Effect of Integrated Nutrient Management on Soil Health and Nutrient Balance Sheet of soybean Under *Vertisols* of Rajasthan

ABSTRACT

Background: A field experiment was conducted during kharif, 2019 at ARS farm, College of Agriculture, Ummedganj, Kota (Rajasthan). **Effect of Integrated Nutrient Management on Soil Health and Nutrient Balance Sheet of soybean Under Vertisols of Rajasthan**. The soil of the experimental field is clay loam having low to medium fertility status and good porosity.

Method: The experiment consisted of 10 treatments viz. T_0 - Control (Absolute), T_1 - RDF (20-40-40), T_2 - 75% RDF + FYM (2.0 t ha^{-1}), T_3 - 50% RDF + FYM (4.0 t ha^{-1}), T_4 - 75% RDF + FYM (2.0 t ha^{-1}) + *Rhizobium,* T_5 - 50% RDF + FYM (4.0 t ha^{-1}) + *Rhizobium*, T_6 - 75% RDF + Vermicompost (1.0 t ha^{-1}), T_7 - 50% RDF + Vermicompost (2.0 t ha^{-1}), T_8 - 75% RDF + Vermicompost (1.0 t ha^{-1}) + *Rhizobium*, T_9 - 50% RDF + Vermicompost (2.0 t ha^{-1}) + *Rhizobium.* The experiment was laid out in randomised block design and was replicated thrice.

Result: Among the nutrient management treatment, application of 50% RDF + Vermicompost (2.0 t ha-1) + Rhizobium (T_9) significantly built up of the soil available nitrogen (258 kg ha^{-1}), available phosphorus (21.67 kg ha^{-1}) and available potassium (445.35 kg ha^{-1}), micronutrient and organic carbon (0.59) was recorded.

Keywords: *Rhizobium japonicum*, FYM, vermicompost, micronutrients, soybean.

INTRODUCTION

Soybean (*Glycine max* L.) belongs to family *Leguminaceae* or *Fabaceae* and Sub- family *Papilionaceae*. Soybean [Glycine max (L.)] is predominantly cultivated under rainfed condition during kharif season at Hadoti region of Rajasthan. Soybean is one of the major kharif oilseed crops in India, mainly in semi-arid tropics of central India comprising the states of Madhya Pradesh, Maharashtra and Rajasthan. Estimated production of soybean in world is 364.33 million tonnes production and area is 127.19 million hectares whereas in India it was 12.10 million tonnes production from an area of 10.80 million hectares in Rajasthan is 1.16 million tonnes production and area is 0.93 million hectares (Anonymous, 2018). Consecutive use of organic manures, biofertilizers and inorganic fertilizers to achieve sustained crop production and maintain the soil health is the basic need of the hour. Use of organic manures alone or in combination with chemical fertilizers will help to improve physico-chemical properties of the soils. Organic manures are used to supply both macro and micronutrients and sustain amount of humic substances particularly humic and fulvic acid that helps to maintain soil reaction. Organic sources of nutrients are derived from animal, human and agriculture wastes (e.g. composting and crop residues). Vermicompost is rich organic manure consist of macro and micronutrients, plant growth promoting substances, beneficial micro-organisms that are necessary for plant growth (Todkari *et. al*. 2001). Seed inoculation with effective *Rhizobium* inoculant is recommended to ensure additional nodulation and N_2 fixation for maximum growth and yield of soybean crop. The organic manures along with bio fertilizers help in reducing the dose of inorganic fertilizer, which in turn reduces the cost of cultivation and help in improving the soil health. Therefore, this study was undertaken to analyze the effect of combined use of organic and inorganic sources of nutrients on growth and yield of soybean in the *Vertisols* of Rajasthan.

