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Effect of Organic Manures and NPK on Nodulation, Microbial Biomass Carbon and Yield of Soybean

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Abstract A field experiment was conducted during *kharif* of 2006 and 2007 to study the effect of FYM, vermicompost, vermiwash and NPK of nutrients on nodulation, growth, microbial biomass and yield in soybean (*Glycine max* L. Merrill) var PS - 1347. The soil was well drained silty clay loam with pH 7.4, high in organic carbon (0.86%), medium in available phosphorus (19.19 kg ha^{-1}) and low in available potassium (130.71 kg ha^{-1}) and nitrogen (240.17 kg ha^{-1}) content. The maximum nodule number were recorded with the application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10% + 50% NPK, (49.00 in 2006 and 53.0 in 2007 plant^{-1} respectively) at 60 DAS in both the years. This treatment also gave maximum nodule and plant dry weight in both the years. All the treatments except FYM @ 5 t ha^{-1} + VW @ 10% significantly increased microbial biomass C at 50% flowering stage and at harvest in 2006. Similarly, VC @ 2.5 t ha^{-1} + VW @ 10%, FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10% and FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10% treatments significantly increased microbial biomass C as compared with 100% NPK at 50% flowering stage in 2007. Application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + 50% NPK numerically increased grain yield in both years over FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} and FYM @ 5 t ha^{-1} + VW @ 10% + 50% NPK. Application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10% + 50% NPK produced maximum grain yield (3209.87 and 3230.88 kg ha^{-1} respectively) in both years. The maximum 100-seed weight was obtained with treatment having FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10%+ 50% NPK in both years.

Keywords FYM, Vermiwash, Vermicompost, Nodulation, Soybean.

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Introduction

Soybean (*Glycine max* L. Merrill) is one of the most important oil seed crops of the world. It contains

exceptionally high and well balanced protein (42-45%) and edible oil (20-22%) with higher biological value, unsaturated fatty acids viz., linoleic fatty acid (19.4%) and amino acids argentine, aspartic acids glutamic acid, glycine, isolucine, lucine and valine. It requires high amount of nutrients due to its high yield potential. The crop removes a large quantity of nitrogen, phosphorus and potash. A good crop producing 6,720 kg/ha biomass removes about 514 kg nitrogen, 480 kg phosphorus and 485 kg potash /ha. Its full nitrogen requirement often is not met by symbiosis only, depends upon the ability of soybean plant for nitrogen fixation about 240-250 kg /ha with rhizobia, but it also gets reduced at seed development stage when requirement of nitrogen is maximum. N, P and K fertilization of soybean during pod filling increased the yield upto 27 to 31% . At higher rate of nitrogen, more protein has been synthesized and lipid metabolism favored. Organic manures are known to improve physical, chemical and biological properties of soil. Because of their low nutrient content and slow acting nature, organic manures along could not meet out the nutritional requirement of crops; therefore, chemical fertilizers also have their own importance. Farm yard manure is most widely used organic source of plant nutrients and plays important role in improving soil fertility and productivity. Another organic source of plant nutrients is vermicompost being widely used now days. There is a great scope to increase soybean production utilizing judicious combinations of organic and inorganic fertilizers. Considering the above, the present investigation was undertaken to study the effect of various organic sources of nutrients on the growth and yield of soybean.

