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Influence of Organic and Inorganic Nutrient Sources on the Yield and Uptake of Major Nutrients in Soybean

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Authors' contributions

This work was carried out in collaboration among all authors. Author SUN did the conceptualization, data curation, formal analysis, investigation writing-original draft. Author ZAD did the project administration, methodology, resources. Author MH did the software, validation. Author AAL did the visualization. Author ES did the validation, visualizations. Author SAD did the investigation, supervision. Author FUR did the methodology, software. Author SI did the validation. Author SUH did the validation, writing-review and editing. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted to study the effect of different organic sources of nitrogen with inorganic fertilizers on crop yield, yield attributes and uptake of major plant nutrients in the soya bean-maize cropping system. The highest soybean yield of 12.9qt^{-1} was obtained with the application of 75% of the recommended dose of nitrogen along with 100% recommended dose of phosphorus (P)& and potassium (K) through inorganic fertilizers+25% recommended dose of nitrogen through vermicompost and the lowest values of all the parameters were obtained from the control treatment. The uptake of nitrogen (N), P&K increased with treatments that received integrated use of organic manures in combination with the recommended dose of nutrients.

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1. INTRODUCTION

"Soybean (*Glycine max* (L) Merrill) is gaining importance as a remunerative crop in different parts of India. It is one of the most important oilseed crops in the world. In crop production, nutrient availability from manure has been recognized for many centuries. Before the introduction of inorganic fertilizers, manure was the primary source of nutrients for crop production. Recently there has been a renewed interest in the use of farmyard manure. This interest is attributed to the necessity of maintaining sustainable agricultural production while preserving the environment. For better utilization of resources and to produce crops with less expenditure, integrated nutrient management (INM) is the best approach. In this approach all the possible sources of plant nutrients are applied based on economic considerations and the balance required for the crop is supplemented with chemical fertilizers" [1-3]. "The combined use of organic and inorganic sources of plant nutrients not only pushes the production and profitability of field crops but also helps in maintaining the permanent fertility status of the soil" [4-7]. "It is highly desirable to make massive efforts to adopt organic sources as a source of plant nutrients as well as soil productivity in developing countries. In India, there is sufficient availability of organic manures like animal dung manure (791.6 mt), crop residues (603.5 mt), green manure (4.50 m ha), rural compost (148.3 mt), city compost (12.2 mt) and biofertilizer (0.41 mt) and these may become a good substitute of chemical fertilizers to maintain the soil physicochemical and biological properties" [8]. "The incorporation of organic manures improves the nutrient content and uptake. Although organic manures contain plant nutrients in small quantities as compared to fertilizer, the presence of growth-promoting principles like enzymes and hormones besides plant materials makes them essential for the improvement of soil fertility and productivity. Integrated use of organic and inorganics through farmyard manure (FYM), vermicompost (VC) and poultry manure (PM) improved the organic carbon and cation exchange capacity. Available N, P_2O5, K_2O and S status of soil increased significantly with organic sources of nutrients over their initial" [9,10-13]. Pandey et al. [14] reported that "the application of manures, irrespective of sources and rates recorded significantly higher soil organic carbon, N, P_2O_5 and K_2O compared to control". Kadam et al. [15] reported that "in the harvest of soybeans, the soil nutrient status was influenced by the application of organic nitrogen sources along with fulvic acid sprays. This is ascribed to the presence of soybean crop which enhances the available N status of soil by nodulation. The soil available N, P_2O_5 and K_2O buildup was higher in all the treatments over initial". Therefore, the study was conducted to find out the suitable combination of organic and inorganic fertilizers to obtain better yield and its influence on nutrient uptake in soybeans.

2. MATERIALS AND METHODS

2.1 Location and Existing soil Nutrient Status

The experiment was carried out at the crop research farm of AAIDU Allahabad. The soil was sandy loam in texture, medium in available N,(165.82 Kg/ha), high in available P_2O_5 (48.06 Kg/ha), fairly rich in available in K (242.20 Kg/ha), with neutral soil reaction (pH 7.38) and was non-saline (EC = 0.101 dsm^{-1}).

2.2 Experiment Details

The experiment was laid out in a randomized complete block design (RCBD), comprising eight treatments and three replications. As presented in Table 1.