MATERIALS AND METHODS

The field experiment was conducted during kharif 2019 at ARS farm at College of Agriculture, Ummedganj, Kota. The soil of the experimental site was medium black (*Vertisol*s) having clay loam texture. The experiment consisted of 10 treatments viz. T_0 - Control (Absolute), T_1 - RDF (20-40-40), T_2 - 75% RDF + FYM (2.0 t ha^{-1}), T_3 - 50% RDF + FYM (4.0 t ha^{-1}), T_4 - 75% RDF + FYM (2.0 t ha^{-1}) + *Rhizobium,* T_5 - 50% RDF + FYM (4.0 t ha^{-1}) + *Rhizobium*, T_6 - 75% RDF + Vermicompost (1.0 t ha^{-1}), T_7 - 50% RDF + Vermicompost (2.0 t ha^{-1}), T_8 - 75% RDF + Vermicompost (1.0 t ha^{-1}) + *Rhizobium*, T_9 - 50% RDF + Vermicompost (2.0 t ha^{-1}) + *Rhizobium.* The experiment was laid out in randomised block design and was replicated thrice. Kota is characterized by sub-tropical, semi-arid climate, temperature often exceed 40˚C during summer and sometimes touches 45˚C, minimum temperature falls below 5˚C during winter season. The average rainfall 575mm, contributed from south-west monsoon during July to September. Soybean crop sown using variety JS-335 with 80kg ha^{-1} seed rate in kharif 2019. Soil samples were analysed for electrical conductivity (EC) of the supernatant liquid with the help of Solubridge or conductivity meter in 1: 2, soil water solution (Jackson, 1967). pH measured by Glass electrode pH meter in 1: 2, soil water solution (Jackson, 1967). Organic carbon in the soil was estimated by Walkley and black (1934) Rapid titration method. Soil samples were analysed for available N using alkaline potassium permanganate, which oxidized and hydrolysed the organic matter present in the soil (Subbiah and Asija, 1956). Available phosphorous was determined through the UV-spectrophotometer by extracting the soil with 0.5 N $NaHCO_3$ pH 8.5 (Olsen's *et al*. 1954) and measuring the intensity of blue colour developed by ammonium molybdate–stannous chloride. Available K in soil was determined by extracting with 1N neutral ammonium acetate (Hanway and Heidel,1952). The available micronutrient was determined using DTPA extractant as described by Lindsay and Norvell (1978). Use the filtrate for measurement of Fe, Mn, Zn and Cu on Atomic Absorption Spectrophotometry (AAS).

Table 1: Initial Physico-Chemical properties of the soil of experimental field

Properties	Values	Method Employed
(A) Mechanical Composition		Hydrometer method (Bouyoucos, 1962)
Sand (%)	14.30	
Silt (%)	36.50	
Clay (%)	49.20	
Textural class	Clay loam	Texture Triangular diagram, (Brady 1983)
(B) Physical properties		
Bulk density (Mg m^{-3})	1.38	Core Sampler method (Piper, 1950)

Particle density (Mg m^{-3})	2.66	Pycnometer or RD bottle method
Porosity (%)	48.2	Calculated by BD and PD
(C) Chemical properties		
Available N (kg ha^{-1})	214 kg ha^{-1}	Alkali permanganate method (Subbiah and Asija, 1956)
Available P (kg ha^{-1})	17 $kgha^{-1}$	Olsen's method (Olsen *et al*., 1954)
Available K (kg ha^{-1})	420 kg ha^{-1}	Neutral normal Ammonium acetate (Hanway and Heidel,1952)
Organic carbon (%)	0.52	Walkley and Black (1934) method
EC (dS m^{-1})	0.36	EC of soil samples was measured on Solubridge in soil:water solution (1:2) (Jackson, 1967)
pH	7.6	Glass electrode pH meter in soil:water solution (1:2) (Jackson, 1967)

RESULTS AND DISCUSSION

Soil physico-chemical properties

The results indicated that soil parameters after harvest showed non- significant variation with pH and EC. Soil reaction (pH) in the experimental soil ranged from 7.52 to 7.60 and it was maximum for 100% RDF (T_1) and minimum for 50% RDF + Vermicompost (2.0 t ha^{-1}) + Rhizobium (T_9). Electrical Conductivity (EC) of the experimental soil ranged from 0.30 to 0.35 and it was maximum for 100% RDF (T_1) and minimum for 50% RDF + Vermicompost (2.0 t ha^{-1}) + Rhizobium (T_9). Application of 50% RDF + Vermicompost (2.0 t ha^{-1}) + Rhizobium (T_9) found highest organic carbon (0.59%) content in soil after harvesting of crop which is significantly superior and at par with 75% RDF + Vermicompost (1.0 t ha^{-1}) + Rhizobium (T_8) and the value is 0.58%. The minimum organic carbon content was recorded in absolute control. Higher production of root biomass might have increased the organic carbon content Ram Lakshmi *et al*. (2015). These observations are in close agreements with the findings of Dhakal *et al*. (2016) and Konthoujam *et al.* (2013) who had indicated that the judicious integration of organic and inorganic sources of nutrition significantly improved the soil available N, P, K, and micronutrient and numerically change in soil pH, electrical conductivity and organic carbon content in soil.

