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Effect of different nutrient management practices for enhancing soybean yield and yield attributes

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Abstract
Soybean is a vital legume crop valued for its nutritional and economic importance, yet its productivity is threatened by declining soil fertility. Sustainable nutrient management is therefore essential to enhance crop performance and maintain soil health. A field experiment was conducted at JNKVV, Jabalpur during *kharif* 2024 to evaluate six nutrient management practices in a randomized block design with four replications. Results revealed that 100% organic nutrient management (T_1) produced the highest growth including plant height (57.85 cm), branches/plant (5.30), leaf area index (4.91), and nodulation (57.08) followed by T_3 (50% organic + 50% inorganic). As regards to yield attributing character i.e. pods/plant, maximum pod count (52.45) was obtained under T_1followed by T_3 however, the other characters like seeds/pod and seed index were not influenced by different treatment. Maximum seed yield was also recorded under 100% organic nutrient management (T_1) which was statistically at par with 100% inorganic fertilizer (T_6).

Keywords: Soybean, nutrient management, organic, inorganic, natural farming, seed yield

Introduction
Soybean (*Glycine max* L.) is known as the "wonder crop" or "miracle crop" because of its several uses. It is a native of North-eastern China belonging to the family Fabaceae. It can grow well in tropical and subtropical climates and requires a warm and moist season. A temperature range of 26 to 30°C appears to be the optimum. In India, soybean has gained significant importance due to its adaptability to diverse agro-climatic conditions, particularly in Madhya Pradesh, which leads in both area and production. Soybean is one of the leading oil and protein-containing crops of the world. Soybean seed contains 20-22% oil, 42-45% protein, 30-35% carbohydrate, and 9-10% total soluble sugar (mainly sucrose, stachyose and raffinose) and a high amount of amino acid, thiamine, vitamins, niacin, riboflavin, phosphorus, calcium and iron. It contributes 25% of the global edible oil production [1].

According to USDA (2023), world soybean production in 2023-24 is estimated to be 394.71 million metric tons from a total area of 136.82 million hectares. With Brazil being the highest producer contributing 39% in global production followed by USA (29%), Argentina (12%), China (5%) and India (3%) [2]. Soybean is extensively grown all over India because of its wide adaptability to agro-climatic conditions. The area under cultivation in India is 13.08 million hectares and production is estimated to be 11.88 million metric tons in 2023-24. Madhya Pradesh stood first with a 5.20-million-hectare area and production of 5.5 million tons in 2023-24 with productivity of 1.2 tons/ hectare, followed by Maharashtra and Rajasthan (Anonymous 2023.

There are several constraining factors that lead to low levels of soybean production among those, low soil fertility level is one of the major factor [3]. One of the causes of declining soil fertility is continuous cropping without the use of organic manures and biofertilizers. So, the application of inorganic fertilizers along with organic inputs can help in increasing soybean production. The declining soil fertility is negatively impacting soybean yields in Madhya Pradesh, with yields steadily decreasing. The continued use of inorganic fertilizers is a major factor in this decline. However, implementing an integrated nutrient management (INM) strategy can help improve soil health and restore fertility.

Excessive use of chemical fertilizers has led to soil degradation and the production of low-quality food, ultimately posing risks to human health. To reduce the accumulation of heavy metals and chemical residues in food, organic agricultural inputs are increasingly being adopted. These inputs are often prepared using locally available materials and agricultural by-products such as barn waste, oil cakes, and farmyard manure (FYM). Among these, *Beejamrit, Jeevamrit* and *Ghanjeevamrit* are commonly used in organic farming systems to enhance plant growth and productivity. *Beejamrit* is specifically used for treating seeds, seedlings, and planting materials. It helps protect young roots from fungal infections and both seed-borne and soil-borne diseases, also promoting the production of growth hormones like IAA and GA_3. It contains beneficial microorganisms naturally found in cow dung, which are cultivated and used as a microbial inoculant for seeds. *Jeevamrit* serves as an organic fertilizer and an effective alternative to synthetic inputs. It provides a rich source of biomass, natural carbon, nitrogen, phosphorus, calcium, and other essential nutrients vital for plant growth and development. Its application enhances the population and activity of soil microorganisms, thereby improving soil fertility and crop yield. *Jeevamrit* is available in two forms - liquid and solid, the latter commonly referred to as *Ghanjeevamrit* [4].

