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Evaluating the long-term influence of organic and inorganic fertilizers on soybean plant growth and yield parameters

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Abstract

The study conducted was situated at the (AICRP) research farm located in the outer region of the College of Agriculture in Indore. Indore is a small city in the western part of Madhya Pradesh, Central India, located on the Malwa Plateau. The experiment was performed with three replications using various combinations of nitrogen (N), phosphorus (P) levels, and crop residues in a randomized block design (RBD). The experimental field comprised medium to black soil, with a pH level of 7.63 and organic carbon content of 0.58%. The soil was found to be low in available nitrogen (208.0 kg/ha), medium in available phosphorus (21.0 kg/ha), and high in potassium (585 kg/ha). The area was divided into gross plots sized 10 x 7.2 m² and net plots sized 9 x 6.4 m², respectively. Plant height (56.4 cm), number of branches/plant (7.2), number of pods/plant (52.1), dry matter accumulation/plant (56.1 g), and seed index (12.1 g) were all much greater across the different nutrient management treatments (FYM 6 t ha⁻¹ + N20 P13) T₆ treatment). Results revealed that the application of T₆ treatment (FYM 6 t ha⁻¹ + N20 P13) showed the maximum uptake of N, P, and K, according to the results. In addition to producing the best net returns (Rs. 84, 865) and highest returns per rupee invested (3.09), the application of 100% of the prescribed dose of fertilizers + FYM @ 6 t per ha for soybeans greatly increased the seed yield (2,497 kg/ha) and straw production (3020 kg/ha). When soybeans were harvested, their organic carbon content varied from 0.35 to 0.78%. Thus, the application of treatment (FYM 6 t ha⁻¹ + N20 P13) T₆ treatment demonstrated the beneficial effect of organic manure application on the decrease of chemical fertilizer.

Keywords: Fertilizer, FYM, growth character, soybean, yield attributes, economics

Introduction

Soybean (*Glycine max* L.) is an important oilseeds pulse crop in world and it belongs to family Leguminosae with sub family Papilionaceae. Over the past few decades, the adoption of intensive cropping systems, coupled with the cultivation of high-yielding crop varieties, has depleted the natural soil fertility, thereby posing a significant threat to sustainable crop production. Additionally, widespread nutrient deficiencies have become a concern Singh *et al.*, (2013) [17]; Bhagwat *et al.*, 2018) [2]. It has protein (40-42%) & 18-20% oil content with additional nutritive value. Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, and Telangana are the states that grow the most soybeans. Madhya Pradesh is known as the "Soya State" because it contributes around 60% of India's soybean farming, making it the oilseed with the largest acreage and production. Sustainable production levels and environmental preservation can result from integrated nutrient management. However, the physical, chemical, and biological properties of the soil as well as crop yields have been shown to improve when manures and chemical fertilizers are used together (Dwivedi *et al.* 2016). Applying FYM accelerated the hydrolysis of ester-bond P to plant-available P by increasing the activity of acid and alkaline phosphatase, phosphodiesterase, inorganic pyrophosphates, and dehydrogenase (Dinesh *et al.*, 2003) [4]. Vermicompost has been shown to improve the development and yield of a variety of plants, including soybeans and other crops, either applied alone or in conjunction with other organic fertilizers (Javed *et al.* 2013) [8]. Therefore, in order to maintain soil health and boost productivity, coordinated management of nutrients and crop residue is important. In addition to boosting agricultural productivity and

sustainability, soil and crop management techniques that make use of organic amendments like animal and crop leftovers may also raise the amount of organic carbon and microbial activity in the soil. Thus, an experiment was carried out to investigate the impact of ongoing manurial application on soybean output in vertisols in Madhya Pradesh's Malwa Plateau region.