Nutrient availability in soil after harvesting the crop and nutrient balance sheet

The data on soil available nitrogen, phosphorus and potassium are presented in Table 2. It was observed that integrated nutrient management resulted into significant influence on available N, P, K in soil. The data showed that available nitrogen in soil was significantly improved with integrated application of chemical fertilizers, rhizobium and vermicompost with respect to the RDF alone and control plots during the experiment. As compared to the initial value of available nitrogen, the application of 75% RDF + Vermicompost (1.0 t ha-1) + Rhizobium improved its status after crop harvest. Although, available nitrogen under RDF after crop harvest remained almost same when compared to that of initial value. The nutrient management practices left the significant effect on available phosphorus and potassium in soil after harvest of soybean crop. The available nutrient status of the soil after harvesting the soybean crop showed considerable increment due to the soil application of different inorganic and organic sources. The highest soil available nitrogen (258 kg ha^{-1}), available phosphorus (21.22 $kgha^{-1}$), available potassium (445.35 $kgha^{-1}$) and micronutrients was recorded with the application of 50% RDF + Vermicompost (2.0 t ha^{-1}) + *Rhizobium* (T_9) after harvesting of crop which is significantly superior and at par with 50% RDF + FYM (4.0 t ha^{-1}) + *Rhizobium* (T_5). The increase in the available N, P, K and micronutrient content of soil might be due to release of those nutrients added through vermicompost with inorganic fertilizers to the soil after mineralization. Organic manures help to increase biological activity of soil microbes and improve soil structure, water holding capacity and other physico-chemical properties of soil

Devi *et al*. (2013). These observations are in close agreements with the findings of Jadhav *et al.* (2007), Dhakal *et al*. (2016), Singh *et al.* (2014), Konthoujam *et al.* (2013), Meshram and Sapre (2019), Bonde and Gawande (2017), Shahina *et al.* (2010) who had indicated that the judicious integration of organic and inorganic sources of nutrition significantly improved the soil available N, P, K, and micronutrient and numerically change in soil pH, electrical conductivity and organic carbon content in soil.

Micronutrient content Fe, Mn, Zn and Cu (mg kg^{-1})

The analysed data for micronutrient also indicated that after crop harvest, the available (DTPA-extractable) Zn and Fe in the soil remained affected by nutrient management practices. Application of 50% RDF + Vermicompost (2.0 t ha^{-1}) + Rhizobium (T_9) recorded the highest Fe, Mn and Zn in soil, which was significantly superior to other treatments but found at par with treatment 75% RDF + Vermicompost (1.0 t ha^{-1}) + Rhizobium (T_8) (5.43 mg kg^{-1}), minimum Fe content in soil was recorded under absolute control (3.76 mg kg^{-1}). The effect of integrated nutrient management on Cu content in soil was found non-significant and DTPA-Cu ranged from 0.75 to 0.77 mg kg^{-1} and it was maximum for 75% RDF + Vermicompost (1.0 t ha^{-1}) + Rhizobium and minimum for absolute control. These observations are in close agreements with the findings of Dhakal *et al*. (2016), Singh *et al.* (2014), Laharia et al. (2013), Dadhich and Somani, (2007).

CONCLUSION

The available nutrient status of the soil after harvesting the soybean crop showed considerable increment due to the soil application of different inorganic and organic sources. The highest soil available nitrogen (258 kg ha^{-1}), available phosphorus (21.67 kg ha^{-1}) and available potassium (445.35 kg ha^{-1}), micronutrient and organic carbon (0.59) was recorded with the application of 50% RDF + Vermicompost (2.0 t ha^{-1}) + Rhizobium (T_9). Hence, this combination of integrated nutrient management proved as productive, remunerative and beneficial for soil health in soils of ARS, Kota.