Modern crop varieties demand higher nutrient inputs, and balanced fertilization is key to achieving both high yield and quality. Organic farming offers a sustainable solution, with organic manures playing a vital role in restoring soil health and supplying essential micronutrients often lacking in chemical fertilizers. Integrating both inputs not only enhances productivity but also supports environmentally sound agriculture.

Material and Methods

Study area

A field experiment was conducted during *kharif* 2024. The field trial was conducted at Instructional Research Farm, Krishi Nagar, Department of Agronomy, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India and is located between 23°18' N latitude and 79°98' E longitude, with an average altitude of approximately 411.78 meters above mean sea level with a total area of 5198 km^2. According to the National Agricultural Research Program's criteria, Jabalpur is located in the "Kymore Plateau and Satpura Hills" agro-climatic zone. The average annual rainfall is 1350 mm. Though rainfall was less abundant during the crop season (from planting to harvesting), its distribution was not uniform. As a result, it encouraged crop establishment, followed by crop growth, development, and yield. These conditions were also quite congenial at this stage. Entire weather conditions were almost favourable for proper growth, development and yield of crops. The field experiment consisted of six treatments and they were tested in randomized block design with four replications. The details of the treatments are given in Table 1. The variety (JS 20-98) has been developed by Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. This variety matures in 96-98 days. The yield is around 25-28 q/ha It possesses high yielding potential under adverse and normal situations both. Multiple resistant against most dreadful diseases like Yellow Mosaic Virus and charcoal rot, including other important diseases *viz.*, blights, bacterial pustules, leaf spots and insect-pests.

Statistical analysis of Treatment

Data recorded on various observations were tabulated and subjected to their statistical analysis by using techniques of the analysis of variance [5]. The significance of the treatments was tested by using 'F' test and when 'F' best shown the significance of the difference between the treatments was further tested with critical difference (C.D.) at 5% level of significance.

Results and Discussion

Effect of different nutrient management practices on crop growth

Plant height: The mean data on plant height of soybean as influenced by different treatments which is given in Table 2 exhibited through Figure 1. Among different treatments, T_1 (100% organic) resulted in higher plant height at 30 (40.24 cm), 60 (60.35 cm), 90 DAS (59.80 cm) and at harvest (57.85 cm) it proved, significantly superior over the rest of the treatments. This superiority can be attributed to the synergistic effects of organic inputs such as FYM, vermicompost and *neemcake* which supply nutrients gradually, enhance soil microbial activity and improve nitrogen availability, a key element of chlorophyll synthesis. Increased chlorophyll facilitates better photosynthesis, promoting enhanced cell division and elongation, which results in improved vegetative growth and plant height [6-10].

Number of branches /plant: The data presented in Table 2 exhibited through Figure 2 the number of branches/plant was found significantly higher at 30 (3.13), 60 DAS (5.75) and harvest (5.30) in T_1 (100% organic) followed by T_3 (50% Organic + 50% Inorganic) at 30 (2.89), 60 DAS (4.78) and harvest (4.84) than the rest of the treatments. This might be due to inclusion of different organic manures i.e., FYM, vermicompost and *neemcake* under T_1 would have facilitated better growth and development ultimately a greater number of branches per plant [6, 9, 11].

Leaf area index (LAI): LAI was significantly affected due to different treatments are presented in Table 2 and Figure 3.The LAI was found maximum (4.91) under T_1 (100% organic) followed by T_3 (50% Organic + 50% Inorganic) (4.86) while minimum (4.55) under T_5 (Farmer practices) (Figure 3). This might be due to the maximum number of leaves found under T_1 and minimum leaves found under T_5 and LAI is positively correlated with the number of leaves/plant [12, 13].

Number of root nodules/plant: The data presented in Table 2 and exhibited through Figure 4 revealed that root nodules/plant showed significant difference under different treatments. Combined application of FYM, vermicompost and *neemcake* under treatment T_1 (100% organic) caused significant superior effect on number of root nodules (16.30) at 30 and (57.08) at 45 DAS followed by T_3 (50% organic +50% inorganic) i.e., 15.29 and 56.39 at 30 and 45 DAS respectively. This might be due to organic inputs providing good moisture and aeration in soil which facilitate the vigorous root system and enhances the microbial activity in the soil [6, 9, 14, 15].

