`s average. Madhya Pradesh is the main producer of soybean in India. Thus, also called as soybean Capital of India.

"To optimize soybean growth, fertilization plays an important role in improving soybean productivity. Naturally, the need of nitrogen for legumes such as soybean has been partially met through the symbiosis of *Rhizobium* bacteria and root nodule, which absorbs nitrogen from the air. However, farmers tend to add chemical fertilizer excessively during soybean cultivation based on assumption that it may increase the yield. On the other hand, soybeans can only absorb 35 to 70 % of the entire nitrogen fertilizer applied" (Abbasi *et al.*, 2010). "An over application of chemical fertilizers leads to a loss of soil fertility by modifying the chemical composition and physical character of the soil and bacterial diversity" (Dinesh *et al.*, 2010) by disturbing soil microflora.

Organic fertilizer is the best alternative as it tends to improve land productivity by mitigating the negative effects of chemical fertilizers and slowing soil degradation. Organic fertilizer has a significant impact on soil nutrient availability, aggregate formation, and soil bacterial communities.

Combined application of organic sources such as bio-fertilizer, cow dung (CD) and vermicompost (VC) may reduce the need for chemical fertilizer, allowing small farmers to save a part of the cost of production. This also increases the yield and yield contributing characters ultimately resulting in increased productivity of soybean (Shirpukar *et al*., 2006). In addition, global environmental pollution can be controlled considerably by reducing the use of chemical fertilizers and increasing the use of organic sources.

In this context, this study was aimed to evaluate the influence of organic and inorganic nutrient sources on growth and yield of soybean (*Glycine max* L.).

MATERIAL AND METHOD

The present experiment entitled "Influence of nutrient sources on growth and yield of soybean (*Glycine max* L)" was carried out at experimental cum demonstration field, SVIAG, SVVV, Indore during *rabi* 2023.

The topography of experimental field was levelled and well drained. Textural class was medium black clay. In view to know the initial fertility status of the soil, representative and composite soil samples were collected from experimental site from 0-30 cm depth randomly from five different locations. The soil samples were analysed in departmental laboratory by using standard analytical methods for determination of soil physical and chemical properties. The soil was low in available nitrogen (210.65 kg ha^{-1}), medium in phosphorus (15.22 kg ha^{-1})

and high in potassium (450.27 kg ha^{-1}). The soil organic carbon content, pH, and EC was 0.50 %, 7.30 %, and 0.75 dSm^{-1}, respectively.

The field experiment was carried out in randomized block design with eight treatments consisted of T_1: absolute control, T_2: 100 % RDF, T_3: 100 % RDN through FYM, T_4: 100 % RDN through vermicompost, T_5: 50 % RDF + 50 % RDN through FYM, T_6: 50 % RDF + 50 % RDN through vermicompost, T_7: 75 % RDF + 25 % RDN through FYM, and T_8: 75 % RDF + 25 % RDN through vermicompost, and each experimental unit was replicated thrice. The field was divided into 24 plots with gross plot size of 3.60 m x 4.50 m each. The experiment was laid out on a well leveled plot with uniform fertility. The land was prepared by ploughing with tractor, followed by one harrowing. The stubbles, debris and weed from previous crops were collected and removed from the plot.

Organic manures viz., well decomposed farmyard manure and vermicompost were applied a week before sowing on dry weight basis as per treatments. Before application these organic sources were analyzed for their nutrient content by using standard analytical methods. Recommended dose of fertilizer 20:40:40 kg N: P_2O_5 K_2O ha^{-1} was applied through urea, SSP and MOP.

The truthful seed of soybean (Cv. JS- 9560) was obtained from seed sale unit, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur and were treated with *Rhizobium japonicum* before sowing. The gap filling was carried out as soon as the mortality was notice after sowing to maintain the optimum plant population.

At physiological maturity stage, initially all border rows from each gross plot were harvested separately and thereafter the remaining plots were harvested as net plot produce. Harvesting of soybean was done manually by cutting plants at their base with sickle and harvested produce was kept for drying for 2 days. The sundried soybean plants were threshed by beating the pods. Then seed and straw yield were separated by winnowing and weighed separately. Thus, plot-wise yields obtained were tabulated, analyzed, and interpreted in experimental result.

Sampling technique

Five representative plants were selected randomly from each net plot to monitor periodical growth and development stages of crop. The selected plants were fixed with wooden sticks and labeled with tags. The same plants were harvested separately for recording bio-metric observations.

The standard method of analysis of variance was used for analyzing the data for Randomized Block Design (Panse and Sukhatme,1985). The f test of significance was used for testing the null hypothesis and appropriate standard error of mean (SE$\pm$) for each treatment effect and where the treatment effect was significant, critical difference (C.D.) at 5 per cent probability level was worked out for testing the significance of treatment differences.