Table 2. Effect of integrated nutrient management on pH, EC, OC, N, P, K and DTPA extractable micronutrients in soil after harvesting the soybean crop

TREATMENT	pH	EC (dsm^{-1})	Organic carbon (%)	Nitrogen ($kg\ ha^{-1}$)	Phosphorous ($kg\ ha^{-1}$)	Potassium ($kg\ ha^{-1}$)	Fe ($mg\ kg^{-1}$)	Mn ($mg\ kg^{-1}$)	Cu ($mg\ kg^{-1}$)	Zn ($mg\ kg^{-1}$)
T_0- Control (Absolute)	7.60	0.35	0.48	200.70	14.17	415.00	3.76	3.80	0.75	0.378
T_1- RDF (20-40-40)	7.65	0.36	0.50	213.19	18.22	421.67	4.33	4.33	0.76	0.53
T_2- 75% RDF + FYM (2.0 t ha^{-1})	7.59	0.34	0.51	225.29	19.57	426.67	4.47	4.47	0.76	0.55
T_3- 50% RDF + FYM (4.0 t ha^{-1})	7.59	0.34	0.51	221.11	19.17	425.67	4.37	4.43	0.76	0.54
T_4- 75% RDF + FYM (2.0 t ha^{-1}) + Rhizobium	7.57	0.31	0.57	248.99	20.64	434.00	5.37	4.90	0.77	0.92
T_5- 50% RDF + FYM (4.0 t ha^{-1}) + Rhizobium	7.53	0.33	0.57	250.00	20.35	436.33	5.00	4.73	0.77	0.79
T_6- 75% RDF+ Vermicompost (1.0 t ha^{-1})	7.58	0.33	0.53	233.33	19.98	430.33	4.83	4.70	0.77	0.61
T_7- 50% RDF + Vermicompost (2.0 t ha^{-1})	7.56	0.33	0.52	229.60	19.73	427.67	4.50	4.63	0.77	0.58
T_8- 75% RDF + Vermicompost (1.0 t ha^{-1}) + Rhizobium	7.53	0.30	0.58	254.77	21.53	441.33	5.43	5.10	0.77	0.93
T_9- 50% RDF + Vermicompost (2.0 t ha^{-1}) + Rhizobium	7.52	0.31	0.59	258.14	21.67	445.00	5.47	5.17	0.77	0.88
S.Em. ±	0.05	0.01	0.01	5.65	0.43	1.61	0.12	0.07	0.01	0.02
CD at 0.05%	**NS**	**NS**	**0.02**	**16.79**	**1.27**	**4.78**	**0.35**	**0.21**	**NS**	**0.05**

