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Nutrients management in soybean (*Glycine max* L.) influenced by integrated nutrient method

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Abstract
A field experiment was conducted during the Kharif season of 2024 at the Research Farm, Department of Agronomy, GH Raisoni University, Saikheda, Madhya Pradesh, to evaluate the effect of different treatments of integrated nutrients methods on the yield and economics of soybean (*Glycine max* L.) variety JS-9560. The soil was medium black and clayey, and the experiment was laid out in a Randomized Block Design with ten treatments replicated thrice. The The treatments are used to find out production by given treatments. T_1 (100% Control), T_2 (100% RDF), T_3 (100% RDF +1% foliar spray-Humic acid), T_4 (100% RDF +1% foliar spray-Fulvic acid), T_5 (RDF + Vermicompost), T_6 (RDF + Poultry manure), T_7 (RDF + FYM).

Results: The highest seed yield (2200.15 kg/ha) and stover yield (2650.10 kg/ha) were recorded under T_6 (100% RDF + Poltury manure), which also resulted in the highest gross return (₹73, 555.20/ha), net return (₹35, 546.88/ha), and benefit-cost ratio (2.35). In contrast, the control treatment recorded the and humic acid lowest values for all parameters. The enhanced performance was attributed to improved nutrient uptake, hormonal stimulation from given 7 treatments, and the vital role of nutrients in metabolic activities. The study concludes that integrated nutrients management is an effective strategy for increasing soybean productivity and profitability under rainfed conditions.

Keywords: Soybean, Humic acid, fulvic acid, vermicompost poultry manure, farm yard manure, growth, yield

Introduction
Soybean (*Glycine max* (L.)), a cornerstone of global agriculture, is an indispensable oilseed crop belonging to the Leguminosae family. It boasts a chromosome number of 2n=40 and is cultivated in both the *Kharif* and *Rabi* seasons in India, demonstrating its adaptability to diverse climatic conditions. Global reports from 2024 highlight the immense scale of soybean cultivation, with an astounding 137 million hectares under production worldwide, yielding approximately 398.2 million metric tons. The global footprint of soybean is truly vast, with key players like the USA, Brazil, Argentina, China, India, and Taiwan leading the charge in production. Notably, India holds the fifth position globally, underscoring its significant contribution to the world's soybean supply. Within India, the total area dedicated to soybean cultivation spans 12.12 million hectares, resulting in a productivity of 12.9 million metric tons. Among Indian states, Madhya Pradesh reigns supreme, with a remarkable 6, 679 hectares under soybean cultivation, earning it the well-deserved moniker of the 'Soy State' of India. This state alone contributes a substantial 41.92% to India's total soybean production, with a robust output of 5.47 million tonnes. Soybean's prominence extends beyond mere agricultural statistics; it's a crop with immense international market demand due to its exceptional nutritional profile and versatile applications. Each tiny bean is a powerhouse, typically containing 18% to 22% oil content and an impressive 36% to 56% protein. In India, soybean contributes significantly to the edible oil sector, with an annual production of around 1.7 million metric tons. As a plant-based protein source, soybean is a dietary marvel, offering a complete amino acid profile crucial for human health. Beyond protein, it's rich in healthy unsaturated fats and an abundance of both soluble and insoluble fiber, which are vital for digestive health and overall well-being. India's total soybean consumption stands at approximately 132 lakh tonnes, reflecting its widespread

integration into the national diet. The versatility of soybean is evident in the myriad of products derived from it, ranging from popular items like soymilk, soy chunks, and tofu to more specialized products like vegan foods and soy sauce. Its nutritional benefits aren't limited to human consumption; soybean is also a highly valued feed ingredient, providing essential nutrients for animal nutrition.

Beyond its economic and nutritional value, soybean plays a pivotal role in ecological sustainability, particularly concerning soil health. As a leguminous crop, soybean possesses the remarkable ability to fix atmospheric nitrogen through a symbiotic relationship with Rhizobium bacteria residing in its root nodules. This natural process converts inert atmospheric nitrogen into ammonia, a form readily usable by plants, thereby enriching soil fertility and reducing the reliance on synthetic nitrogen fertilizers. On average, soybean contributes approximately 6.5% nitrogen content to the soil. This nitrogen fixation not only benefits the current crop but also leaves behind residual nitrogen for subsequent crops in the rotation. Furthermore, soybean significantly contributes to the enhancement of soil organic matter, increasing it by 2% to 4%. This seemingly small percentage has profound implications for soil health, dramatically improving the water-holding capacity of the land. Enhanced organic matter also fosters a thriving microbial community, creating a healthy soil environment that supports beneficial microbes and insects without disruption. As a cover crop, soybean acts as a natural shield, effectively protecting the soil from both water and wind erosion.