Materials and Methods

The field experiment was conducted at NE Borlaug Crop Research Center of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, to study the effect of organic and inorganic sources of nutrients on soybean var PS 1347 during rainy season *(kharif)* of 2006 and 2007. The experimental soil was well drained silty clay loam with pH 7.4, high in organic carbon (0.86%), medium in available phosphorus (19.19 kg/ha) and low in available potassium (130.71 kg/ha) and nitrogen (240.17 kg/ha) content . There were ten treatments viz., NPK 100% , FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1}, FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10%, FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + NPK 50%, FYM @ 5 t ha^{-1} + VW @ 10% + 50% NPK, VC @ 2.5 t ha^{-1} + VW@ 10% + 50% NPK, FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10%+ 50% NPK, FYM @ @ 10 t ha^{-1} + 50% NPK, VC @ 2.5 t ha^{-1} + 50% NPK and VW @ 10% + 50% NPK, replicated thrice in randomized block design (RBD). Basal N, P_2O_5 and K_2O (20:60:40) were applied through urea, single super phosphate and murate of potash. FYM and vermicompost were applied at the time of sowing and two sprays of vermiwash were given at 30 and 45 DAS. The farm yard manure (FYM), vermi compost (VC) and vermiwash (VW) were obtained from the instruction diary farm of Pantnagar, University. FYM, VC and VW contained 0.67%, 1.55% and 17.73 ppm N, 0.27%, 0.42% and 17.73 ppm P, and 0.98%, 1.87% and 55.3 ppm K respectively. FYM and vermicompost were applied at sowing time and two sprays of vermiwash were done at 30 and 40 DAS. For recording observations on nodulation and growth parameters, five plants were randomly selected from each plot. Nodules were carefully detached from the washed roots and counted, nodules of each replication after counting were dried in open glass petri dishes at 65 ± 2^0C for 48 hours in an oven till constant weight and plant dry weight was also recorded in the same manner. After threshing and proper cleaning the grain yield of individual plot was recorded and converted into kg/ha.

Results and Discussion

The enhancement in nodule number of soybean plant as obtained by the application of FYM, vermiwash and vermicompost over 100% NPK in both the years as indicated in the results, might be due to increase in *bradyrhizobial* survival and activity in soil, because of more available nutrients and carbon. Application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} numerically increased nodule number and their dry weight than 100% NPK at 60 DAS in the both years. It might be due to the improvement in the physical condition of soil and more availability of nutrients to plant. Similarly, Bajracharya et al. [1] reported that the application of vermicompost @ 2.5 t ha^{-1} and FYM @ 5 t ha^{-1} gave highest nodule number per plant compared to the *B. japonicum* inoculation and *B. japonicum* +

Table 1. Effect of FYM, vermicompost, vermiwash and NPK on soil microbial biomass C (µg g^{-1} soil) and protein content at 50% flowering.

	At 60 DAS									
	Nodule (No/plant)		Nudule dry weight (mg/plant)		Shoot dry weight (g/ plant)		Microbial biomass C (µg g^{-1} soil) at 50% flowering stage		Microbial biomass C (µg g^{-1} soil) at harvesting stage	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
NPK 100%	25.00	36.60	182.00	282.00	25.20	30.33	255.56	256.32	245.59	262.90
FYM @ 5 t ha^{-1}+VC @ 2.5 t ha^{-1}	45.30	39.00	370.50	370.50	29.33	34.00	308.11	171.50	298.35	270.33
FYM @ 5 t ha^{-1}+VC@ 2.5 t ha^{-1} +VW @ 10%	38.66	40.66	383.33	316.66	27.00	41.00	303.56	282.90	297.59	266.70
FYM @ 5 t ha^{-1}+ VC@ 2.5 t ha^{-1} +NPK 50%	48.33	41.33	377.06	377.06	28.00	40.33	323.06	275.69	280.65	274.16
FYM @ 5 t ha^{-1}+VW@10%+50% NPK	41.66	41.00	292.08	294.08	27.00	42.33	305.65	261.52	296.65	266.16
VC @ 2.5 t ha^{-1}+VW @10%+50% NPK	40.00	40.33	322.00	316.91	26.66	41.33	280.65	273.04	270.26	267.46
FYM @ 5 t ha^{-1}+VC@ 2.5 t ha^{-1} + VW @ 10%+50% NPK	39.30	49.30	269.60	319.60	30.33	43.33	308.26	292.01	302.50	277.63
FYM @ 10t ha^{-1}+50% NPK	49.00	53.00	384.00	388.55	29.00	36.33	305.40	272.27	298.27	268.60
VC @ 2.5 t ha^{-1}+ 50% NPK	48.60	40.30	372.20	372.20	27.53	36.66	283.59	273.59	275.13	265.90
VW @ 10%+50% NPK	41.00	49.00	342.00	342.00	25.83	38.66	291.44	265.29	282.11	264.63
SEm (±)	2.68	2.24	9.06	20.72	3.28	2.47	7.54	7.93	2.61	5.33
CD (p = 0.05)	7.73	6.49	26.59	59.86	NS	7.13	22.95	NS	7.63	NS
CV	12.10	9.41	5.35	10.79	15.05	11.69	4.70	5.03	1.62	3.45