"In the case of the recommended dose of fertiliser (RDF), Nitrogen was applied in two splits in the form of Urea while entire doses of P and K were applied as basal in the form of single super phosphate and muriate of potash, respectively. Soil samples were collected before sowing and after harvesting of crops. After harvesting soybean crop seed samples were analysed for oil content and NPK uptake with standard procedures" (Jackson, 1973). In organic nutrient management practices, - 100% RDN is given through 1/3rd FYM, 1/3rd VC and 1/3rd PM, in integrated nutrient management practices -50% recommended dose of nitrogen (RDN) is given through fertilizers and 50% RDN through 1/3rd FYM, 1/3rd VC and 1/3rd PM and in chemical nutrient management practices -100% recommended chemical fertilizers only were added. These manures were applied based on

the nitrogen equivalent basis and nutrient requirement of each crop. The phosphorus requirement of the plants was supplemented through rock phosphate in organic nutrient management practices. The nutrient composition of FYM, vermicompost and poultry manure was 0.5-0.18 -0.53, 1.2-0.70-0.94 and 1.9-0.85-1.02 % N, P and K, respectively. The organic manures according to the treatment details were applied two weeks before the sowing of crops for both organic and integrated nutrient management (INM) plots. "The collected samples were analysed for physical and chemical properties following standard procedures. The data collected from the experimental field and laboratory analysis were subjected to statistical analysis. Standard statistical methods were used" (Gomez and Gomez., 1984).

3. RESULTS

3.1 Effect of Treatments on Growth and Yield Parameters of Soyabean

The number of pods per plant is an important parameter that governs the yield of a crop. The number of pods per plant was recorded at 60 days after seeding (DAS). The highest number (72 pods/plant) was recorded in T_7 (75%RDFN through inorganic fertilizers+25%RDFN through VC (4.74kg/ha) treatment at 60 DAS (Table 2 and Fig. 1). Increased number of pods [per plant were noticed with the application of vermicompost @ 4.74 q/ha to supply 25% RDFN. Seed weight is an important attribute, which has a direct influence on the yield. The highest thousand seed weight was found in T_7 treatment (Table 2 and Fig. 1). The seed yield for different treatments ranged between 8.22 to 12.9 q/ha.T_7 recorded the highest seed yield per hectare at 12.9 q/ha. It was 56.93% higher than the control. The next best treatment was T_8, i.e., 75% RDFN through inorganic fertilizers + 25% RDFN through PM (244 Kg/ha) (Table 2, Fig. 1).

3.2 Effect of Treatments on Nutrient Uptake in Soyabean

N uptake by crop was significantly influenced by different treatments. Uptake of the crop increased with crop growth and was highest at 75 DAS. The highest N uptake (4.99 Kg/ha) was recorded in T_7 treatment and was followed by T_8 Treatment at 25 DAS. The control recorded the lowest uptake of N. The highest N uptake (22.2 Kg/ha) was recorded in T_7 treatment and was followed by T_8 treatment at 50 DAS. The highest N uptake (51.5 Kg/ha) was recorded in T_7 treatment and was followed by (44.8 kg/ha) T_8 treatment at 75DAS (Table 3 and Fig. 2). The highest P uptake (0.91kg/ha) was recorded in T_7 treatment followed by (0.90kg/ha) T_8 treatment at 25 DAS. The highest P uptake (9.60kg/ha) was

Table 1. Experiment details

Treatments	Growth and yield parameters to be recorded	Nutrient parameters to be recorded (Kg/ha)
T_1 Control (0:0:0)	Pods/Plant 60DAS, 1000 seed weight (g), Seed yield (q/ha), % yield increase over control	Nitrogen uptake at 25, 50 and 75 Days after Sowing (DAS) each
T_2 RDF(40:50:40)kg/ha		
T_3 50%RDFN through inorganic fertilizers +50%RDFN through FYM[1] (4878kg/ha)		
T_4 50%RDFN through inorganic fertilizers +50%RDFN through VC[2] (948kg/ha)		Phosphorus uptake at 25, 50 and 75 Days after Sowing (DAS) each
T_5 50%RDFN through inorganic fertilizers +50%RDFN through PM[3] (948kg/ha)		Phosphorus uptake at 25, 50 and 75 Days after Sowing (DAS) each
T_6 75%RDFN through inorganic fertilizers +25%RDFN through FYM (2439kg/ha)		
T_7 75%RDFN through inorganic fertilizers +25%RDFN through VC (474kg/ha)		
T_8 75%RDFN through inorganic fertilizers +25%RDFN through PM (244kg/ha)		

