Original Research Article

Response of Integrated Nutrient Management Practices on Soil Health Parameters and Yield attributes of Soybean (*Glycine max* L.) var. JS-9560

Abstract

A field trial was carried out during the *Kharif* season 2021-22 at the Research farm, of Naini Agriculture Institute. 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 (cm), number of branches $plant^{-1}$, pods $plant^{-1}$, seed pod^{-1} and seed yield (2337.25 kg ha^{-1}) T_9 were to be found best treatment combination.

Keywords: Biofertilizer, Inorganic fertilizer, Soil properties vermicompost, Soybean, *etc.*

UNDER PEER REVIEW

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 (Aziz *et al.,* 2019). 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 (Raj *et al.,* 2021). 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 (Gai, 2017). 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. Thus, it helps in fixing more of atmosphere Nitrogen in root nodules (Mamatha *et al.,* 2018). 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 (Biswas *et al*., 2014)**.** 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. It supplies nearly 40% protein and 20% edible oil with Sulphur containing amino acid (Ravi *et al.,* 2019). The amount of N_2- fixed kg ha^{-1} soybean

UNDER PEER REVIEW

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 (Raja *et al*., 2017).

Comment [v1]: The objective of the study was not clearly presented

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, which is located on the outskirts of Prayagraj city. 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 ^{0}C, with lows of 40 to 50 ^{0}C. The relative humidity levels ranged from 20% to 94 %. 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 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} At 20, 40, and 60 days after seeding, the soil surface was scraped followed by weeding three times. The details treatment combinations were shown in table.1 and standard protocols were followed are shown in table.2 as detailed.

Comment [v2]: The protocol was not clearly detailed nor the methodology of the application

Comment [v3]: Sentence without verb

Comment [v4]: Absence of the statistical procedure

Results and Discussion

UNDER PEER REVIEW

Physical analysis of soil

Comment [v5]: This paragpaph is not well structured and do not present separately the significance of parameters (very short)

The detailed analyses of Integrated Nutrient Management on Bulk density, Particle density, Pore space (%) and Water Holding Capacity (%) are shown in table.3. The maximum bulk density (1.31 Mg m-3) and particle density (2.37 Mg m-3) were recorded significantly in T_1 and the minimum bulk density (1.18 Mg m-3) and particle density (2.08 Mg m-3) were recorded significantly in T_9, and respectively minimum pore space (47.53 percent) and water holding capacity (42.78 percent) were recorded in T_1 and maximum pore space (51.23 percent) and maximum water holding capacity (62.06 %) in T_9. A similar discovery was made by (Paliwal, 2021)

Chemical analysis of soil

Comment [v6]: This paragpaph is not well structured and do not present separately the significance of parameters (very short)

The detailed analyses of Integrated Nutrient Management post-harvest soil pH, EC, organic carbon, Available N, P, K and Sulphur are shown in table.4. and pH 7.34, EC 0.157 ds m^{-1}, soil organic carbon 0.432 %, available 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} minimum was recorded significantly in T_1 Table 4 and maximum soil pH 7.64, EC 0.226 ds m^{-1}, soil organic carbon 0.613 %, available 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} significantly was found in T_9. The similar finding was reported by (Sikka *et al.*, 2018)

Morphological Parameters and Yield attributes of soybean

The Growth and yield parameters were significantly influenced by application of different combination nitrogenous fertilizer such as Plant height (cm)**,** Number of branches per plant**,** No. of pod per plant, No. of seed per pod, Seed yield (kg ha^{-1}), Straw yield (kg ha^{-1}) the detailed analyses show in table 5. However maximum Plant height (cm) (29.58, 76.16 and 97.18 at 30 DAS**,** at 60 DAS and at harvesting respectively)**,** number of branches per plant (7.15)**,** No. of pod per plant (74.82), No. of seed per pod (4.46), Seed yield (2337.25 kg ha^{-1}), Straw yield (3515.34 kg ha^{-1})

Conclusion

UNDER PEER REVIEW

The trail was concluded that the best findings were reported from treatment T_9 [RDF @ 100 % + Rhizobium @ 100 % + PSB @ 100% + VC @ 100% + Sulphur @ 100%] was best treatment combinations 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. Study revealed that application of T_9 produced optimum yield which is economically and practically feasible to farmers and the different treatment concerned.