Material and methods: A field experiment was carried out during *Kharif* 2021, a field experiment was conducted on medium to black soil with a pH of 7.63 and an organic carbon content of 0.58% at Research Farm, College of Agriculture, RVSKVV, Indore. The soil had high levels of potassium (585 kg/ha), medium levels of phosphorus (21.0 kg/ha), and moderate levels of nitrogen (208.0 kg/ha). The experiment was laid out in a Randomized Block Design (RBD) with three replications consisting of nine treatments. The treatments included: T₁: Control (no nutrient application); T₂: Fertilizer application at N₂₀P₁₃ (20 kg N ha⁻¹ + 13 kg P ha⁻¹); T₃: Fertilizer application at N₃₀P₂₀ (30 kg N ha⁻¹ + 20 kg P ha⁻¹); T₄: Fertilizer application at N₄₀P₂₆ (40 kg N ha⁻¹ + 26 kg P ha⁻¹); T₅: Fertilizer application at N₆₀P₃₅ (60 kg N ha⁻¹ + 35 kg P ha⁻¹); T₆: Farmyard manure (FYM) @ 6 t ha⁻¹ applied during the rainy season in combination with N₂₀P₁₃ (20 kg N ha⁻¹ + 13 kg P ha⁻¹); T₇: Soybean crop residues @ 5 t ha⁻¹ in combination with N₂₀P₁₃ (20 kg N ha⁻¹ + 13 kg P ha⁻¹); T₈: Farmyard manure (FYM) @ 6 t ha⁻¹; and T₉: Soybean crop residues @ 5 t ha⁻¹. The crop residues and FYM are applied 7 days before sowing and mixed well in soil. Inorganic fertilizers are applied as basal dose at sowing. The produce is sold @ Rs. 4 per kg of grain yield.

Results and Discussion

Effect on Growth Attributes: Plant height, total dry matter (TDM), number of seeds per plant, and test weight are the main growth parameters of soybeans that are affected by different treatments, as shown in Table 1. There were statistically significant differences between the treatments. Treatment T₆ (FYM 6t/ha + N20P13) had the highest values for these growth parameters, whereas the control treatment, T₁, had the lowest values. T₆ (56.4 cm) had the highest plant height, followed by T₅ (56.2 cm), T₇ (55.3 cm), T₄ (55.1 cm), T₈ (52.2 cm), T₃ (52.4 cm), T₉ (49.4 cm), and T₂ (48.3 cm). There was statistical similarity between these treatments. T₁ had the lowest plant height (43.1 cm), which was statistically lower than the treatments T₆, T₅, T₇, T₄, T₈, T₃, and T₉. The number of branches per plant, number of pods per plant, TDM, number of seeds per plant, and test weight all showed a similar pattern. The control treatment had the lowest test weight (11.4 g), whereas T₆ (FYM 6t/ha + N20P13) had the highest (12.1 g), which was comparable to the other treatments and statistically better than T₁. The study's findings are consistent with those of Kumar *et al.* (2010)^[9], Kumar and Kumawat (2014)^[10], and Kumar *et al.* (2018)^[11].

Effect on Yield Attributes

Seed yield (kg ha⁻¹): As per the data from Table 2 displays the statistics on soybean seed yield as affected by various treatments.

Treatment T₆ (FYM 6 t/ha + half of the required amount of N and P) produced the highest soybean seed production of 2497 kg/ha, followed by T₇ (Residues 5 t/ha + T₂) at 2313 kg/ha, T₅ (N60P35) at 2262 kg/ha, and T₄ (N40P26) at 2112 kg/ha. The yields for T₃ (N30P20) and T₈ (FYM 6 t/ha) were 1991 kg/ha and 1890 kg/ha, respectively, while T₉ (Residues 5 t/ha) and T₂ (N20P13) recorded yields of 1775 kg/ha and 1679 kg/ha, respectively. Treatment T₆ demonstrated advantage over the other treatments, while T₄, T₅, and T₆ were statistically equivalent. With a seed yield of 1342 kg/ha, the control treatment (T₁) outperformed all other treatments statistically. These findings are consistent with the results of Schilling *et al.* (2021)^[14] and Sharma *et al.* (2021)^[15].

Straw yield (kg ha⁻¹): The trends in soybean straw yield align with the trends observed in soybean seed yield across the different treatment combinations. As shown in Table 2, the mean straw yield of soybean was highest with the INM treatment (T₆ - FYM 6 t/ha + N20P13), yielding 2313 kg/ha. In contrast, the control treatment (T₁) recorded the lowest straw yield at 1342 kg/ha. These results are consistent with the findings of Ogallala *et al.*

Harvest index (%): The data on the harvest index of soybean, presented in Table 2 shows that the highest harvest index of 45.26% was achieved with treatment T₆ (FYM 6 t/ha + N20P13). The lowest harvest index of 42.17% was recorded in the control treatment (T₁). The combination of organic and inorganic fertilizers, along with micronutrients, created favorable soil conditions that improved nutrient availability, which was reflected in the crop's yield attributes. These findings are consistent with the research by Sikka *et al.* (2013)^[16], Singh *et al.* (2018b)^[18], and Tomar *et al.* (2018)^[20].