recorded in treatment T_7 at 50 DAS. The highest P uptake (16.30kg/ha) was recorded in T_7 treatment followed by T_8 treatment (11.70kg/ha) at 75 DAS. The control recorded the lowest at all stages (Table 4 and Fig. 3). K uptake was estimated at 25DAS, 50DAS and 75 DAS. The highest K uptake (3.65kg/ha) was recorded in T_7 at 25DAS. The highest K uptake of 21.3kg/ha and 45.6kg/ha was recorded in T_7 treatment at 50 DAS and 75 DAS respectively. The lowest uptake of K at all the stages was recorded in the control treatment (Table 5 and Fig. 4).

4. DISCUSSION

The number of pods per plant height of soybean varied significantly with different treatment combinations of inorganic and organic fertilizers (Table 2). "The highest number of pods were recorded with the treatment comprising RDFN and vermicompost. On the other hand, a combination of fertilizers applied to plots increased 1,000 seed weight and over control". Patil and Udmale [16]. Different combinations of inorganic and organic fertilizers showed significant variations in seed yield (Table 2). "The results revealed that seed yield increased significantly with inorganic and organic fertilizers combination treatment over control. Among the combinations, Treatment T_7 showed maximum seed yield followed by T_8 than other combinations. This might be due to the optimum and continuous supply and availability of nutrients through organic sources which help in better uptake of nutrients that ultimately enhance

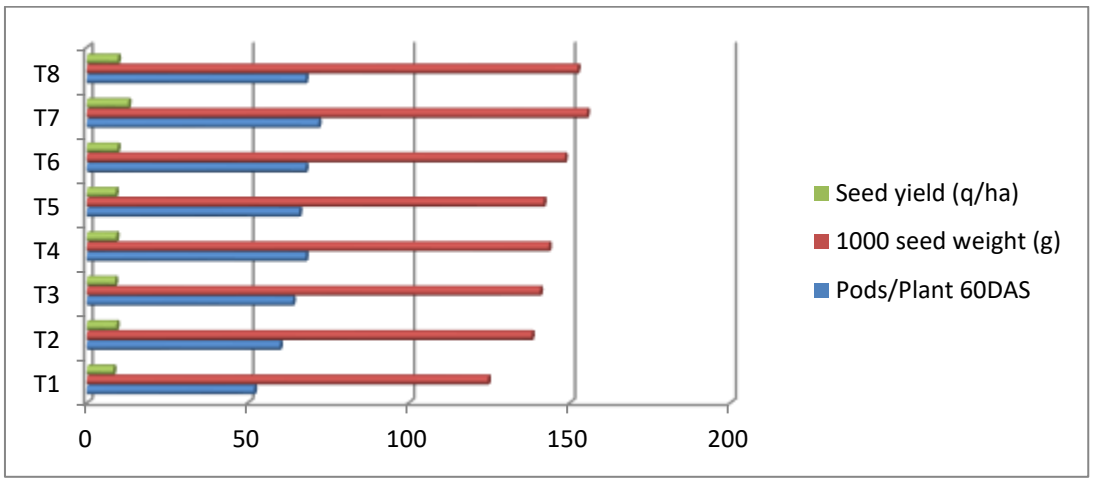

Fig. 1. Graphical representation of the effect of treatments on yield, yield attributes of Soybean-Maize cropping system