It also plays a crucial role in controlling weed populations, thereby reducing the need for chemical herbicides. The benefits of incorporating soybean into crop rotations are manifold. Rotating soybean with cereal crops like wheat and maize, or even other legumes like cowpea (e.g., Soybean-Wheat, Soybean-Maize, Soybean-Cowpea-Wheat), offers a sustainable approach to agriculture. Such rotations significantly reduce the need for external nitrogen inputs for the succeeding crops, leading to cost savings for farmers and reduced environmental impact. Moreover, these rotations have been shown to lead to higher yields in both the cereal and legume components of the system. This practice also effectively breaks the cycles of diseases and pests, contributing to healthier crops and diminished reliance on chemical pesticides. Ultimately, the cultivation of soybean embodies a holistic approach to agriculture, fostering both productivity and environmental stewardship. The architectural marvel of the soybean plant begins beneath the soil with its robust taproot system. This primary root grows downwards, anchoring the plant firmly and providing access to deeper water and nutrient reserves. The depth of penetration can vary, typically reaching between 60 to 90 cm, influenced by factors such as the specific soybean variety, prevailing soil conditions, and environmental effects like rainfall and temperature. From this central taproot, a network of lateral roots branches out, exploring the surrounding soil. These lateral roots are particularly efficient, reaching the center of the inter-row spacing within 5 to 6 weeks of planting. This extensive root system is crucial for holding soil particles together, thereby preventing erosion and improving soil structure. It also plays a vital role in absorbing water and nutrients from a wider soil volume. Crucially, the taproot and lateral roots of soybean are home to specialized structures known as root nodules. These nodules are fascinating microcosms where the magic of nitrogen fixation occurs. Within these nodules, the symbiotic Rhizobium bacteria reside, tirelessly converting atmospheric nitrogen into a usable form for the plant. This intricate process of nitrogen formation begins within the root nodules, demonstrating the remarkable biological machinery at play beneath the ground, directly contributing to the plant's vigor and the soil's enrichment. To maximize soybean's growth and productivity, a balanced approach to nutrient management is essential. While the plant benefits immensely from its natural nitrogen-fixing capabilities, supplementary nutrition, particularly in critical growth stages, can significantly boost yields. Alongside the Recommended Dose of Fertilizers (RDF), the inclusion of humic acid and fulvic acid proves highly beneficial. These organic compounds act as powerful chelators and biostimulants, providing enhanced nourishment to the plant roots. They play a crucial role in boosting the uptake of essential nutrients and promoting chlorophyll production, especially during the vital flowering and pod formation stages. This enhanced nutritional support directly translates to an increase in grain size, contributing to higher overall yields. Beyond synthetic and organic amendments, embracing natural fertilizers offers a sustainable and cost-effective approach for farmers. Vermicompost, poultry manure, and farmyard manure (FYM) are excellent examples of such natural amendments. These organic fertilizers are rich in a wide spectrum of essential nutrients, providing a holistic feeding to the soybean plant. Their availability in the market at cheap and affordable costs makes them an attractive option for farmers, promoting sustainable agricultural practices and contributing to the overall health and productivity of soybean cultivation.

Materials and Methods

At the students' research area of the agronomy faculty of the School of Agricultural Sciences, G. H. Raisoni University, Sausar, Pandhurna, Madhya Pradesh, under the 2024 *Kharif Season*, the agronomic research "Nutrients management Practices in soybean (*Glycine max* L.)" was done.

The field experiment was conducted during the Kharif season of 2024 at the Research Farm of the Department of Agronomy, School of Agricultural Sciences, GH Raisoni University, Saikheda, Tehsil Saunsar, District Pandhurna, Madhya Pradesh. The soil of the experimental site was Coarse sand 15.23%, Fine sand 26.40%, Silt 25.12%, Clay 33.24%, Textural class:-Clay loam. The subtropical climate of Saikheda, . Geographically, the district of Pandurna lies within the Satpura Plateau Agro-climatic Zone. Its southwest face is where the Satpura Range is. Its ranges are latitude 78.40° to 79.24° East and longitude 21.28° to 22.49° North. Summer can be extremely hot and dry, with rare occasions of 38 or 42 °C highs. The months of April to June are the summer months, and they are followed by the monsoon rains season, which is from July to September. 1, 183 mm of rainfall in the wet season. Dry days prevail in the winter season, which runs from October to March. 4-6 °C may be the lowest temperature during the winter.

The experiment was laid out in a Randomized Block Design (RBD) comprising ten treatments and three replications, totaling 30 plots. Each net plot measured 3 × 2 meters, while the gross experimental area covered 350.5 m². The crop sown was soybean (*Glycine max* L.) variety JS-9560, using a seed rate of 75 kg/ha and spaced at 30 × 5 cm using dibbling method. The recommended dose of fertilizers (RDF) was 30:75:30 NPK kg/ha. A common basal application of nitrogen and phosphorus was applied before sowing. The land preparation included one deep ploughing followed by two harrowings and leveling.

The treatments are used to find out production by given treatments. T_1 (100% Control), T_2 (100% RDF), T_3 (100% RDF +1% foliar spray-Humic acid), T_4 (100% RDF +1% foliar spray-Fulvic acid), T_5 (RDF + Vermicompost), T_6 (RDF + Poultry manure), T_7 (RDF + FYM) The treatments were randomly allocated to plots within each replication.