RESULT AND DISCUSSION

Growth Studies

Application of 75 % RDF + 25 % RDN through vermicompost recorded significantly maximum growth characters *viz*., plant height (42.33 cm), number of branches plant^{-1} (9.90), number of leaves (23.33) plant^{-1} at 60 DAS, number of root nodules plant^{-1} (47.27) at 60 DAS , dry matter accumulation plant^{-1} (22.78 g) at harvest, and leaf area plant^{-1} (13.17 dm^2) as compare to all other treatments and was at par with RDF treatment. The lowest growth characters *viz*. plant height (29.57 cm), number of branches plant^{-1} (8.00), number of leaves (14.93) plant^{-1} at 60 DAS, number of root nodules plant^{-1} (28.87) at 60 DAS, dry matter accumulation plant^{-1} (15.65 g) at harvest, and leaf area plant^{-1} (8.83 dm^2) at 60 DAS, was recorded under treatment absolute control.

The increase in plant height with 75 % RDF + 25 % RDN through vermicompost was mainly due to its influence on vegetative crop growth resulting in higher plant height. This may be owing to continuous availability of nutrients to soybean plants because of their slow release of nutrients from vermicompost during the crop season. Moreover, vermicompost added a good amount of NPK in the soil, besides supplying other essential macro and micro-nutrients. This clearly indicated the need for adding organic manures to the soil conjunctive with inorganic fertilizers, which increased the availability of nutrients considerably resulting in a positive effect on growth parameters. The early-stage crop accumulates more amounts of constituents and nutrients from organic and chemical sources which results to stimulate the cell division in the meristematic tissue and increase in vegetative growth of plant which favors the maximizing growth of branches, increase in number of leaves plant^{-1}and leaf area of plants. The results were closely conformity with findings of Devi *et al.,* (2013), Patil and Udmale (2016), Durgeshwari *et al.,* (2022), Meena *et al.,* (2022) and Verma *et al*., (2017).

The increase in dry matter with 75 % RDF + 25 % RDN through vermicompost was mainly due to its higher vegetative growth. This might be due to optimum supply and availability of nutrients continuously through organic source which help in better uptake of nutrient resulted into more synthesis of nucleic acid and amino acid, amide substances in growing region and meristematic tissue ultimately enhancing cell division and thereby increased all the growth attributes in these treatments. These findings are in accordance with the results of Verma *et al*., (2017) and Meena *et al.,* (2022).

Table 1: Growth attributes of soybean as influenced by different treatments.

Treatments	**Growth attributes**					
	Plant height (cm) plant^{-1}	**Number of branches plant^{-1}**	**Number of leaves plant^{-1} (60DAS)**	**Number of nodules plant^{-1}**	**Dray matter g plant^{-1}**	**Leaf area dm^2 plant^{-1} (60 DAS)**
T_1: Absolute control	29.57	8.00	14.93	28.87	15.65	8.83
T_2: RDF	40.00	9.27	22.33	44.67	21.34	12.37

T_3: 100 % RDN through FYM	31.27	8.70	19.67	30.80	16.95	10.00
T_4: 100 % RDN through Vermicompost	31.33	8.77	20.27	32.17	17.62	10.23
T_5: 50 % RDF + 50 % RDN through FYM	31.50	8.87	21.00	35.67	18.27	10.63
T_6: 50 % RDF + 50 % RDN through VC	31.90	8.97	21.20	39.00	19.51	11.20
T_7: 75 % RDF + 25 % RDN through FYM	32.17	9.03	21.33	42.33	20.59	11.57
T_8: 75 % RDF + 25 % RDN through VC	42.33	9.90	23.33	47.67	22.78	13.17
S. Em. $\pm$	2.00	0.28	0.47	1.29	0.71	0.34
CD at 5%	6.05	3.84	1.42	3.92	2.16	1.03
General mean	**33.76**	**24.51**	**20.51**	**37.65**	**19.09**	**11.00**

Yield Attributes

In a similar vein, noticeably higher yield contributing character such as number of pods (29.33) plant^{-1}, pod yield plant^{-1} (21.33 g), and seed yield plant^{-1} (10.83 g), was recorded in treatment 75 % RDF + 25 % RDN through vermicompost than rest of the treatments and was on par with treatment RDF. Whereas, the minimum number of pods (20.93) plant^{-1}, pod yield plant^{-1} (13.20 g), and seed yield plant^{-1} (7.00 g), was recorded under treatment absolute control.

Test weight and harvest index were found to be non-significant effect among different treatments under study.