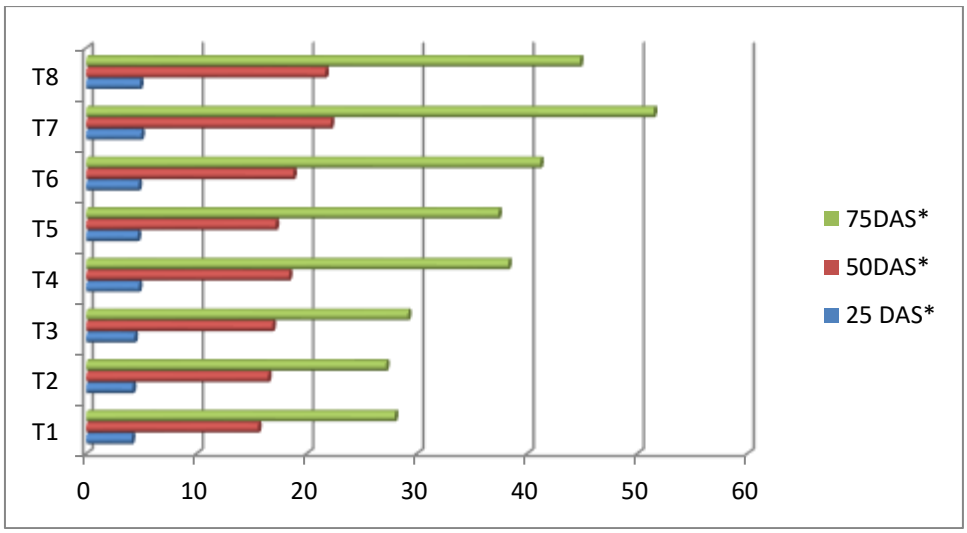

Fig. 2. Graphical representation of the effect of treatments on N uptake (kg/ha) by soybean in soybean-maize cropping system

Table 2. Effect of treatments on yield, yield attributes of soybean-maize cropping system

Treatments	Pods/Plant 60DAS	1000 seed weight (g)	Seed yield (q/ha)	% increase over control
T_1 Control (0:0:0)	52	124.65	8.22	
T_2 RDF(40:50:40)kg/ha	60	138.28	9.22	12.16
T_3 50%RDFN through inorganic fertilizers +50%RDFN through FYM[1] (4878kg/ha)	64	140.86	8.78	6.81
T_4 50%RDFN through inorganic fertilizers +50%RDFN through VC[2] (948kg/ha)	68	143.56	9.14	11.19
T_5 50%RDFN through inorganic fertilizers +50%RDFN through PM[3] (948kg/ha)	66	141.96	8.97	9.12
T_6 75%RDFN through inorganic fertilizers +25%RDFN through FYM (2439kg/ha)	68	148.56	9.58	16.54
T_7 75%RDFN through inorganic fertilizers +25%RDFN through VC (474kg/ha)	72	155.39	12.9	56.93
T_8 75%RDFN through inorganic fertilizers +25%RDFN through PM (244kg/ha)	68	152.53	9.68	7.76
CD(p=0.05)	NS	3.78	1.91	

RDFN= Recommended dose of fertilizer nitrogen

Table 3. Effect of treatments on N uptake (kg/ha) by soybean in soybean-maize cropping system

Treatments	25 DAS*	50DAS*	75DAS*
T_1 Control (0:0:0)	4.13	15.6	28.0
T_2 RDF(40:50:40)kg/ha	4.22	16.5	27.2
T 50%RDFN through inorganic fertilizers +50%RDFN through FYM[1] (4878kg/ha)	4.38	16.9	29.2
T_4 50%RDFN through inorganic fertilizers +50%RDFN through VC[2] (948kg/ha)	4.77	18.4	38.3
T_5 50%RDFN through inorganic fertilizers +50%RDFN through PM[3] (948kg/ha)	4.67	17.2	37.4
T_6 75%RDFN through inorganic fertilizers +25%RDFN through FYM (2439kg/ha)	4.75	18.8	41.2
T_7 75%RDFN through inorganic fertilizers +25%RDFN through VC (474kg/ha)	4.99	22.2	51.5
T_8 75%RDFN through inorganic fertilizers +25%RDFN through PM (244kg/ha)	4.89	21.7	44.8
CD(p=0.05)	0.66	0.34	1.89

cell division and thereby increase all the growth attributes". Prasad et al. [17]. The result revealed that treatments T_7, T_6 and T_4 produced 56.93%, 16.54% and 11.19% higher yields over control (T_0). The maximum grain yield might be attributed to the maximum dry matter weight per plant, number of pods per plant, seeds per plant and 1,000-seed weight. This might be due to an adequate supply of nutrient elements at the right time from organic and inorganic sources, which helped in optimum dry matter partitioning from the source to sink during the reproductive stage of the Soybean crop consequently increasing the seed yield of soybean. Increased nutrient uptake and assimilation by crop plants at the reproductive stage enhanced the thousand seed weight. Similar findings were reported by Maheshbabu et al. [18]. The result corroborates with the findings of Patwary [19]; Yamika et al. [20]. The uptake of N, P and K by the soybean

was influenced by the different integrated nutrient management treatments. The plant height and crop dry matter production might have resulted in a higher uptake of nitrogen). Better crop growth conditions favoured the uptake of P. This finding is also supported by Babhulkar et al. [21]. Increased uptake of potassium might be due to better crop dry matter production and crop growth. The present report is consistent with the findings of Kadam et al. [15]. The higher uptake of N, P and K is attributed to the continuous and steady supply of available nutrients throughout the crop growth period because of the application of organic and inorganic inputs [22-27].

