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CONJUNCTIVE ORGANIC AND MINERAL FERTILIZATION- ITS ROLE IN NUTRIENT UPTAKE AND YIELD OF SOYBEAN UNDER MOLLISOL

MAHENDRA SINGH*, KASTURIKASEN BEURA[1], AMIT KUMAR PRADHAN[1] AND NARENDRA KUMAR[2]
*[1]Department of Soil Science and Agricultural Chemistry,
BAU, Sabour, Bhagalpur- 813 210, Bihar (INDIA)
[2]Department of Soil Science, GBPUAT, Pantnagar - 263 145, Uttarakhand (INDIA)
e-mail: mahendra_saini_soil@yahoo.co.in

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***Corresponding author**

ABSTRACT

A field experiment was conducted during *Kharif* 2006-07 and 2007-08 to demonstrate the effect of combined application of organic and mineral fertilizer on the available nutrient status of soil, its translocation in plant and on the subsequent yield of soybean. Ten integrated management modules were evaluated under Mollisols of Tarai region in Randomized block design. The maximum N and P concentration in plants at harvest (8.46 and 7.69% N for 2006 and 2007 respectively and 0.95 and 0.66% P for 2006 and 2007 respectively) was recorded with the treatment FYM @ 5 t ha^{-1} + Vermicompost (VC) @ 2.5 t ha^{-1} + Vermiwash (VW) @ 10% + 50% NPK. The same treatment maintained a higher available content of N (285.03 kg ha^{-1} for 2007 and 291.80 kg ha^{-1} for 2008) which was significantly higher than the control (*i.e.* 100% NPK). The maximum grain yields (3209.87 and 3230.88 kg ha^{-1} in 2006-07 and 2007-08 respectively) was also recorded by the combined application of FYM @ 5 tha^{-1} +VC @ 2.5tha^{-1} +VW@ 10% + 50%NPK. Thus it was observed that the treatment consisting of both organic and inorganic nutrient sources performed best among all the treatments used in the experiment.

INTRODUCTION

Soybean (*Glycine max* L. merril) is known to be one of the most important oil seed crops throughout the world for its high and well balanced protein (42-45%) and edible oil (20-22%) content having higher biological value, unsaturated fatty acids *viz.* linoleic fatty acid (19.4%), amino acids, argentine, aspartic acids, glutamic acid, glycine, isolucine, lucine and valine *etc.* (Smith and Circle, 1972). Soybean production in India is 7.8 million tonnes covering an area of 5.9 m ha (Anonymous, 2008). Since Soybean is a nutrient exhaustive crop, the continuous use of NPK fertilizers under intensive cropping system has adverse effects on soil properties such as soil structure, density, pH, quantity and quality of organic matter, nutrient cycling within the soil profile (Senwo et al., 1998) thereby affecting the sustainability of crop production, besides causing environmental pollution (Virmani, 1994). Farmers are facing a lot of problem as far as availability of chemical fertilizers for soybean production is concerned (Meena and Ghasolia, 2013). At the same time scarcity of mineral fertilizer and depletion of soil biological quality is becoming a prominent problem. Integrated nutrient management has the potential to solve the problem to a greater extent. There is great scope to increase soybean production by adopting balanced fertilization and conjunctive application of both organic and inorganic fertilizer sources (Sangeeta *et al.,* 2014). The present study was carried out with the hypothesis that among the factors responsible for low productivity in soybean, inadequate fertilizer use and emergence of multiple nutrient deficiencies due to poor recycling of organic resources and unbalanced use of fertilizers are the most important (Chaturvedi *et al.,* 2010). There is great scope to increase soybean production by adopting balanced fertilization by conjunctive application of both organic and inorganic fertilizer sources (Singh *et al.,* 2006). With this backdrop, the present investigation was undertaken to study the effect of combined application of mineral and organic fertilizers on soil fertility, nutrient uptake and yield of soybean.