Comment [v7]: . It

Comment [v8]: delete

Comment [v9]: This

Comment [v10]: delete

References

Comment [v11]: Standardize the style of the references according to the journal instructions

Aziz, M.A., Mushtaq, T., Ahmad, M., Dar, E.A., Mahdi, S.S., Qureshi, A.M. and Jahangir, I.A. (2019) Effect of Integrated nutrient management on growth, yield and nutrient uptake by soybean. *Annals of Plant and Soil Research* 19 (2):154 – 158

Bardsley, C E. and Lancaster, J.D. (1960) Determination of Reserve sulfur and soluble sulfates in soil, *soil science society of America journal* vol. 24(4)

Biswas, M.R., Rahman, M.W., Haque, M.M., Sharmin, M. and Barua, R. (2014) Effect of potassium and vermicompost on the growth, yield and nutrient contents. *Open Science Journal of Bioscience and Bioengineering*. 1(3): 33-39.

Bouyoucos, G.J. (1927) The hydrometer as a new method for the mechanical analysis of soils. *Soil Science* 23, 343-353.

Fisher, R.A. and Yate, F. (1963) Statistical tables for biological, agricultural and medical research. *oliver and Boyd Edinburg*, London. 57 - 63.

Gai, Z., Zhang, j. and Li, C. (2017) Effects of starter nitrogen fertilizer on soybean root activity, leaf photosynthesis and grain yield, *PLoS ONE* 12 (4)

Jackson, M.L. (1973) Soil chemical analysis, *Prentice Hall, Pvt. Ltd. New Delhi*, 239 -241.

Mamatha, N., Shaker, K.C., Padmaja, G. and Reddy, M.M. (2018) Influence of Nitrogen and Sulphur Application on Yield and Quality of Soybean (Glycine max L.) *International Journal of Current Microbiology and Applied Sciences*, 7(12): 3452-3457

Comment [v12]: Indicates the pages

Comment [v13]: This reference make confusion it's a book or a chapter in a book

Comment [v14]: This reference make confusion it's a book or a chapter in a book

UNDER PEER REVIEW

Munsell, Albert H. (1971) A pigment color system and notation. *The American Psychological* 23(2), 236-244.

Muthuval, P., Udayasoorian, C., Natesan, R., Ramaswami, P.R. (1992) Introduction to soil analysis.

Olsen, S.R., Cole, C.V., Watnable, F.S. and Dean, L.A. (1954) Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *USDA Circular 939*, Washington, DC, USA 8 - 60.

Piper, C.S. (1960) Soil and Plant Analysis. *Interscience Publishers*, NewYork, NY,. 128-136.

Paliwal, K. and Golani, M. (2021) Integrated Nutrient Control for Enhancing Growth and Yield Properties, Monetary Performance and Soil Health in Soybean (Glycine Max) Cropping System. *International Journal of Agriculture Innovations and Research* Vol. 10 (1), 2319-1473

Raj, R.K., Kumari, S., Sinha, K.K., Pandit, A. and Kumar, S. (2021) Impact of integrated nutrient management for maximizing productivity and profitability of Soybean [(Glycine max (L.) Merrill], *The Pharma Innovation Journal*; 10(9): 1452-1455

Raja, D. and Takankhar, V.G. (2017) Effect of Liquid Biofertilizers (Bradyrhizobium and PSB) on Availability of Nutrients and Soil Chemical Properties of Soybean (Glycine max L.), Int. J. Pure App. Biosci. 5 (5): 88-96

Ravi, S., jadhav, R.L., Ravi, M.V. and Naik, A. (2019) Effect of Sulphur and Boron Nutrition on Chemical Properties of Soil after Harvest of Soybean *International Journal of Current Microbiology and Applied Sciences* 8(4): 485-489

Richards, L.A. (1954) Diagnosis and improvement of saline and alkaline Soils. USDA Hand Book No. 60. *Oxford and IBH Pub. Co.*, New Delhi.

Sikka, R., Singh, D., Deol, J.S. and Kumar, N. (2018) Effect of integrated nutrient and agronomic management on growth, productivity, nutrient uptake and soil residual fertility status of soybean, *Agric. Sci. Digest*., 38 (2) 103-107

Subbiah, B.V. and Asija, G.L. (1956) A rapid procedure for the estimation of available nitrogen in *soils Current Science* 25*:* 259 - 260.