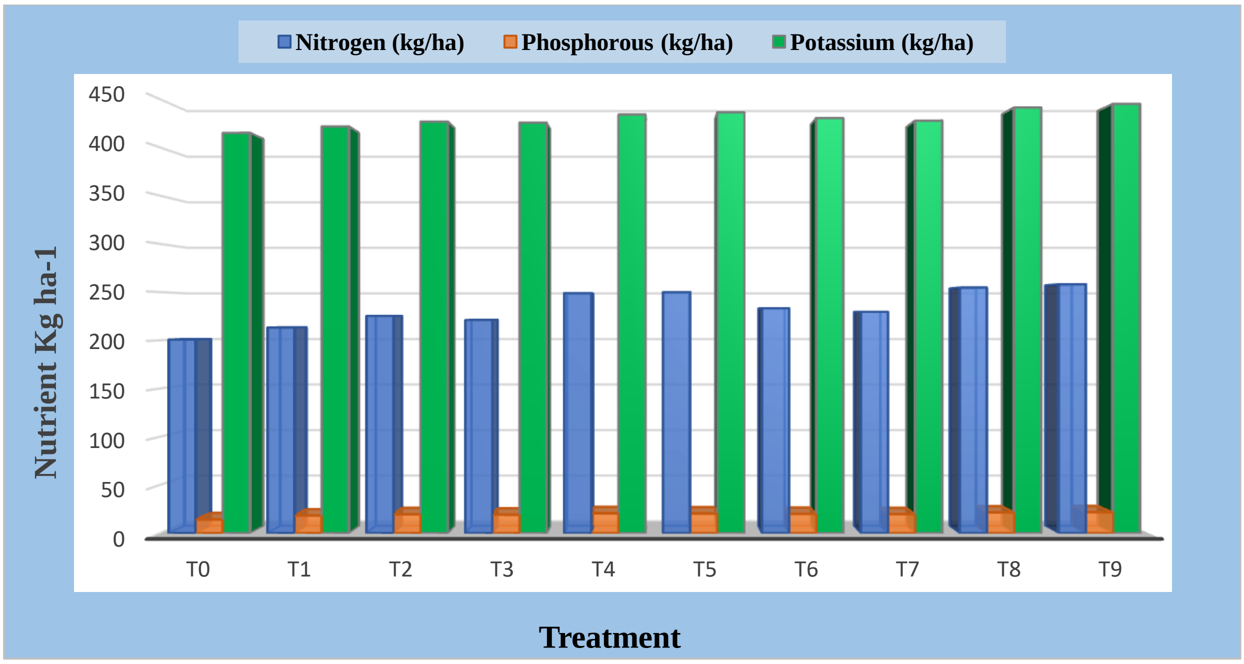

Figure 1. Effect of integrated nutrient management on nutrient content in soil after harvesting the soybean crop

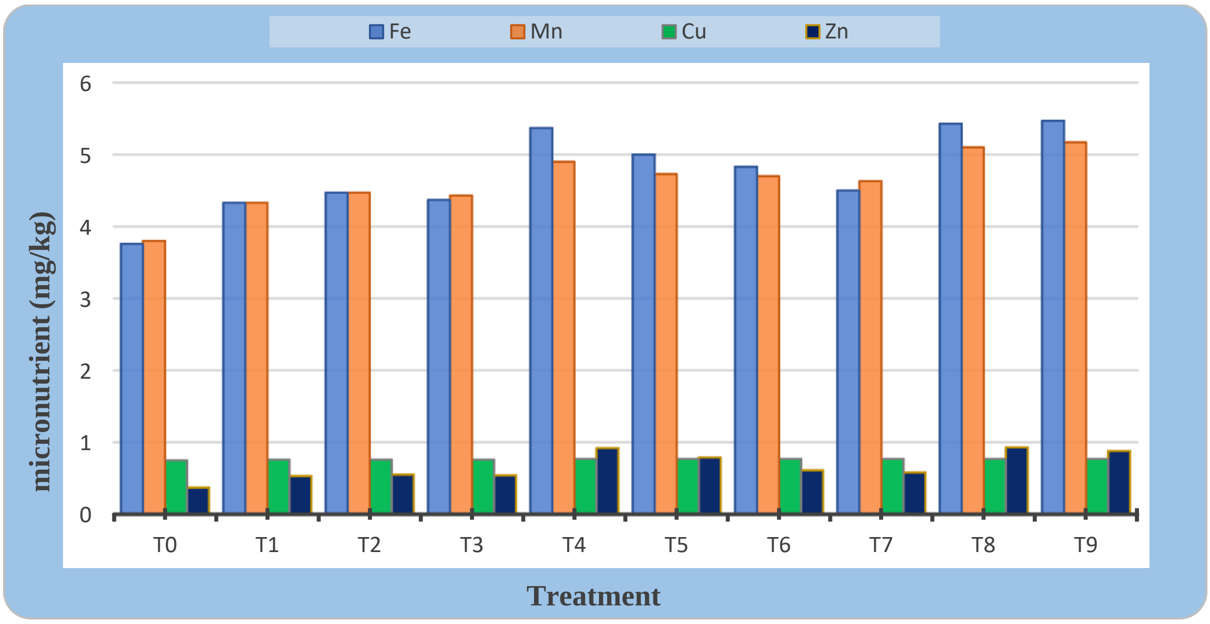

Figure 2. Effect of integrated nutrient management on micronutrient content (mg kg^{-1}) in soil after harvesting the soybean crop