MATERIAL AND METHODS

Experimental site

The experiment was set up at E–2 block of the Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand during *kharif* seasons of 2006-07 and 2007-08. The experimental soil was well drained silty clay loam in texture with pH of 7.4, high organic carbon content (0.86%), medium available phosphorus (19.19 kg ha^{-1}) , low available potassium (130.71 kg ha^{-1}) and slightly low nitrogen contents (240.17 kg ha^{-1}).

The experiment was laid out taking Soybean (*Glycine max* l. merril) var. PS 1347 crop in a randomized block design with the following ten treatments having three replications each:

Basal nitrogen (N), phosphorus (P) and potassium (K) at the ratio of 20: 60: 40 were applied through urea, graded dose of SSP and Muriate of potash. The FYM, VC and VW were obtained from the Instructional Diary Farm of Pantnagar University, and were analyzed for their nutrient content. FYM, VC and VW were found to contain 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 the time of sowing and two sprays of vermiwash were given at 30 and 40 DAS.

Soil and plant analysis

Mineralizable nitrogen was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus was extracted from the soil with 0.5M $NaHCO_3$ (pH 8.5) as described by (Olsen *et al.,* l954) and for determination of available potassium the soil was equilibrated with 1N neutral ammonium acetate (Hanway and Heidel, 1952). Nitrogen and phosphorus content in plants were analyzed by modified Kjeldhal and vanadomolybdo phosphoric yellow colour method in nitric acid system respectively (Jackson 1973). After threshing and proper cleaning, the straw and grain yield of individual plot was recorded with single pan balance and are expressed in kg per hectare.

RESULTS AND DISCUSSION

Available N, P and K in soil at harvest

The available N, P, K content in soil increased with application of the T7 treatment (*i.e.* FYM @ 5 tha-1 +VC @ 2.5tha-1 +VW@ 10% + 50%NPK) for both the years (Table II). It is an established fact that the nutrient status of soil increases by addition of organic matter. The higher value of available N (285.03 kg ha^{-1}-in 2006-07 and 291.80 kg ha^{-1} in 2007-08) in T7 than the control might be due to nitrogen fixation by soybean crop. Raut and Ghonshikar (1971) also observed increase in nodulation and N content in soil due to *Rhizobium* inoculation. The higher available phosphorus (24.03 kg ha^{-1} in 2006 and 25.30 kg ha^{-1} in 2007) with the same treatment (*i.e.* T7) may be due to the enhanced action of phosphate solubilizing bacteria (PSB) which increases the availability of P in the soil. Exchangeable K content was also found to be the highest (*i.e.* 133.70 kg ha^{-1} in 2006-07 and 134.16 kg ha^{-1}in 2007-08) in soils receiving the T7 treatment. The application of FYM @ 5 t ha^{-1} + VW @ 10% + 50% NPK increased available N, P and K content in soil in both years over 100% NPK and FYM @ 5 t ha^{-1} + VW @ 10%. This shows that addition of NPK boosted the nutrient content in soil. These findings corroborate with results of Prakash (2001) who, reported that application of NPK + FYM + VC + VW significantly increased organic carbon (%), available N, and available P (kg ha^{-1}) in comparison to control. Similar results were reported by Singh *et al.* (2004), Sharma and Verma (2011) and Kumar *et al.* (2014) in paddy.

Nitrogen content in straw and grain

The effect of various integrated nutrient management practices on nitrogen content in soybean grain and straw has been presented in Table III. The maximum nitrogen content in straw (1.99%) was recorded in case of the T7 treatment during 2007 which is 1.69 times more than the control treatment. The same trend was also found in case of grain yield. The application of FYM, vermiwash and vermicompost alone or in combination numerically increased N content in soybean grain over the recommended dose of NPK.

The increase in N content in grains and straw might be due to the addition of organic matter and application of recommended dose of NPK which led to the formation of more nodules by rhizobia which in turn fixed more nitrogen in plant. The results were in agreement with Kumar (2002) and Bhavana *et al.* (2014) who found that application of enriched compost increased N content in plants. Similarly, Abraham and Lal (2003) reported that the content of total N in plant increased due to the application of FYM + vermicompost + RD (NPK) *i.e.* 33% over control. The possible reason of increase in nitrogen content was the increment in the availability of nutrients in soil. Similarly, (Bhriguvanshi 1988) also reported that application of inorganic fertilizers along with enriched compost increased nitrogen content in grain. Another reason of enhanced N concentration in grain might be due to high concentration of N in vermicompost and vermiwash and its subsequent release on decomposition (Kapur and Kanwar (1989).