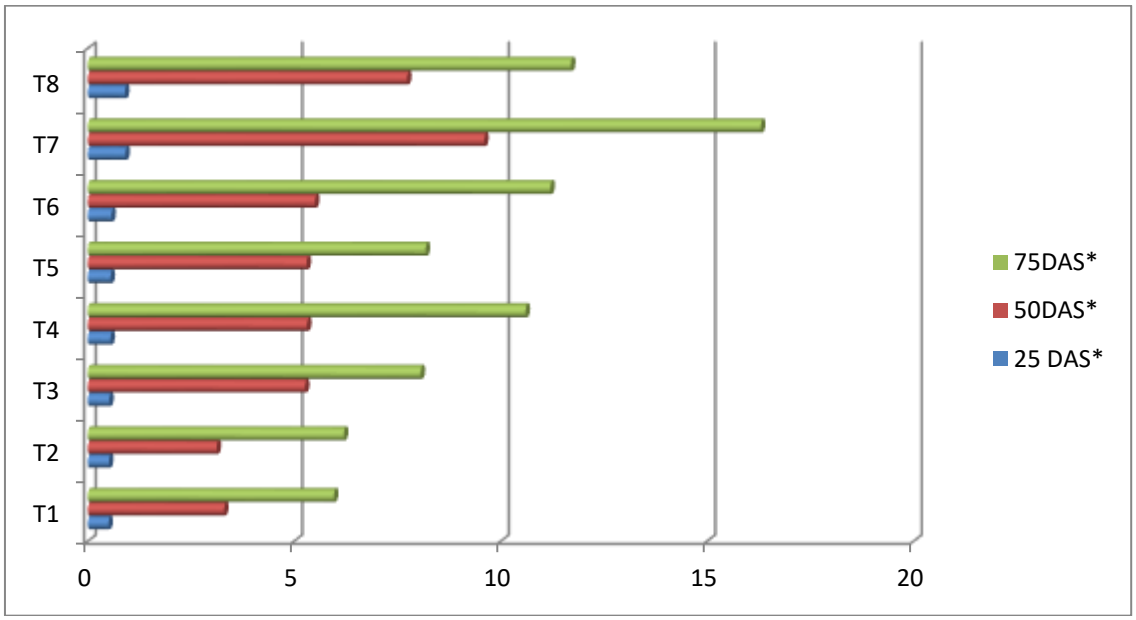

Fig. 3. Graphical representation of the effect of treatments on P uptake (kg/ha) by soybean in soybean-maize cropping system