Economics: The economic evaluation of soybean cultivation revealed that the application of FYM 6 t/ha + N20P13 resulted with maximum seed yield of 2497 kg/ha, with net returns of Rs. 84,865 per hectare and a return per rupee of 3.09. This treatment also yielded the maximum gross returns of Rs 112,365. In comparison, the treatment with Residues 5 t/ha + T₂ produced 2313 kg/ha, with net returns of Rs. 76,585 per hectare and a return per rupee of 2.78, and gross returns of Rs. 104,085. As per the data Table 2, the economic impact was evaluated using gross returns, net returns, and the benefit-cost ratio. In comparison to the control treatment (T₁), treatments T₇ (Residues 5 t/ha + T₂), and T₉ (Residues 5 t/ha), treatment T₆ (FYM 6 t/ha + N20P13) produced the best net return. T₆ had the highest B:C ratio (3.09), which was statistically similar to treatments T₂ (N20P13), T₄ (N40P26), T₅ (N60P35), and T₃ (N30P20). Additionally, these treatments outperformed T₁ (control), T₇, T₈ (FYM 6 t/ha), and T₉. These findings are consistent with those of Chaturvedi and Chandel (2005)^[3], who found that applying 100% recommended doses of fertilizers (RDF) and FYM increases soybean production, which raises net returns and the benefit-cost ratio. Additionally, the results agreed with those of Tiwari *et al.* (2021)^[19].

Table 1: Plant growth and yield attributing characters of soybean as influenced by different treatments at harvest

	Treatments	Plant height (cm)	No. of branch/plant	No. of pods/plant	Dry matter/plant (g)	100 seed weight (g)
T ₁	Control	43.1	5.2	25.2	35.2	11.4
T ₂	N20 P13	48.3	5.5	31.0	47.7	11.5
T ₃	N30 P20	52.4	6.3	42.1	51.1	11.6
T ₄	N40 P26	55.1	6.4	42.3	53.3	11.8
T ₅	N60 P35	56.2	6.4	49.4	54.1	11.8
T ₆	FYM 6 t/ha+ T ₂	56.4	7.2	52.1	56.1	12.1
T ₇	Residues 5 t/ha+T ₂	55.3	6.1	51.6	54.6	12.0
T ₈	FYM 6 t ha ⁻¹	52.2	6.4	49.4	52.2	11.8
T ₉	Residues 5 t ha ⁻¹	49.4	6.3	48.1	51.3	11.8
	SE m (±)	3.0	0.4	2.3	3.1	0.2
	CD 5%	7.1	1.1	6.1	8.0	0.6

Table 2: Seed and straw yield, harvest index and economics of soybean production due to various treatments

Treatments	Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	HI (%)	Gross Returns (Rs h ⁻¹)*	Net returns (Rs h ⁻¹)	B:C Ratio
T ₁ -Control	1342	1840	42.17	60390	38390	1.75
T ₂ - N20 P13	1679	2243	42.81	75555	52555	2.29
T ₃ -N30 P20	1991	2645	42.95	89595	66095	2.81
T ₄ -N40 P26	2112	2780	43.17	95040	71040	2.96
T ₅ -N60 P35	2262	2747	45.16	101790	75790	2.92
T ₆ - FYM 6 th ⁻¹ +T ₂	2497	3020	45.26	112365	84865	3.09
T ₇ -Residues5tha ⁻¹ +T ₂	2313	2799	45.25	104085	76585	2.78
T ₈ -FYM 6 t h ⁻¹	1890	2330	44.79	85050	58050	2.15
T ₉ -Residues 5t h ⁻¹	1775	2305	43.50	79875	52875	1.96
SEm±	67	50	0.90			
CD at 5%	191	142	2.55			

Market rate of soybean Rs 45 /kg. FYM Rs 750/ton

Conclusion

In order to increase soybean growth and output, the study emphasizes the significance of both organic and inorganic fertilization. The lowest growth metrics and soybean yield were produced by the control treatment (T₁), highlighting the limited efficacy of depending only on native soil fertility. On the other hand, treatment T₆, which applied 6 tons of farmyard manure (FYM) per hectare together with a balanced dose of N20 P13 (nitrogen and phosphorus), showed the biggest increases in yield and growth metrics. The combined effects of organic and inorganic fertilizers are responsible for treatment T₆'s improved performance. Better root development and nutrient uptake were probably facilitated by the FYM's increased microbial activity, improved soil structure, and higher soil organic carbon content. Higher yields and ideal plant development resulted from the added nutrients from N20 P13 supporting the growing process. In summary, the combination of FYM and nutritional supplementation enhanced economic returns and maximized soybean yield, making it a viable approach to sustainable soybean farming. The success of Treatment T₆ shows how important integrated nutrient management is to attaining better agricultural results.

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