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Impact of Integrated Nutrient Management Practices on Soil Health Parameters and Yield Attributes of Soybean (*Glycine max* L.) var. JS-9560 in Inceptisol of Alluvial Soil, District Prayagraj, Uttar Pradesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field trial was carried out during the *Kharif* season 2021-22 at the Research farm, of Naini Agriculture Institute Prayagraj India. The experiment was laid down in randomized block design comprised three fertility levels control NPK @ 100%, *Rhizobium* + PSB @ 100%, Vermicompost and Sulphur @ 100%, 75% and @ 50% respectively replicating thrice and *rhizobium* phosphate solubilizing bacteria (PSB) inoculation. Among the fertility levels, the application of 100% N, P, K, 40 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1}, 40 kg K_2O ha^{-1} and 100% Vermicompost 5 t ha^{-1}, Sulphur 20 kg ha^{-1} in the experiment. It was concluded that the texture of soil sandy loam, the soil health parameters respectively Bulk density ranged between 1.21 to 1.31 Mg m^{-3}, Particle density 2.08 to 2.50 Mg m^{-3} Pore space 45.12% to 51.23% water holding capacity 36.14% to 62.06% Organic carbon 0.319% to 0.613%, soil pH ranged between 7.34 to 7.78, EC ranged between 0.157 to 0.265 dsm^{-1}, Nitrogen 182.56 to 320.75 kg ha^{-1}, Phosphorus 16.12 to 33.67 kg ha^{-1}, Potassium 182.24 to 238.76 kg ha^{-1}, Sulphur 16.03 to 29.58 mg kg^{-1}, It was observed that for post-harvest, treatment T_9 was best in yield attributes plant height 97.18 cm, number of branches $plant^{-1}$ 7.1, 5, pods $plant^{-1}$ 74.83, seed pod^{-1} 4.44 and seed yield (2337.25 kg ha^{-1}) T_9 were to be found best treatment combination.

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Keywords: Biofertilizer; district Prayagraj; inorganic fertilizer; soil properties; vermicompost; soybean.

1. INTRODUCTION

Soybean, being an important pulse crop, needs special mention to overcome crisis in edible oil production in the country. It is also called as **"Gold of Soil"**. Soybean (*Glycine max* L.) with its 40-42% protein and 20-22% oil has already emerged as one of the major oilseed crops in India [1]. Soybean production is estimated to rise by 14 per cent to nearly 119 lakh tones this year on higher sowing area and likely improvement in productivity, according to industry body SOPA. In its estimate released on Sunday, Indore-based soybean Processors Association of India (SOPA) said that the total area under soybean for the year 2021 is 119.984 lakh hectares. The government's area estimate is 123.677 lakh hectares. In last year's *Kharif* season, total soybean acreage stood at 118.383 lakh hectare."Estimated total production of soybean crop for all India for the year 2021 is 118.889 lakh tones, which is higher by 14.337 lakh tons (13.71 per cent) as compared to last year," The production stood at 104.55 lakh tones last year (SOPA 2021). reported that the combined application of' inorganic and organic manures significantly enhanced the growth attributes and yield of' soybean as compared to the sole application of either of them use of organic manures in integration with fertilizers meets the need of micronutrients of soybean. Vermicompost is the microbial composting of organic wastes through earthworm activity to form organic fertilizer which contains higher level of organic matter, organic carbon, total and available N, P, K and micronutrients, microbial and enzyme activities. Additionally, such integration of organic and inorganic nutrients plays an important role in economizing the use of fertilizers under increasing cost, which is restricting their use to an optimum level [2]. Nitrogen requirement of soybean can be met by soil Nitrogen. High levels of soil nitrogen inhibit symbiotic N_2-fixation, and under these conditions the soil supplies the majority of the plant's nitrogen needs [3]. Phosphorous is another primary nutrient required for soybean crops for Soybean yield, protein content, oil content, nitrogen fixation, root proliferation, leaf area, and stress tolerance activity were affected by phosphorous fertilization. Nodule formation of soybean is directly depending on the application of P fertilizer. It enhances the activity of Rhizobium and increased the formation of root nodules [4,5]. Thus, it helps in fixing more of atmosphere Nitrogen in root nodules [6]. Potassium (K) is used by plants for maintaining cell turgidity, translocation of starch, water, nutrients, protein synthesis, and starch formation. Potassium helps to cope with stress, diseases, pest, and balanced uptake of other nutrients [7]. Sulfur (S) As a secondary nutrient, Sulfur (S) plays a critical role in the growth and development of high-yielding soybeans: Necessary for optimum growth during the vegetative and reproductive stages [8-11]. It supplies nearly 40% protein and 20% edible oil with Sulphur containing amino acid [12]. The amount of N_2-fixedkg ha^{-1} soybean have been up to 450 kg N ha^{-1}. Soybean depends on its symbionts for larger part of its N requirements for effective growth and dry matter production. Phosphate solubilizing bacteria (PSB) have the capacity to convert insoluble phosphate into soluble forms for plant growth. reported that inoculation of PSB improved nodulation, root and shoot biomass, straw and grain yield and P and N uptake of the crop. Soil microorganisms play significant role in mobilizing P for the use of plant and large fraction of soil microbial population can dissolve insoluble phosphate in soil [13].