Phosphorus content in straw and grain

The phosphorus content in soybean grain and straw has been influenced considerably by fertilizer and organic manure application during both the years. The incorporation of organics gave significantly higher P content in grain and straw over control. The treatment T7 accumulated significantly higher phosphorus concentration in plants (0.95%) in 2006-07 over all the other treatments and was at par with the T2 treatment. Similar findings were documented by (Bhavana 2014), (Verma and Rawat, 1999) who reported that application of enriched compost along with fertilizer increased the P content in plant. The phosphorus content in grain of soybean was numerically increased in both the years with application of recommended NPK and FYM, vermicompost and vermiwash. The increase in P content in plants might be due to increase in available P through the fertilizers and addition of different composts also increases the microbial population in soil which in turn increase the available P in soil by producing organic acids.

Protein content in grain

The treatments did not have any significant effect on seed protein which ranged from 35.44 to 43.63 and 35.56 to 38.81

Table I: Treatment structure

T1	:	100% NPK (Control)
T2	:	Farmyard Manure (FYM) @ 5 t ha^{-1} + Vermicompost (VC) @ 2.5 t ha^{-1}
T3	:	FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Vermiwash (VW) @ 10 %
T4	:	FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + 50% NPK
T5	:	FYM @ 5 t ha^{-1} +VW@10%+50% NPK
T6	:	VC @ 2.5 t ha^{-1} + VW@10% + 50%NPK
T7	:	FYM @ 5 tha^{-1} +VC @ 2.5tha^{-1} +VW@ 10% + 50%NPK
T8	:	FYM @ 10 t ha^{-1} + 50%NPK
T9	:	VC @ 2.5tha^{-1} + 50%NPK
T10	:	VW @10% + 50%NPK

Table II: Effect of treatments on nutrient availability in soil

Treatment	Available NPK (kg ha^{-1})					
	N	P	K			
	2006	2007	2006	2007	2006	2007
T1	252.36	260.50	19.40	20.06	115.66	121.86
T2	274.23	276.93	21.33	22.40	122.53	121.76
T3	275.70	262.86	21.33	21.46	128.20	127.83
T4	272.33	265.66	21.23	21.90	119.50	122.13
T5	276.16	284.50	20.93	21.23	122.76	124.36
T6	265.70	267.00	20.60	20.93	125.73	126.10
T7	285.03	291.80	24.03	25.30	133.70	134.16
T8	272.20	279.86	20.20	21.63	118.20	122.93
T9	274.63	276.96	22.16	23.26	119.76	123.83
T10	265.73	275.06	21.66	22.43	119.53	121.26
SEm (±)	5.41	6.89	2.71	1.82	3.99	4.60
CD (P=0.05)	15.62	20.99	NS	NS	NS	NS
CV	3.46	4.58	14.14	13.78	16.61	6.06

Table III: Effect of treatments on nutrient content in plant parts and protein content in grain

Treatment	N in straw(%)		P in straw(%)		N in grain(%)		P in grain(%)		Protein content (%)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T1	1.20	1.18	0.22	0.25	5.67	5.69	0.35	0.34	35.44	35.56
T2	1.47	1.50	0.46	0.26	6.24	5.93	0.39	0.39	39.00	37.06
T3	1.27	1.50	0.38	0.31	6.30	6.01	0.40	0.42	39.38	37.56
T4	1.28	1.50	0.38	0.36	5.83	5.86	0.40	0.39	36.44	36.63
T5	1.16	1.48	0.32	0.32	5.68	6.21	0.45	0.41	35.50	38.81
T6	1.13	1.68	0.33	0.26	6.17	5.82	0.43	0.40	38.56	36.38
T7	1.48	1.99	0.46	0.25	6.98	5.70	0.49	0.41	43.63	35.63
T8	1.31	1.56	0.31	0.34	6.31	5.71	0.41	0.36	39.44	35.69
T9	1.35	1.58	0.30	0.31	6.34	5.75	0.42	0.40	39.63	35.94
T10	1.32	1.62	0.33	0.30	6.08	6.07	0.41	0.39	38.00	37.94
SEm (±)	0.07	0.14	0.02	0.03	0.64	0.26	0.02	0.02		
CD (P = 0.05)	0.18	NS	0.06	NS	NS	NS	0.05	NS	NS	NS
CV	8.55	15.18	10.51	16.28	20.07	7.52	8.5	9.4		