Result and discussion

Effect of given 7 Treatments on yield of soybean

During the Research, we found that the average accumulation of dry matter per plant was 9.30 g, 12.33 g, 20.75 g at 30, 60, 90 days after sowing, and at harvest 22.73 respectively. The crop produced only 0.3 grams of dry matter per plant and showed a very slow accumulation of dry matter, especially up to 30 days after sowing. The treatment T_6, which included 100% RDF along with Poultry Manure, produced a significantly higher dry matter per plant at 30, 60, and 90 days after sowing, as well as at harvest, when compared to the other treatments. It was found to be on par with treatment T_3, which consisted of 100% RDF plus a 1% foliar spray of Humic acid. On the other hand, treatment with just 8.99 g, 11.04 g, 17.19 g and 20.97 g had the lowest dry matter production per plant.

Table 1: Effects of various treatments on the mean dry matter accumulation plant^{-1} of soybean

Treatments	Dry Matter production/Plant (g)			
	30 DAS	60 DAS	90 DAS	At harvest
100% Control	7.50	10.85	15.53	16.02
100% RDF	8.98	10.91	15.75	17.06
100% RDF +1% foliar spray-Humic acid	8.99	11.04	17.19	20.97
100% RDF +1% foliar spray-Fulvic acid	9.07	11.50	20.14	21.01
RDF + Vermicompost	9.24	12.43	20.60	21.75
RDF + Poultry manure	9.30	12.33	20.75	22.73
RDF + FYM	9.18	11.90	20.45	21.07
SE (m)±	0.29	0.48	0.56	0.75
CD at 5%	2.27	2.46	2.64	2.80

B) Effect of 7 Treatments on economics of soybean

The treatment (T_6) (100% RDF along with Poultry Manure), produced a significantly higher Seed Yield 2200 Kg/ha. Compared to the other treatments. It was found to be on par with treatment T_3, which consisted of 100% RDF plus a 1% foliar spray of Humic acid. On the other hand, treatment with just, had the lowest seed yield 1920 kg/ha.

Treatments	Seed yield Kg/ha	Straw Kg/ha	Harvest index (%)
100% Control	1845	1920	32.05
100% RDF	1888	1945	35.68
100% RDF +1% foliar spray-Humic acid	1920	2100	37.37
100% RDF +1% foliar spray-Fulvic acid	1965	2223	39.23
RDF + Vermicompost	2100	2450	41.28
RDF + Poultry manure	2200	2650	43.55
RDF + FYM	2000	2300	39.89
SE (m)±	0.35	2.15	0.61
CD at 5%	2.93	6.36	2.76

The application of integrated nutrition management had a considerable impact on the gross monetary returns. Treatment T_3 (100% RDF + 1% foliar spray-Humic acid) (55881 ₹/ha), with lowest gross economic returns the application of T_4 (100% RDF through Poultry Manure) recording highest gross monetary returns (73555 ₹/ha).

The effects of various treatments on the B: C ratio, gross financial returns, & net Financial results

Treatments	Economics (rs/ha)			
	COC	GMR	NMR	B:C Ratio
100% Control	27520	50561	20980	1.80
100% RDF	28140	50912	22530	1.83
100% RDF +1% foliar spray-Humic acid	28560	55881	27815	1.95
100% RDF +1% foliar spray-Fulvic acid	28956	61512	29950	2.12
RDF + Vermicompost	30120	69444	33270	2.33
RDF + Poultry manure	32932	73555	35546	2.35
RDF + FYM	29580	70803	33148	2.24
SE (m)±	4.49	11.23	9.28	0.51
CD at 5%	11.24	16.80	14.89	2.81

Conclusion

In conclusion, the field experiment conducted during the Kharif season of 2024 demonstrated that the

- When 100% RDF + 1% foliar spray of humic acid (T_3) was given to soybean, it led to growth traits like enhancing plant height, more branches, dry matter accumulation, yield parameters, & grain yield; yet, application of 100% RDF + 1% foliar spray of fulvic acid (T_4) was compact similar both have minimum

Results

- Treatment of application 100% RDF + 1% foliar spray-humic acid (T_3) was similar to the application of (T_4) 100% RDF + 1% foliar spray-fulvic acid in terms of yield attributes or characteristics among, no. of seeds/pod, no. of Pods/plant, test weight, and seed yield.
- The treatment of application 100% RDF + 1% foliar spray-humic acid (T_3), (T_5) RDF + Vermicompost, (69444 ₹/ha) & ratio of B:C (2.23). and (T_6) RDF + Poultry manure yielded (73555 ₹/ha) & ratio of B:C (2.35) cost effective or profitable economic returns in terms of net financial returns (However, application of treatment 100% RDF plus 1% foliar spray-fulvic acid (T_3) produced compact minimum results. (28560₹/ha) & ratio of B:C (1.95).
- These findings are based on the outcome of a one-year study, and thus further detail and experimentation are necessary to reach a valid recommendation.

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