2. MATERIALS AND METHODS

During the *kharif* 2021-2022, an experiment was done at the crop Research farm of the Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences Prayagraj, Uttar Pradesh, It's at 25°24'30" north latitude, 81°51'10" east longitude, and 98 meters above sea level. The location's highest temperature ranges from 46 to 48^0C, with lows of 40 to 50^0C. The relative humidity levels ranged from 20% to 94%. The objective of study was to analysis the effect of integrated nutrient management on Physico - chemical properties, growth and yield attributes of soybean. The average yearly rainfall in this area is roughly 1100 mm. Prayagraj has a sub-tropical and semi-arid climate, with rain falling primarily between July and September. The levels of N P K, Rhizobium, and PSB @ 100%, and vermicompost and Sulphur @ 50%, @ 75%, and @ 100%, respectively, were used to control the treatments. At the time of sowing, seed inoculation was done with rhizobium and PSB (20 gm kg^{-1} seed). The recommended fertilizer dosage Sulphur 20 kg ha^{-1}, Nitrogen 40 kg ha^{-1}, Phosphorus 60 kg ha^{-1}, Potassium 40 kg ha^{-1}, Vermicompost 5t ha^{-1} in various treatment

T_1 absolute control, T_2 Rhizobium + PSB @ 100% , T_3 NPK @ 100% + Rhizobium + PSB @ 100% + V. C. @ 100%, T_4 NPK @ 100% + Rhizobium + PSB @ 100% + V. C. @ 75%, T_5 NPK @ 100% + Rhizobium + PSB @ 100% + V. C. @ 50%, T_6 NPK @ 100% + Rhizobium + PSB @ 100% + Sulphur @ 100%, T_7 NPK @ 100% + Rhizobium + PSB @ 100% + Sulphur @ 75%, T_8 NPK @ 100% + Rhizobium + PSB @ 100% + Sulphur @ 50%, T_9 NPK @ 100% + Rhizobium + PSB @ 100% + V. C. @ 100% + Sulphur @ 100% , At 20, 40, and 60 days after seeding, the soil surface was scraped followed by weeding three times. During kharif season, soybean crop generally does not require any irrigation. Spring crop would require about five to six irrigation. Method of Analysis and their Scientist name are respectively Muthuaval et al*.,* [14] calculated the bulk density of soil and represented it in (Mg/m^3), Muthuaval et al*.*, [14] calculated the particle density of soil and represented it in (Mg/m^3), Muthuaval et al*.,* [14] calculated the Pore Space of Soil and represented in percent (%), Muthuaval et al*.,* [14] calculated the Water Holding Capacity and represented in percent (%), Jackson, 1973 used a digital pH metre to record the pH of the soil. Wilcox, [15] used a digital conductivity metre to determine the electrical conductivity (dS m^{-1}) of the soil. The organic carbon content (%) of the soil was determined using the wet oxidation method developed by Walkley and Black in [16]. Subbiah and Asija [17] proposed a modified alkaline permanganate oxidation method for measuring available nitrogen (kg ha^{-1}). The 0.5 M sodium bicarbonate method (Olsen's extractant) was used to assess available Phosphorus (kg ha^{-1}) in soil. Available Potassium (kg ha^{-1}) was determined using the neutral normal ammonium acetate (pH 7.0) method established by Jackson in 1958 with a flame photometer. Bardsley and Lancaster, [18] used Turbidimetric method to measure the amount of Available Sulphur (mg kg^{-1}).