Table 2: Yield attributes of soybean as influenced by different treatments.

Treatments	Yield attributes				
	Number of pods plant^{-1}	**Pod yield (g) plant^{-1}**	**Seed yield (g) plant^{-1}**	**Test weight**	**Harvest index**
T_1: Absolute control	20.93	13.20	7.00	104.73	40.78
T_2: RDF	26.30	19.00	9.83	108.50	39.33
T_3: 100 % RDN through FYM	23.10	14.13	7.27	105.40	43.92
T_4: 100 % RDN through Vermicompost	23.30	15.47	7.60	104.53	42.86
T_5: 50 % RDF + 50 % RDN through FYM	24.03	15.53	7.63	106.23	42.86
T_6: 50 % RDF + 50 % RDN through VC	24.47	17.53	8.30	107.23	41.56

T_7: 75 % RDF + 25 % RDN through FYM	25.10	17.67	8.50	108.67	40.85
T_8: 75 % RDF + 25 % RDN through VC	29.33	21.33	10.83	109.67	39.24
S. Em. $\pm$	1.32	1.17	0.58	1.95	1.86
CD at 5%	4.02	3.56	1.76	NS	NS
General mean	**24.57**	**16.73**	**8.37**	**106.87**	**41.42**

The feasible reason for higher values for yield attributes such as number of pods, pod yield plant^{-1}, and seed yield plant^{-1} could be because of the integration and availability of mineral fertilizers, organic manures along with consortia throughout the growing period of crop, this leads to ease of nitrogen availability to the crop, thus plant did not place in nutrient stress condition at any stage. This outcome was already obtained by Devi *et al.*, (2013), Verma *et al.*, (2017), and Durgeshwari *et al.*, (2022).

Yield

The grain, straw and biological yield of soybean was significantly influenced by different treatments. Application of 75 % RDF + 25 % RDN through vermicompost recorded significantly higher grain yield (15.30 q ha^{-1}), straw yield (23.69 q ha^{-1}) and biological yield (38.99 q ha^{-1}) over rest of the treatments and was on par with treatment RDF. While lowest seed yield (6.32 q ha^{-1}), straw yield (9.19 q ha^{-1}), and biological yield (15.50 q ha^{-1}) at harvest was observed under treatment absolute control.

The maximum yield might be attributed to maximum dry matter weight plant^{-1}, number of pods plant^{-1}, and seeds plant^{-1}. This might be due to adequate supply of nutrient element at the right time from organic and inorganic sources which helped optimum dry matter partitioning from the source to sink during reproductive stage of plant that maximize accumulation of photosynthesis to the pod; consequently, increase the grain yield of soybean. The increase in biological yield may be because of the constructive role of organic manures in promoting biological activity of soil, thus increase mobilization of nutrient from both chemical and organic sources, while additional supply of consortia increased nutrient uptake and better translocation of nutrients thus finally enhanced the biological yield. These findings are in accordance with the results of Bachhav *et al.*, (2012), Devi *et al.*, (2013), and Durgeshwari *et al.*, (2022).

Table 3: Yield of soybean as influenced by different treatments.

Treatments	**Grain yield (q ha^{-1})**	**Straw yield (q ha^{-1})**	**Biological yield (q ha^{-1})**
T_1: Absolute control	6.32	9.19	15.50
T_2: RDF	14.21	22.11	36.32
T_3: 100 % RDN through FYM	10.34	13.21	23.54
T_4: 100 % RDN through Vermicompost	11.34	15.22	26.56

T_5: 50 % RDF + 50 % RDN through FYM	12.92	17.23	30.15
T_6: 50 % RDF + 50 % RDN through VC	13.49	19.04	32.53
T_7: 75 % RDF + 25 % RDN through FYM	13.78	20.10	33.88
T_8: 75 % RDF + 25 % RDN through VC	15.30	23.69	38.99
S. Em. $\pm$	0.45	1.14	1.00
CD at 5%	1.36	3.45	3.03
General mean	**12.21**	**17.47**	**29.68**

CONCLUSION

The application of 75 % RDF + 25 % RDN through vermicompost demonstrated comparable outcomes. Consequently, this treatment resulted in higher growth, yield attributes and yield as compared to the remaining treatments. Hence, it is advisable to apply 75 % RDF + 25 % RDN through vermicompost for getting maximum yield of *rabi* soybean.

In the context of integrated nutrient management strategies that consider economic factors, it could be said that combine application of 75 % RDF and 25 % RDN through vermicompost can be used to achieve elevated gross returns, net monetary returns and benefit-cost (B:C) as this treatment was at par with the treatment receiving 100 % recommended dose of fertilizer.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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