Dry weight of root nodules/plant: The data presented in Table 2 exhibited the dry weight of root nodules/plant was found non-significant at 30 DAS whereas in 45 DAS it was significantly higher (0.43) in T_1 (100% organic) followed by T_3 (50% organic + 50% inorganic) i.e., 0.42. The superior nodule dry weight in T_1 may be attributed to the continuous and balanced nutrient release from organic inputs, which likely enhanced rhizobial activity and nodule development. The gradual mineralization of organic matter provides a sustained nitrogen supply, which supports vigorous root growth and encourages symbiotic nitrogen fixation, thereby increasing nodule biomass [16, 17].

Effect of different nutrient management practices on yield attributes characters

Number of pods/plant: The number of pods/plant differed significantly among treatments. The highest pod count (52.45 pods/plant) was recorded in T_1 (100% organic), followed by T_3 (50% organic + 50% inorganic) with 50.77 pods/plant (Table 3). This might be due to inclusion of different organic manures which improved the agronomic performance of soybean and increased crop yield [18].

Number of seed/pod: Data from Table 3 revealed that the seeds per pod was not influenced significantly by different treatments.

Seed index (g): The data pertaining to seed index (100-seed weight) of soybean influenced by different treatments are shown in Table 3 data revealed that seed index was not influenced significantly by different treatments.

Effect of different nutrient management practices on soybean yields

Seed yield and stover yield (kg/ha): The seed yield is the ultimate result of various interacting growth factors, development and yield contributing attributes. Data pertaining to seed and stover yield (kg/ha) as influenced by various treatments are presented in Table 4 and exhibited through Figure 5. Both the yields of soybean i.e., seed (874.18 kg/ha) and stover (1935.45 kg/ha) was obtained maximum under T_1 (100% organic) than the rest of the treatments. As the seed yield is positively correlated with yield attributes [19, 20].

Harvest index

Data from Table 4 revealed the harvest index was not influenced significantly by different treatments.

Table 1: Treatment details

Treatment No.	Nutrient Details
T_1 100% Organic nutrient management	Manures- 1/3 N through FYM i.e., 1340 kg/ha, 1/3 N through vermicompost i.e., 471 kg/ha, 1/3 N through neemcake i.e., 120 kg/ha
T_2 50% organic NM+NF inputs BJG	Manures- 1/3 N through FYM i.e., 670 kg/ha, 1/3 N through vermicompost i.e., 235.5 kg/ha, 1/3 N through neemcake i.e., 60 kg/ha Remaining through Ghanajeevamrit 250kg/ha and Jeevamrit 500 lit/ha
T_3 50% organic+50% Inorganic NM	Manures- 1/3 N through FYM i.e., 670 kg/ha, 1/3 N through vermicompost i.e., 235.5 kg/ha, 1/3 N through neemcake i.e., 60 kg/ha Fertilizers – Urea – 21.5 kg/ha SSP – 187.5 kg/ha MOP –16.5 kg/ha
T_4 25% organic +NF inputs BJG + 25% inorganic NM	25% nutrients through manures- FYM - 335 kg/ha Vermicompost -117.5 kg/ha Neemcake - 32 kg/ha 25% nutrients through fertilizers- Urea – 10.5 kg/ha SSP – 93.5 kg/ha MOP – 8.25 kg/ha remaining through Ghanajeevamrit & Jeevamrit - Same as T2
T_5 Farmer practice	Fertilizers – DAP – 50 kg/ha
T_6 100% Inorganic	Fertilizers Urea – 43.5 kg/ha SSP – 375 kg/ha MOP – 33 kg/ha

Table 2: Effect of different nutrient management practices on crop growth attributes