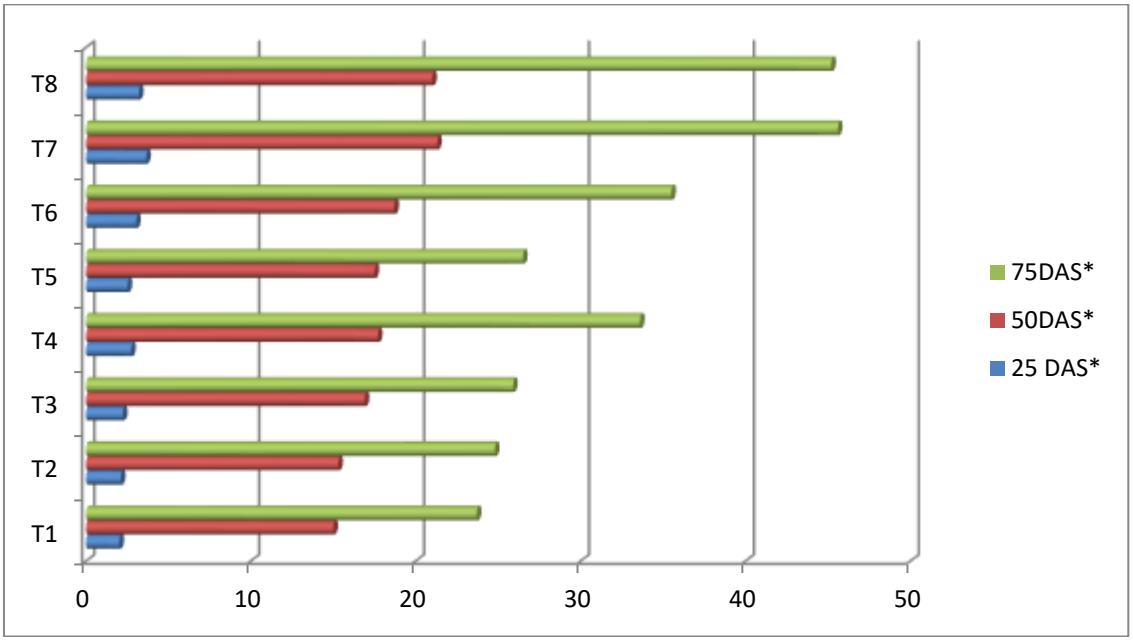

Fig. 4. Graphical representation of the effect of treatments on K uptake (kg/ha) by soybean in soybean-maize cropping system

Table 4. Effect of treatments on P uptake (kg/ha) by soybean in soybean-maize cropping system

Treatments	25 DAS*	50DAS*	75DAS*
Control (0:0:0) T_1	0.50	3.30	5.96
RDF(40:50:40)kg/ha T_2	0.51	3.12	6.20
50%RDFN through inorganic fertilizers +50%RDFN through FYM[1] (4878kg/ha) T_3	0.52	5.26	8.06
50%RDFN through inorganic fertilizers +50%RDFN through VC[2] (948kg/ha) T_4	0.55	5.31	10.60
50%RDFN through inorganic fertilizers +50%RDFN through PM[3] (948kg/ha) T_5	0.55	5.30	8.18
75%RDFN through inorganic fertilizers +25%RDFN through FYM (2439kg/ha) T_6	0.57	5.50	11.20
75%RDFN through inorganic fertilizers +25%RDFN through VC (474kg/ha) T_7	0.91	9.60	16.30
75%RDFN through inorganic fertilizers +25%RDFN through PM (244kg/ha) T_8	0.90	7.73	11.70
CD(p=0.05)	0.01	0.11	0.23

Table 5. Effect of treatments on K uptake (kg/ha) by soybean in soybean-maize cropping system

Treatments	25 DAS*	50DAS*	75DAS*
T_1 Control (0:0:0)	2.02	15.0	23.7
T_2 RDF(40:50:40)kg/ha	2.11	15.3	24.8
T_3 50%RDFN through inorganic fertilizers +50%RDFN through FYM[1] (4878kg/ha)	2.24	16.9	25.9
T_4 50%RDFN through inorganic fertilizers +50%RDFN through VC[2] (948kg/ha)	2.74	17.7	33.6
T_5 50%RDFN through inorganic fertilizers +50%RDFN through PM[3] (948kg/ha)	2.52	17.5	26.5
T_6 75%RDFN through inorganic fertilizers +25%RDFN through FYM (2439kg/ha)	3.04	18.7	35.5
T_7 75%RDFN through inorganic fertilizers +25%RDFN through VC (474kg/ha)	3.65	21.3	45.6
T_8 75%RDFN through inorganic fertilizers +25%RDFN through PM (244kg/ha)	3.21	21.0	45.2
CD(p=0.05)	0.05	0.61	0.90

5. CONCLUSION

Due to imminent concerns regarding the effects of inorganic fertilizers and of course, the slow returns from organic nutrients amidst a galloping population and retreating land holdings, the combination of organic and inorganic fertilizers is the most sensible agri-input approach. However, studies are required in different scenarios at micro levels to determine optimal combination setups of chemical and organic sources in different crops. We cannot have the same yardstick for a crop in all regions. Therefore, this study was conducted in Kashmir Valley in the Shalimar Soyabean-1 variety to study optimal fertilizer combinations. It was observed that if we replace 25% of the recommended dose of chemical fertilizers with 474kg/ha vermicompost, there is a gain of approximately 39% in grain yield over the recommended chemical fertilizer dose in soybean crop.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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