vermicompost @ 5 t ha^{-1}. In 2006 and 2007 the maximum nodule number (49.00 and 53.00) per plant and their dry weight (384.00 and 388.55) gram per plant were found with the application of treatment FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10% + 50% NPK, this treatment also significantly increased nodule number per plant at DAS in both the years over FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1}, VC @ 2.5 t ha^{-1} + VW @ 10%, VW @ 10%+ 50% NPK, VC @ 2.5 t ha^{-1} + VW @ 10% + 50% NPK, it may be due to the improvement in the soil porosity and more availability of nutrients to the plant. These findings were in agreement with Matho and Yadav [2] who also reported that application of vermicompost (25q ha^{-1} equivalence) and DAP (100 kg ha^{-1} equivalence) + foliar spray of vermiwash (10%) at 30 DAS increased nodule number per plant in vegetable pea by 23.6% over control. The application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + 50% NPK numerically increased nodule number per plant in both years over FYM@ 5 t ha^{-1} + VC @ 2.5 t ha^{-1}. Similar findings were reported by Singh and Rai [3] who found that the combined application of NPK + FYM + VC recorded the highest number of nodules per plant (38.45 and 37.89 nodules $plant^{-1}$) of soybean during 2000-01. Application of 100% RDF (NPK) did not differ significantly with other treatment for nodule number and nodule dry weight per plant (Table 1) in both the years. All the treatments significantly increased nodule number per plant over application of 100% NPK in first year. In the year of 2007, the application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} +50% NPK, FYM @ 10 t ha^{-1} + 50% NPK and VW @ 10% + 50% NPK produced significantly more number of nodule by 34.69, 44.8% and 33.88% than application 100% NPK. Application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} numerically increased plant dry weight per plant over 100% NPK, FYM @ 5 t ha^{-1} and VC @ 2.5 t ha^{-1} at all growth stages of plant in both years in 2006. In both the years maximum plant dry weight (30.33 and 43.33g $plant^{-1}$) at 60 DAS was found with the application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10% + 50% NPK, it might be due to the improvement in the soil porosity and more availability of nutrients to the plant. These findings corroborate with Khutate et al. [4] who observed that the application of 75% NPK + 25% vermicompost (5.76 q ha^{-1}) or FYM (50%) recorded

Table 2. Effect of different composts and NPK on biological, grain and straw yield of soybean.

Treatments	BY (kg ha^{-1})		GY (kg ha^{-1})		SY (kg ha^{-1})		100-seed weight (g)	
	2006	2007	2006	2007	2006	2007	2006	2007
NPK 100%	6913.5	7080.2	2716.0	2213.0	4197.5	4867.1	9.96	10.60
FYM @ 5 t ha^{-1}+VC @ 2.5 t ha^{-1}	6728.3	6898.3	2870.3	2810.6	3734.5	4087.7	10.45	10.70
FYM @ 5 t ha^{-1}+VC @ 2.5 t ha^{-1} + VW @ 10%	6543.2	6643.2	2832.0	3127.3	3611.1	3515.8	10.17	11.50
FYM @ 5 t ha^{-1}+VC @ 2.5 t ha^{-1} + NPK 50%	6728.3	6728.3	3024.6	2931.2	3703.7	3797.1	10.50	10.50
FYM @ 5 t ha^{-1}+VW @ 10% +50% NPK	6851.8	7018.5	2637.0	2912.1	3981.4	4106.3	10.40	11.06
VC @ 2.5 t ha^{-1}+VW @ 10%+50% NPK	6975.3	7175.3	3024.6	2748.1	3950.6	4427.1	10.32	10.90
FYM @ 5 t ha^{-1}+VC @ 2.5 t ha^{-1}+ VW @ 10% + 50% NPK	7123.4	7190.1	3209.8	3230.8	3913.5	3959.2	10.58	11.60
FYM @ 10 t ha^{-1} + 50% NPK	6388.8	6588.8	2746.9	2815.1	3364.2	3773.7	10.26	10.20
VC @ 2.5 t ha^{-1} + 50% NPK	6728.3	6895.0	2962.9	2859.2	3765.4	4035.7	10.11	10.30
VW @ 10% + 50% NPK	6161.9	6295.2	2685.1	2858.4	3487.6	3436.8	10.13	11.30
SEm (±)	279.6	294.3	167.2	165.9	281.7	453.4	0.29	0.86
CD (p =0.05)	NS	NS	NS	486.30	NS	NS	NS	NS
CV	7.40	7.58	9.94	10.33	13.10	14.77	4.80	14.43