3. RESULTS AND DISCUSSION

3.1 Physical Analysis of Soil

Treatment T_9 has show the effective soil health parameter of pre and post harvest of soil has show on Table 2 and 3 significantly results which is minimum bulk density (1.18 Mg m^{-3}), particle density (2.08 Mg m^{-3}), and maximum bulk density (1.31 Mg m^{-3}), particle density (2.37 Mg m^{-3}) reported in T_1 control and highest pore space (51.23%) and water holding capacity (62.06%) found in T_9 compare to the T_1 pore space (47.53%) and water holding capacity (42.78%) due to the effect of vermicompost, bio-fertilizer and integrated nutriment management. Increase microbial activity of soil improve water holding capacity bulk density, particle density and porosity of soil. The similar result was reported by [19,1].

3.2 Chemical Analysis of Soil

The detail analysis of soil parameters pre and post harvest of soil analysis show on Table 3 and Table 4. Due to effective application of varmicompost, bio-fertilizer and integrated nutrient management under has shown the significant results of soil parameters increases the soil organic carbon 0.613%, pH 7.64, EC 0.226 dS m^{-1},Nitrogen 320.75 kg ha^{-1}, Phosphorus 33.67 kg ha^{-1}, Potassium 238.76 kg ha^{-1} and sulphur 29.58 mg kg^{-1} maximum found in T_9 and minimum soil organic carbon 0.432%, pH 7.34, E C 0.157 dS m^{-1}, Nitrogen 210.12 kg ha^{-1}, Phosphorus 20.63 kg ha^{-1}, Potassium 206.77 kg ha^{-1} and sulphur 19.3 mg kg^{-1} found in T_1 control due to the adding of vermicompost influence the microbial activity of soil, increases soil organic carbon and availability of NPK and sulphur. The similar results was reported by [20,12].

Table 1. Particular of treatment combination for soybean

S. No.	Treatments	Dosage ha^{-1} in percentage	Symbol
1.	Level of N, P and K	N P K @ 100%	I_1
2.	Level of vermicompost	Vermicompost @100%	V_1
		Vermicompost @ 75%	V_2
		Vermicompost @ 50%	V_3
3.	Level of Sulphur	Sulphur @100%	S_1
		Sulphur @ 75%	S_2
		Sulphur @ 50%	S_3
4.	Level of Rhizobium and PSB	Rhizobium and PSB @ 100%	R_1

Table 2. Physico-chemical analysis of pre-sowing soil

Particulars	Results	Method scientist year
Physical properties		
Sand (%)	61.2	
Silt (%)	22.1	Bouyocous, 1972
Clay (%)	16.7	
Textural class	Sandy loam	
Bulk Density Mg m^{-3}	1.31	
Particle Density Mg m^{-3}	2.37	
Pore space (%)	45.29	Muthuval et al., [14]
Water Holding Capacity (%)	42.50	
Soil colour	Dry soil - Pale brown colour Wet soil – Olive brown colour	Munsell 1905
Chemical properties		
Soil pH	7.26	Jackson 1954
Electrical conductivity (dS m^{-1})	0.18	Wilcox [15]
Soil organic carbon (kg ha^{-1})	0.45	Walkley and Blackman [16]
Available Nitrogen (kg ha^{-1})	235.21	Subbiah and Asija [17]
Available Phosphorus (kg ha^{-1})	18.34	Olsen et al., [21]
Available Potassium (kg ha^{-1})	175.65	Toth and Princes [22]
Available Sulphur (mg ha^{-1})	19.35	Bardsley and Lancaster [11]

Table 3. Effect of integrated nutrient management on bulk density particle density water holding capacity (%), Pore Space (%)