Toth, S. J., & Prince, A. L. (1949) Potassium determination in plant digests by flame photometer. *Soil, Plant and water Analysis by PC Jaiswal*, 275-279.

Comment [v15]: Incomplete reference

Comment [v16]: This reference make confusion it's a book or a chapter in a book

Comment [v17]: Indicate the volume and the issue

UNDER PEER REVIEW

Walkley, A. and Black, I.A. (1947) Critical examination of rapid method for determining organic carbon in soils, effect of variation in digestion condition and of inorganic soil constituents. *Soil Science*, 632-251.

Wilcox, L.V. (1950) Electrical Conductivity. *Am. Water works Assoc. J.* 42: 776.

Comment [v18]: Indicate the volume and the issue

VIEW

Table 1: Details of treatment combination for soybean

Treatment	Treatment combination	Symbol
T_1	Absolute control	$I_0 R_1 V_0 S_0$
T_2	Rhizobium + PSB @ 100%	$I_0 R_1 V_0 S_0$
T_3	I @ 100% + Rhizobium + PSB @ 100% + V. C. @ 100%	$I_1 R_1 V_1 S_0$
T_4	I @ 100% + Rhizobium + PSB @ 100% + V.C. @ 75%	$I_1 R_1 V_2 S_0$
T_5	I @ 100% + Rhizobium + PSB @ 100% + V.C.@ 50%	$I_1 R_1 V_3 S_0$
T_6	I @ 100% + Rhizobium + PSB @ 100% + Sulphur @ 100%	$I_1 R_1 V_0 S_1$
T_7	I @ 100% + Rhizobium + PSB @ 100% + Sulphur @ 75%	$I_1 R_1 V_0 S_2$
T_8	I @ 100 + Rhizobium + PSB @ 100% +Sulphur @ 50%	$I_1 R_1 V_0 S_3$
T_9	I @ 100% + Rhizobium + PSB @ 100% +V.C. @ 100 % + Sulphur @ 100%	$I_1 R_1 V_1 S_1$

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

Comment [v19]:

Particulars	Results	Method scientist year
Physical properties		
Sand (%)	61.2	

Comment [v20]: These results are yours I think. In this case, you must indicate this work in the materials and methods and the reference source (below) will be non sense

Silt (%)	22.1	Bouyocous, 1972
Clay (%)	16.7	
Textural class	Sandy loam	
Bulk Density Mg m^{-3}	1.31	Muthuval *et al.*, 1992
Particle Density Mg m^{-3}	2.37	
Pore space (%)	45.29	
Water Holding Capacity (%)	42.50	
Soil color	Dry soil - Pale brown color Wet soil – Olive brown color	Munsell 1905
Chemical properties		
Soil Ph	7.26	Jackson 1954
Electrical conductivity (%)	0.18	Wilcox 1950
Soil organic carbon (kg ha^{-1})	0.45	Walkley and Blackman 1947
Available Nitrogen (kg ha^{-1})	235.21	Subbiah and Asija 1956
Available Phosphorus (kg ha^{-1})	18.34	Olsen *et al.*, 1954
Available Potassium (kg ha^{-1})	175.65	Toth and Princes 1949
Available Sulphur (mg ha^{-1})	19.35	Bardsley and Lancaster 1960

Source: Soil Plant and Water Analysis (Jaiswal, 2011)

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

Comment [v21]: We do not found in this table any indication on the statistical analysis (letters) Since you have a pre-sowing status, you must compare the evolution of the different parameters (pre-sowing-post harvest) between the different treatemants and not the final status

UNDER PEER REVIEW

T_9	1.18	2.08	51.23	62.06

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
R_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

Comment [v22]: Since you have a pre-sowing status, you must compare the evolution of the different parameters (pre-sowing-post harvest) between the different treatemants and not the final status
We do not found in this table any indication on the statistical analysis (letters)

Comment [v23]: R or T

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

Comment [v24]: We do not found in this table any indication on the statistical analysis (letters)

UNDER PEER REVIEW

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
C.D.	1.06	0.06	0.26	0.55	24.56
F - test	S	S	S	S	S

UNDER PEER REVIEW