the highest plant dry weight plant^{-1} over control.

The soil microbial biomass C was higher at 50% flowering stage in comparison to harvesting stage due to application of FYM and vermicompost along with NPK. It might be due to improvement in physico-chemical properties of soil with application of FYM and vermicompost along with NPK, which produced favorable atmosphere for building up of microbial population in soil. Secondly, at 50% flowering stage maximum metabolic and physiologic activity in plant takes place, which increases release of root exudates and thereby microbial population. The maximum microbial biomass C (μg g^{-1} soil) at both stages was recorded with the application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10% + 50% NPK in the both years except at 50% flowering in 2006, it might be possibly due to the improvement in the soil physical properties like soil structure, soil aeration, porosity and more availability of nutrients concentration in soil to the plant. Similarly,. Matho and Yadav [2] have reported that application of enriched compost significantly increased soil microbial biomass C in soil. Recommended NPK dose also increased soil microbial biomass carbon in soil due to increased in availability of N and P to soil microorganism for their growth.

Yield and yield attributes

The application of FYM, vermicompost, vermiwash numerically increased grain yield of soybean in the both years over 100% NPK (Table 2). It might be due to the improvement in soil physical conditions, increased biological activity of the soil and enrichment in soil health. Application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + 50% NPK numerically increased grain yield in both years over FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} and FYM @ 5 t ha^{-1} + VW @ 10% + 50% NPK. This may be due to the improvement in physical and biological properties of soil. The maximum grain and biological yield of soybean were recorded with treatment having FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10% + 50% NPK in both years. It is possibly due to the improvement in physical and biological properties of soil and increase nutrient supply to crop. These findings were in corroboration with Thomas and Lal [5] who observed that application of farm compost + poultry manure or vermicompost in combination with inorganic fertilizers showed synergistic effect on the growth of the crop (soybean-mustered- cowpea) and showed increase in the yield attributes of crops. The numerical increase in straw yield was found in both the years by application of FYM, vermicompost, vermiwash over 100% NPK. This may be due to the

improvement in soil health. Similarly, Khutate et al. [4] observed that the application of 75% NPK + 25% vermicompost (5.76 q ha^{-1}) or FYM 50% (17.78 q ha^{-1}) increased seed yield (1795 kg ha^{-1}) and stover yield (2762 kg ha^{-1}) of soybean over control. In the present study maximum straw yield was observed with treatment FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10% + 50% NPK in both years. This may be due to the enrichment of soil due to addition of composts. Application of the FYM, vermicompost, vermiwash and recommended dose of NPK numerically increased 100-seed weight of soybean in the both years. It might be due to the improvement in soil physical conditions, increased biological activity of the soil and enrichment of nutrients in soil. The maximum 100-seed weight was obtained with treatment having FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + VW @ 10% + 50% NPK in both years. Therefore, the productivity of soybean can be increased with the integrated use of organic and inorganic nutrient sources.

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