Treatment	Bd (Mg m^{-3})	Pd (Mg m^{-3})	Pore space (%)	Water holding capacity (%)
T_1	1.31	2.37	47.53	42.78
T_2	1.29	2.35	47.66	44.67
T_3	1.17	2.09	50.76	61.53
T_4	1.19	2.15	49.92	61.17
T_5	1.19	2.16	48.79	59.44
T_6	1.28	2.21	47.61	45.18
T_7	1.27	2.19	47.68	45.23
T_8	1.26	2.18	47.73	45.38
T_9	1.18	2.08	51.23	62.06
S. Em. (±)	0.01	0.01	0.38	0.093
C.D. (P=0.05)	0.03	0.02	1.15	0.279
F-test	NS	NS	NS	NS

Table 4. Effect of integrated nutrients on post-harvest soil pH, EC, organic carbon, Available N, P, K and Sulphur

Treatment	pH (w/v)	EC (dS m^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (mg kg^{-1})
T_1	7.34	0.157	0.432	210.12	20.63	206.77	19.93
T_2	7.41	0.169	0.457	216.58	21.18	211.31	20.44
T_3	7.61	0.221	0.598	265.33	31.65	233.19	25.06
T_4	7.58	0.214	0.581	253.38	28.08	227.94	24.87
T_5	7.51	0.203	0.572	242.41	25.64	224.16	23.12
T_6	49	0.176	0.552	223.45	21.33	214.39	28.77
T_7	7.45	0.183	0.517	228.86	22.94	219.18	27.92
T_8	7.54	0.196	0.489	235.77	23.39	222.88	26.76
T_9	7.64	0.226	0.613	320.75	33.67	238.76	29.58
S. Em. (±)	0.04	0.005	0.004	1.63	0.38	1.04	0.093
C.D. (P=0.05)	0.13	0.015	0.011	4.18	1.15	3.12	0.279
F-test	S	S	S	S	S	S	S

Table 5. Morphological parameters and yield attributes of soybean

Treatment	Plant height (cm)	No. of branches plant^{-1}	No. of Pods plant^{-1}	No. of seed pod^{-1}	Seed Yield (kg ha^{-1})
T_1	74.78	3.47	44.26	2.57	898.91
T_2	85.00	4.86	48.06	2.86	1065.25
T_3	89.82	6.95	71.08	4.27	1986.25
T_4	73.19	6.74	68.89	4.23	1766.36
T_5	83.18	5.92	67.27	3.14	1512.25
T_6	89.65	5.83	61.25	4.19	1763.36
T_7	60.54	5.67	58.07	3.83	1636.25
T_8	80.78	5.53	56.92	3.67	1416.36
T_9	97.18	7.15	74.83	4.46	2337.25
S.Em. (±)	0.69	0.02	0.09	0.18	8.19
C.D.	1.06	0.06	0.26	0.55	24.56
F - test	S	S	S	S	S

3.3 Yield Attributes of Soybean

The detail analysis response of integrated nutrient management on yield attributes of soybean has show on Table 5 .which is topmost yield attributes plant height 97.18 cm, number of branches plant $^{-1}$ 7.15 ˈpods plant^{-1}74.83, seed pod^{-1} 4.46 and seed yield 2.33 t ha^{-1} has show in T_9 and lowest plant height 74.78 cm, number of branches plant $^{-1}$ 3.47, pods plant^{-1} 44.26, seed pod^{-1} 2.57 and seed yield 0.89891 t ha^{-1} found in T_1 control caused by adding of vermicompost, bio-fertilizer and availability of NPK and sulphur. The similar result was reported by [23,24] (Chaudhari et al*.,* 2019).

4. CONCLUSION

The trail was concluded that the best findings were reported from treatment T_9 [RDF @ 100% + Rhizobium @ 100% + PSB @ 100% + VC @ 100% + Sulphur @ 100%]. It was best treatment with respect to Bulk density, particle density, pore space, water holding capacity, pH, EC (dS m^{-1}), organic carbon (%), available N, P, K (kg ha^{-1}) and S (mg kg^{-1}) on sandy loam soil. This Study reveled that application of T_9 produced optimum yield 2337.25 kg ha^{-1} which is economically and practically feasible to farmers.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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