Table 3. Nutrient balance sheet of Nitrogen

TREATMENT	Nitrogen (kg/ha)						
	Initial soil N status (a)	**N added (b)**	**N Uptake by crop (c)**	**Expected nutrient balance (d=(a+b)-c)**	**Actual nutrient balance (e)**	**Apparent gain/loss (f=e-d)**	**Actual difference of initial and final (g=e-a)**
T_0- Control (Absolute)	210	0	51.06	158.94	200.7	41.76	-9.3
T_1- RDF (20-40-40)	210	20	61.25	168.75	213.19	44.44	3.19
T_2- 75% RDF + FYM (2.0 t ha^{-1})	210	25	71.99	163.01	225.29	62.28	15.29
T_3- 50% RDF + FYM (4.0 t ha^{-1})	210	30	71.02	168.98	221.11	52.13	11.11
T_4- 75% RDF + FYM (2.0 t ha^{-1}) + Rhizobium	210	25	111.11	133.89	248.99	115.1	38.99
T_5- 50% RDF + FYM (4.0 t ha^{-1}) + Rhizobium	210	40	96.61	153.39	250	96.61	40
T_6- 75% RDF+ Vermicompost (1.0 t ha^{-1})	210	25	85.15	149.85	233.33	83.48	23.33
T_7- 50% RDF + Vermicompost (2.0 t ha^{-1})	210	35	82.99	162.01	229.6	67.59	19.6
T_8- 75% RDF + Vermicompost (1.0 t ha^{-1}) + Rhizobium	210	35	117.93	127.07	254.77	127.7	44.77
T_9- 50% RDF + Vermicompost (2.0 t ha^{-1}) + Rhizobium	210	40	98.52	151.48	258.14	106.66	48.14

Table 4. Nutrient balance sheet of Phosphorous

TREATMENT	Phosphorous (kg/ha)						
	Initial soil P status (a)	P added (b)	P Uptake by crop (c)	Expected nutrient balance (d=(a+b)-c)	Actual nutrient balance (e)	Apparent gain/loss (f=e-d)	Actual difference of initial and final (g=e-a)
T_0- Control (Absolute)	17	0	5.5	11.5	14.17	2.67	-2.83
T_1- RDF (20-40-40)	17	40	6.56	50.44	18.22	-32.22	1.22
T_2- 75% RDF + FYM (2.0 t ha^{-1})	17	34	7.69	43.31	19.57	-23.74	2.57
T_3- 50% RDF + FYM (4.0 t ha^{-1})	17	28	7.59	37.41	19.17	-18.24	2.17
T_4- 75% RDF + FYM (2.0 t ha^{-1}) + Rhizobium	17	34	11.76	39.24	20.64	-18.6	3.64
T_5- 50% RDF + FYM (4.0 t ha^{-1}) + Rhizobium	17	28	10.26	34.74	20.35	-14.39	3.35
T_6- 75% RDF+ Vermicompost (1.0 t ha^{-1})	17	48	9.06	55.94	19.98	-35.96	2.98
T_7- 50% RDF + Vermicompost (2.0 t ha^{-1})	17	56	8.83	64.17	19.73	-44.44	2.73
T_8- 75% RDF + Vermicompost (1.0 t ha^{-1}) + Rhizobium	17	48	12.41	52.59	21.53	-31.06	4.53
T_9- 50% RDF + Vermicompost (2.0 t ha^{-1}) + Rhizobium	17	56	10.47	62.53	21.67	-40.86	4.67

Table 5. Nutrient balance sheet of Potassium

TREATMENT	Potassium (kg/ha)						
	Initial soil K status (a)	K added (b)	K Uptake by crop (c)	Expected nutrient balance (d=(a+b)-c)	Actual nutrient balance (e)	Apparent gain/loss (f=e-d)	Actual difference of initial and final (g=e-a)
T_0- Control (Absolute)	420	0	45.77	374.23	415	40.77	-5
T_1- RDF (20-40-40)	420	40	53.26	406.74	421.67	14.93	1.67
T_2- 75% RDF + FYM (2.0 t ha^{-1})	420	40	61.74	398.26	426.67	28.41	6.67
T_3- 50% RDF + FYM (4.0 t ha^{-1})	420	40	60.93	399.07	425.67	26.6	5.67
T_4- 75% RDF + FYM (2.0 t ha^{-1}) + Rhizobium	420	40	90.57	369.43	434	64.57	14
T_5- 50% RDF + FYM (4.0 t ha^{-1}) + Rhizobium	420	40	80.26	379.74	436.33	56.59	16.33
T_6- 75% RDF+ Vermicompost (1.0 t ha^{-1})	420	50	71.57	398.43	430.33	31.9	10.33
T_7- 50% RDF + Vermicompost (2.0 t ha^{-1})	420	60	69.8	410.2	427.67	17.47	7.67
T_8- 75% RDF + Vermicompost (1.0 t ha^{-1}) + Rhizobium	420	50	92.92	377.08	441.33	64.25	21.33
T_9- 50% RDF + Vermicompost (2.0 t ha^{-1}) + Rhizobium	420	60	81.78	398.22	445	46.78	25

References

Anonymous 2017-18. Annual report. DES, Ministry of Agricultural & Farmer's Welfare, Government of India, Krishi Bhawan, New Delhi.