Table IV: Effect of different treatments on nutrient uptake and yield of soybean

Treatment	Uptake of N and P (kg ha^{-1})				Grain yield(kg ha^{-1})	
	N	P				
	2006	2007	2006	2007	2006	2007
T1	81.40	84.05	15.45	17.93	2716.0	2213.0
T2	98.94	102.97	31.18	18.12	2870.3	2810.6
T3	87.16	101.11	25.61	20.41	2832.0	3127.3
T4	82.46	101.73	25.94	24.33	3024.6	2931.2
T5	82.62	104.56	19.61	22.43	2637.0	2912.1
T6	90.88	121.04	20.71	18.52	3024.6	2748.1
T7	105.59	143.07	32.70	24.73	3209.8	3230.8
T8	84.46	105.58	19.92	20.35	2746.9	2815.1
T9	90.79	109.44	19.65	21.73	2962.9	2859.2
T10	81.59	101.63	20.45	18.90	2685.1	2858.4
SE_m (±)	10.87	12.03	1.62	1.98	167.2	165.9
CD (P = 0.05)	NS	NS	4.52	NS	NS	486.30
CV	11.45	19.62	11.89	16.01	9.94	10.33

per cent, in 2006-07 and 2007-08 respectively (Table III). The T7 treatment showed the highest grain protein of 43.63 and 38.81 per cent in 2006-07 and 2007-08 respectively. This was possibly due to translocation of more nitrogen to seed for protein formation.

Nitrogen and Phosphorus uptake by plant

It is obvious from the data that the maximum N and P uptake in both the years was recorded with the T7 treatment which showed plant N uptake of 105.59 and 143.07 kg ha^{-1} in 2006-07 and 2007-08 respectively and P uptake of 32.70 and 24.73 kg ha^{-1} in 2006-07 and 2007-08 respectively (Table IV) which was higher than all the treatments under consideration. The nitrogen uptake by soybean grains, straw as well as total nitrogen uptake increased with the application of N fertilizer alone or in combination with FYM or vermicompost or vermiwsash over control. This is due to improvement in physico-chemical properties of soil along with increased mineralization of nutrients which resulted in more nutrients uptake (Tiwari and Nema, 1999). Addition of various organic sources in combination with inorganic fertilizer increased phosphorus uptake by the crop might be because of enhanced available phosphorus content of soil as well as improved soil physical conditions rendering native phosphorus available. Similar result were obtained by (Maheswari *et al.,* 2003) who reported that the application of vermiwash at 1:5 dilutions with VC @ 5 t ha^{-1} gave higher N and P uptake (136.0 and 7.74 kg ha^{-1}) in soybean over VC @ 10 t ha^{-1}. These results are in agreement with Sharma and Mishra (1997) who conducted a field experiment on black clay soil, soybean cv. JS 71-05 were given 0-40 kg N ha^{-1}, 6 t FYM ha^{-1}, 5 t VC and 10% VW increased nitrogen and phosphorous uptake by soybean plant over control.