Treatment	Plant height (cm)				No. of branches/plant			LAI at 60 DAS	Root nodules/plant		Dry weight nodules/plant (g)	
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	Harvest		30 DAS	45 DAS	30 DAS	45 DAS
T_1 100% Organic	40.24	60.35	59.80	57.85	3.13	5.75	5.30	4.91	16.30	57.08	0.04	0.43
T_2 50% Organic + B, J, G	39.07	57.09	53.10	51.74	2.88	4.16	4.68	4.67	14.94	55.35	0.04	0.29
T_3 50% Organic + 50% Inorganic	35.82	58.53	55.84	52.54	2.89	4.78	4.84	4.86	15.29	56.39	0.04	0.42
T_4 25% Organic +B, J, G + 25% Inorganic	35.42	56.54	52.90	51.20	2.78	4.25	4.50	4.76	14.53	55.38	0.03	0.33
T_5 Farmer practices	33.19	54.45	51.85	50.67	2.31	4.28	3.95	4.55	12.11	52.28	0.03	0.29
T_6 100% Inorganic	39.36	60.28	56.00	55.03	2.80	4.35	4.20	4.80	13.97	53.26	0.04	0.34
SEm ±	1.38	1.85	1.28	1.30	0.11	0.04	0.05	0.04	0.29	0.31	0.004	0.013
CD (p=0.05)	3.15	2.57	2.86	3.90	1.35	2.13	1.15	0.19	1.68	0.71	NS	0.04

Table 3: Effect of different nutrient management practices on yield attributes characters

Treatments	Pods/plant	Seed/pod	Seed index (g)
T_1 100% Organic	52.45	2.90	11.15
T_2 50% Organic + B, J, G	46.34	2.68	10.85
T_3 50% Organic + 50% Inorganic	50.77	2.78	10.50
T_4 25% Organic +B, J, G + 25% Inorganic	48.04	2.73	10.95
T_5 Farmer practices	41.96	2.62	10.20
T_6 100% Inorganic	49.33	2.78	10.30
SEm ±	0.21	0.03	0.46
CD (p=0.05)	0.63	NS	NS

Table 4: Effect of different nutrient management practices on soybean yield

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
T_1 100% Organic	874.18	1935.45	32.86
T_2 50% Organic + B, J, G	780.45	1801.48	32.13
T_3 50% Organic + 50% Inorganic	842.00	1860.80	32.63
T_4 25% Organic +B, J, G + 25% Inorganic	798.74	1839.57	31.43
T_5 Farmer practices	730.03	1726.00	33.33
T_6 100% Inorganic	858.25	1875.48	33.66
SEm ±	6.28	21.16	1.13
CD (p=0.05)	18.93	54.40	NS