Bouyoucos, G.J. 1962. Hydrometer method for making particle size analysis of soil. *Agronomy Journal* **55**: 464-465.

Bonde, A.S., and Gawande, S.N. 2017. Effect of integrated nutrient management on soil properties and yield of soybean (*Glycine max). Annals of Plant and Soil Research* **19**(2): 205–209.

Brady, N.C. 1983. The nature and properties of soils. MacMillan Publishing Company, New York and Collier MacMillan Publisher, London pp. 750.

Dadhich, S., & Somani, L. (2007). Effect of integrated nutrient management in a soybean-wheat crop sequence on the yield, micronutrient uptake and post-harvest availability of micronutrients on typic ustochrepts soil. *Acta Agronomica Hungarica*, **55(**2), 205-216.

Devi, K.N., Singh, T.B., Athokpam, H.S., Singh, N.B., Shamurailatpam, D. 2013. Influence of inorganic, biological and organic manures on nodulation and yield of soybean (*Glycine max Merril L*.) and soil properties. *Australian journal of crop science*; **7**(9):1407-1415.

Dhakal, Y., Meena, R.S. and Kumar, S. 2016. Effect of INM on nodulation, yield, quality and available nutrient status in soil after harvest of greengram. *Legume Research*, **39**(4):590-594.

Hanway, J.J. and Heidel, H. 1952 Soil analysis method as used in Iowa state college Soil testing Laboratory. Lowa State College of Agriculture Bulletin **57**, 1-3.

Jadhav, P.M., Rane, S.D., Ranshur, N.J. and Todmal, S.M. 2007. Effect of integrated nutrient management on quality and yield of soybean. *The Asian Journal of Soil Science* **2**(1); 68-73.

Jeckson, M.L. 1967. Soil chemical analysis. Prentice Hall of India, New Delhi.

Konthoujam, N.D., Tensubam, B.S., Athokpam, H.S., Naorem, B.S. and Shamurailatpam, D. 2013. Influence of inorganic, biological and organic manures on nodulation and yield of soybean (*Glycine max* L. Merrill) and soil properties. *Australian Journal of Crop Science* **7**(9): 1407-1415.

Laharia, G. S., Patil, D. U., & Damre, P. R. (2013). Effect of organic sources on soil fertility, nutrient uptake and yield of soybean. *Crop Research*, **45**(1to3), 155-159.

Meshram, N. and Sapre, N. 2019 Effect of integrated nutrient management on growth and yield of soybean [*Glycine max* (l.) Merrill]. *Plant Archive* **19**(2):2933-2936.

Olsen, S.R., Cole, C.V. Watanabe F.S. and Dean, L.A. 1954. Estimating of available phosphorus in soil by extraction with sodium bicarbonate USDA Circular., 939.

Piper, C.S. 1950. Soil and plant analysis. Hans Publication, Bombay.

Ram Lakshmi, Ch. S., Chandra Sekhar Rao, P. Sreelatha, T., Padmaja, G., Madhavi and Rao, P.V. 2015 Effect of integrated nutrient management on soil properties, yield and nutrient uptake in rice-green gram cropping system in an Inceptisol of Andhra Pradesh. *Journal of the Indian Society of Soil Science* **63**(4): 400-405.

Shahina, T.K., Sammi, U.K., Singh, V.M and Biswas A.K. 2010. Changes in organic and inorganic forms of nitrogen in a Typic Hoplustert under soybean-wheat system due to conjoint use of inorganic fertilizers and organic manures. *Journal of Indian Society of Soil Science* **58**(1):78-85.

Singh, M., Kumar, N., Das, A., & Rakshit, R. (2014). Soybean Response to Organic and Inorganic Fertilization on Aquic Hapludoll Soil. *Environment & Ecology*, 34(4B), 1634-1638.

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

Todkari, A.K., Dwivedi, A.K., Dikshit, P.R. and Tiwari, A. 2001. Vermicompost and organic matter consists of macro and micronutrients, plant growth promoting substance. necessary for plant growth. *Journal of Indian Society of Soil Science* **50**(4): 472-475.

Walkley, A. and Black C.A. 1934. Estimation of soil organic carbon by the chromic acid titration method. *Soil Science* **37** (1): 29-38.