Yield of soybean

The effect of various integrated nutrient management practices on the grain yield of soybean showed wide variations among the treatments compared. Inorganic fertilizers in combination with organic sources increased the grain yield of Soybean significantly over the control. The T7 treatment significantly increased grain yield (3209.8 kg ha^{-1} in 2006-07 and 3230.8 kg ha^{-1} in 2007-08) over the control. It is due to the improvement in soil physical conditions, increased biological activity of the soil and enrichment in the soil health. These findings corroborate with results of (Pattanashetti *et al.,* 2002) who reported that the application of organic manures (FYM + vermicompost + poultry manures) increased the grain yield of soybean over control. Similarly, (Tomar *et al.,* 2006) also reported that application of FYM @ 10 t ha^{-1} gave highest seed yield (ha^{-1}) of soybean over control. These findings were in accordance with Bhavana *et al.* (2014) and Bachhav and Sabale (1996) who recorded maximum grain yield of soybean in consecutive years with treatment having mineral and organic fertilizers. These results are in agreement with the research findings of Virkar *et al.* (2008) in soybean and Vadgave (2010) in green gram.

The data indicated that, combination of organic and mineral fertilizers resulted in maximum straw and grain yield, nutrient content and uptake and also enhanced the soil nutrient status. It may thus be concluded that the treatment consisting of both organic and inorganic nutrient sources *i.e.* FYM @ 5 tha^{-1} +VC @ 2.5tha^{-1} +VW@ 10% + 50%NPK was the best among all the treatments used for the experiment.

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REFERENCES

Anonymous 2008. Directors Report and Summary Tables of Experiment. *National Research Centre for Soybean*. ICAR 3.

Bachhav, P. R. and Sabale, R. N. 1996. Effect of different sources of nitrogen on growth parameters, yield and quality of soybean. *J Maharastra Agric. University*. **21(2):** 244-247.

Bhavana, G., Gabhane, V. V., Nagdeve, M. B., Sonune, B. A. and Ganvir, M. M. 2014. Effect of integrated nutrient management on soil fertility, nutrient balance, productivity and economics of soybean in an Inceptisol of semi arid region of Maharashtra. *Karnataka J. Agric. Sci.* **27(3):** 303-307.

Bhriguvanshi, S. R. 1988. Enrichment of organic manure and their effect on yield and nutrient uptake by wheat. *J. Indian Soc. Soil Sci.* **36**: 510-514.

Chaturvedi, S., Chandel, A. S., Dhyani, A. S. and Singh, A. P. 2010. Productivity, profitability and quality of soybean (residual soil fertility as influenced by integrated nutrient management. *Indian J. Agron.* **55(2):** 133-137.

Hanway, J. J. and Heidel, H. 1952. Soil analysis methods as used in Iowa State College Soil Testing Laboratory. *Iowa. Agric.* **57:** 1-31.

Jackson, M. L. 1973. Soil chemical analysis book published. *By prentice Hall of India Pvt. Ltd., New Delhi.* pp. 389-392.

Kapur, K. K. and Kanwar, R. P. 1989. Direct and residual effect of urban compost, FYM, vermicompost and fertilizer doses on properties of Vertisols. *J. Sustain. Agric.* **48(2):** 332-338.

Kumar, R. D. 2002. Effect of chemically enriched compost on rapeseed and population of some beneficial soil microorganism *M. Sc. Ag. Thesis. GBPUA&T, Pantnagar, U. S. Nagar.*

Kumar, A., Meena, R. N., Lalji, Y. and Gilotia, Y. K. 2014. Effect of organic and inorganic sources of nutrient on yield, yield attributes and nutrient uptake of rice cv. PRH-10. *The Bioscan*. **9(2):** 595-597.

Maheswari, T. U., Haripriya, K. and Kamalakannan, S. 2003. Impact of foliar organic nutrients on nutrient uptake pattern of chilli (*Capsicum annum L.*). *South Indian Horti.* **51(1/6):** 168-172.

Meena, S. and Ghasolia, R. P. 2013. Effect of phosphate solubilizers and FYM on microbial population of soybean field [Glycine Max (L.) Merrill]. *The Bioscan*. **8(3):** 965-968.

Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A. 1954. Estimation of valuable phosphorus in soil by extraction with sodium bicarbonate. *USDA Circular No. 939, Washington.*

Pattanashetti, V. A., Agasimani, C. A. and Babalad, H. B. 2002. Effect of manures and fertilizers on yield of maize and soybean under intercropping system. *J. Maharastra Agric. University*. **27(2):** 206-207.