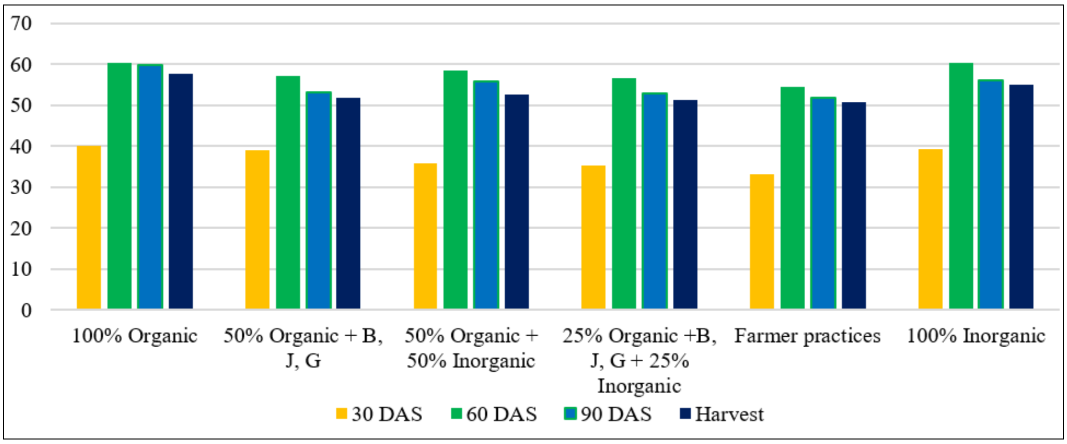

Fig 1: Plant height of soybean as influenced by different treatments

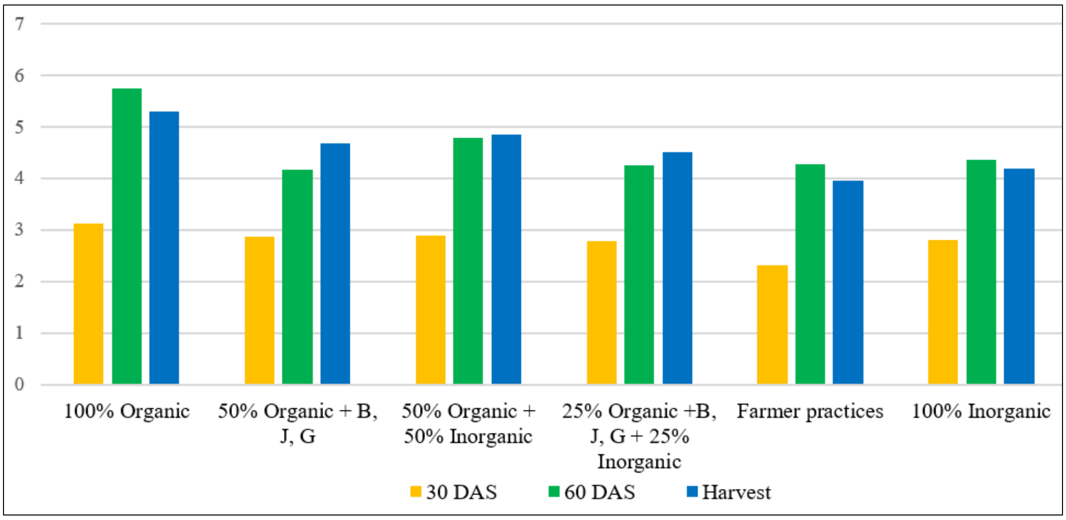

Fig 2: Number of branches/plant of soybean as influenced by different treatments

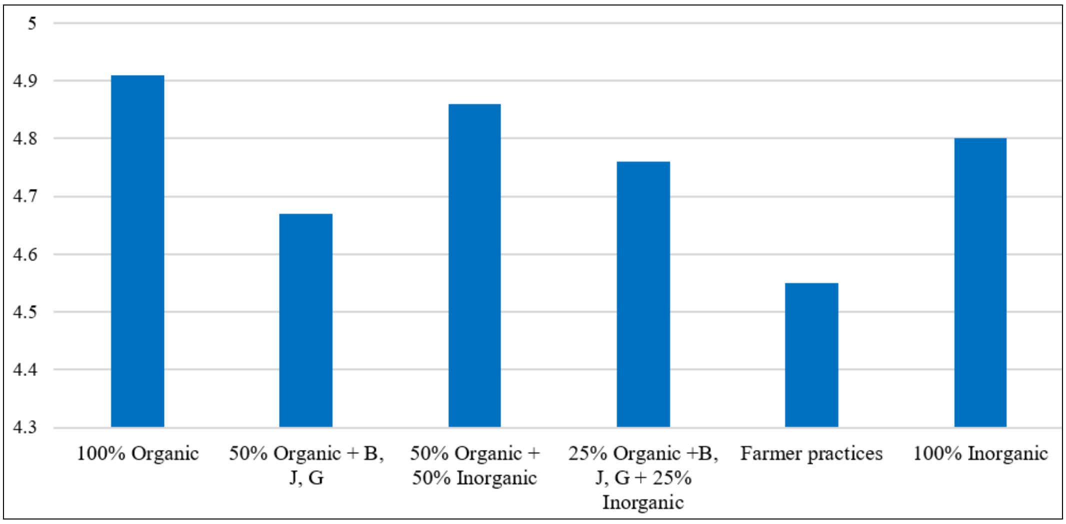

Fig 3: LAI of soybean as influenced by different treatments

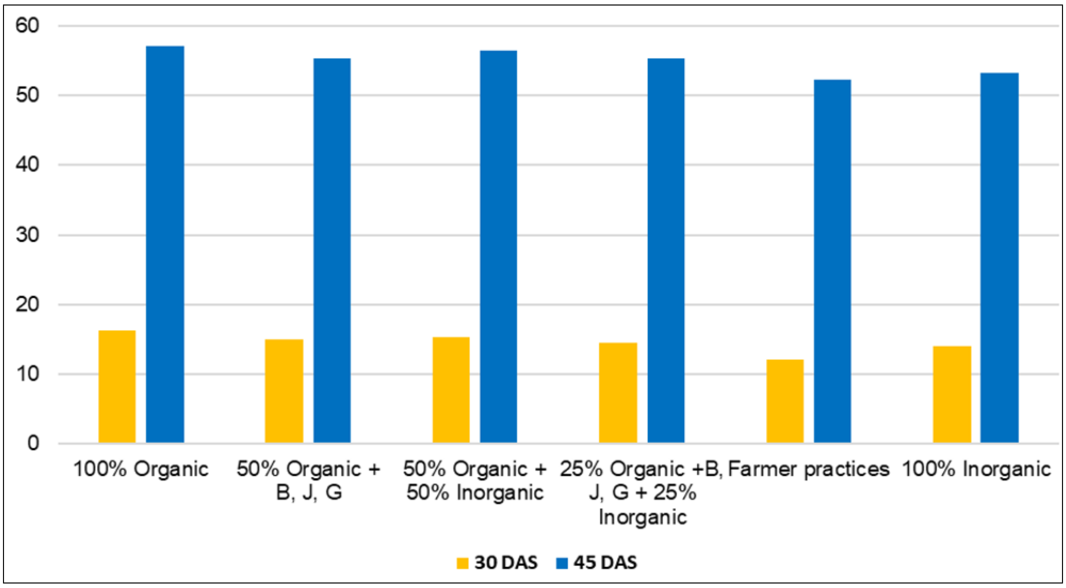

Fig 4: Number of root nodules/plant of soybean as influenced by different treatments

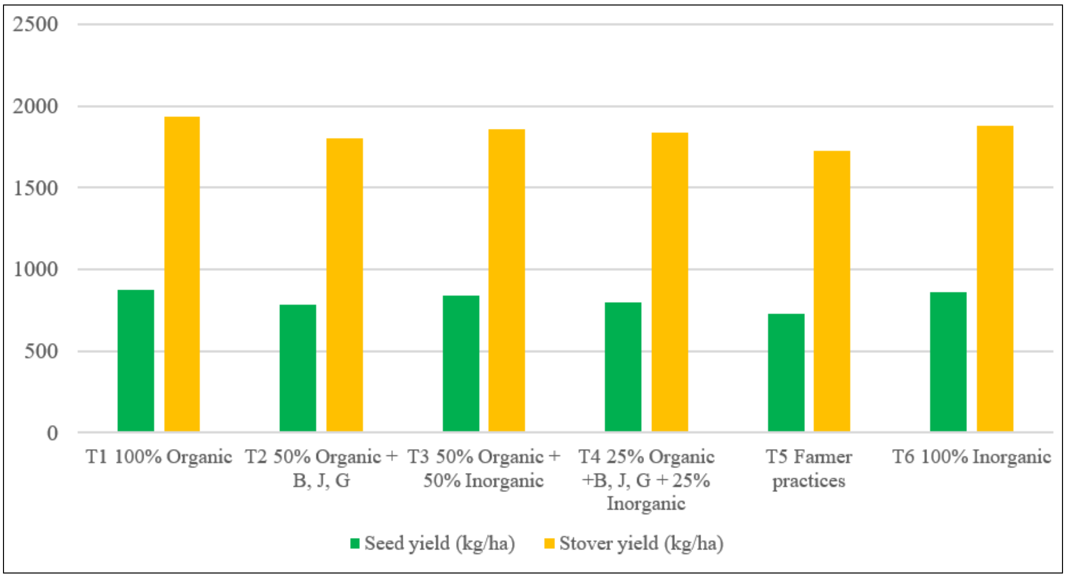

Fig 5: Seed yield and stover yield of soybean as influenced by different treatments

Conclusion

Based on the foregoing results and discussion the growth parameters like plant height, number of branches, LAI, number of root nodules/plant, dry weight of nodules/plant were affected due to different nutrient management practices at all the growth stages. Among different nutrient management treatments, T_1 (100% organic) gave the highest results for different growth stages of soybean crop. It proved significantly superior over the rest of the treatments. However, the lowest results were observed in T_5 (Farmer practices). The seed yield is the ultimate result of various interacting growth factors, development and yield contributing attributes. Among different nutrient management treatments, significantly highest seed yield was recorded in treatment T_1 (100% organic) as compared to other nutrient management practices. However it was at par with T_6 (100% inorganic). These findings emphasize that organic nutrient management practices can play a vital role in improving soybean growth, nodulation and yield while also contributing to sustainable agriculture.

Competing interests

Authors have declared that no competing interests exist.

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