Prakash, V., Ghosh, B. N. and Singh, R. D. 2001. Long-term effects of organic and inorganic fertilization on nodulation, micro-flora and soil properties in soybean-wheat cropping sequence under rainfed Inceptisol of north-west Himalayas. *Ann. Agric. Res. New Series* **22(2):** 287-289.

Raut, S. P. and Ghonshikar, C. P. 1971. Effect of seed inoculation with *Rhizobium japonicum* on nodulation and grain yield of soybean. *Soybean Abstr.* **64(2):** 834-835.

Reddy, B. G. and Reddy, M. S. 1999. Available macronutrients status in soil as influenced by integrated management in maize-soybean cropping system. *J. Res. ANGRAU.* **27(4):** 55-62.

Sangeeta, S., Singh, V. K. and Kumar, R. 2014. Effect of integrated nutrient management on yield and quality of cauliflower (Brassica Oleracea var. Botrytis L.). *The Bioscan*. **9(3):** 1053-1058.

Senwo, Z. N. and Tatabai, 1998. Amino acid composition of soil organic matter. *Bio. Fert. Soil.* **26:** 235-342.

Sharma, R. A. and Mishra, O. R. 1997. Crop residues, FYM and fertilizer use in relation to growth, yield and nutrient uptake by soybean. *Crop Res Hissar.* **13(1):** 51-5.

Sharma R. and Verma 2011. Effect of rhizobium, Farm yard manure and chemical fertilizers on sustainable production and profitability of rajmash (Phaseolous vulgaris L.) and soil fertility in dry temperate region of north-western Himalayas. *Legume Res.* **34(4):** 251-258.

Singh, R. and Rai, R. K. 2004. Yield attributes, yield and quality of soybean (Glycine max) as influenced by integrated nutrient management. *Indian J. Agron.* **49(4):** 271-274.

Singh, R. K., Ghosh, P. K., Bandyopadhyay, K. K., Misra, A. K., Mandal, K. G. and Hati, K. M. 2006. Integrated plant nutrient supply for sustainable production in soybean - based cropping system. *Indian J. Fertil.* **1(11):** 25-32.

Singh, S. R., Nasar, G. R. and Singh, U. 2007. Productivity and nutrient uptake of soybean (*Glycine max.*) as influenced by bioinoculant and farm yard manure under rainfed condition. *Indian J. Agron.* **52(4):** 325-329.

Smith, A. K. and Circle, S. J. 1972. Soybean: Chemistry and Technology, V-1 (Proteins) pp. 93-143.

Subbiah, B. V. and Asija, C. L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.* **25:** 328.

Tiwari, R. J. and Nema, G. K. 1999. Response of sugarcane (*Saccharum officinarum*) to direct and residual effect of press-mud and nitrogen. *Indian J. Agric. Sci.* **69(9):**

Tomar, S. S., Jain, P. C. and Agrawal, R. L. 2006. Effect of nutrient management practices on yield and quality of soybean. *Crop Research India* **7(1):** 96-99.

Vadgave, S. 2010. Studies on integrated nutrient management on seed yield, quality and storability of greengram. *M. Sc. thesis, Univ. of Agric. Sci., Dharwad.*

Verma, L. N. and Rawat, A. K. 1999. Low grade rock phosphate a complimentary phosphorus source in soybean (*Glycine max*) and wheat (*Triticum aestivum*) cropping system. *Indian J. Agric. Sci.* **69(4):** 297-299.

Virkar, A. T. and Tumbare, A. D. 2008. Effect of integrated nutrient management on growth and yield of soybean-wheat cropping sequence. *J. Agric. Res. Technol.* **36(3):** 358-363.

Virmani, S. M. 1994. The twenty first-Dr.R.V.Tamhane memorial lecture: UNCEED Agenda 21: the new challenge for soil research. *J. Indian Soc. Soil Sci.* **49:** 521-523.