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Integrated effect of organic and inorganic sources of nutrients on vegetable soybean production (*Glycine max*)

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Abstract
A field experiment was conducted at Zonal Agricultural Research Station, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru to study the influence of integrated nutrient management on growth, yield and nutrient uptake of vegetable soybean. Application of 125% RDF (75% N through fertilizer + 25% through compost) + Triple microbial inoculations recorded significantly higher vegetable pod yield (95.30 q ha^{-1}), haulm yield (294.80 q ha^{-1}). The same treatment also recorded higher N, P and K uptake (178.54, 29.84 and 143.75 kg ha^{-1}, respectively) followed by 100% RDF (75% N through fertilizer + 25% through compost) + Triple microbial inoculations.

Keywords: vegetable soybean, yield, nutrient uptake

Introduction
Soybean being a high protein and energy crop and its productivity is often limited due to low availability of essential nutrients or imbalanced nutrition. Continuous use of chemical fertilizers alone leading to reduction in the crop yield and resulted in imbalance of nutrients in the soil, which has adverse effects on soil health. Use of organic alone does not result in spectacular crop yield due to their low nutrient status. Dependency on chemical fertilizers alone may not provide a viable economic option. Therefore, to maintain soil productivity on a sustainable basis, an integrated nutrient management approach, using both organic and inorganic sources should be adopted. Continuous use of organic helps to build soil humus and improves beneficial microbes in soil, besides improving the soil physical, chemical and biological properties. The chemical fertilizers provide one or more essential plant nutrients in adequate quantities without improving the soil properties. Thus, a judicious use of combination of chemical fertilizers, organics and biofertilizers helps to maintain soil productivity. At present package of practice for production of grain soybean has been recommended and there were no attempts made to quantify the nutrient demand for vegetable soybean cultivation which has greater production potential and having a calorific value in human diet. An appropriate combination of chemical fertilizers, organics and biofertilizers would not only meet the nutrient requirement for production of vegetable soybean to get higher productivity and returns at low cost but also improve soil health.

Material and Methods
A field experiment carried out at Zonal Agricultural Research Station, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru during *kharif* season on a red sandy clay loam soil with pH of 5.64, organic carbon 0.45 per cent. The soil was medium in available nitrogen, available P_2O_5 and available K_2O of 278.5, 38.49 and 175.08 kg ha^{-1}, respectively. The experiment was laid out in Randomized Complete Block Design with three replications and 12 treatment combinations.
Seeds of vegetable soybean (var. Karune) were sown on last week of July. The fertilizer was applied in the form of urea, Single Super Phosphate (SSP), Muriate of Potash (MOP) as per the treatments at the time of sowing. The farm yard manure was applied well before sowing as per treatments. Quantity of FYM to be added to each treatment was calculated on the basis of N content of FYM to substitute 25 and 50 per cent of N through FYM treatment wise. Bio-inoculants such as *Rhizobium japonicum*, PSB (*Bacillus megatherium* var. *phoshaticum*) and VAM at 1000 gm ha^{-1} seed treated as per the treatment combinations.

All other cultivation practices were followed as per the recommended package of practice by the University of Agricultural Sciences, Bengaluru.

Results and Discussion

Yield: Application of 125% RDF (75% N through fertilizer + 25% through compost) + TMI (T_{12}) recorded significantly higher vegetable pod yield (95.30 q ha^{-1}) and haulm yield (294.80) (Table 1). The higher vegetable pod yield could be attributed to integrated use of both inorganic, organic source of nutrients and biofertilizers as this could ascertain continuous supply of nutrients throughout the growth of crop from early stage to maturity. The results obtained are in conformity with the earlier findings of Chavhan *et al*. (2007) [4], Kumbhar *et al*. (2007) [6], Ranjan *et al*. (2008) [8]. In addition to this, triple inoculation of *Rhizobium*, PSB and VAM results in cumulative effects such as supply of N and P to the crop along with production of growth promoting substances like auxin, gibberlins and cytokinins. These results are in agreement with the findings of Nagaraju and Mohan kumar (2010) [7].

Quality attributes: Application of 125% RDF (75% N through fertilizer + 25% through compost) + TMI (T_{12}) (36.94) and protein yield (879.59) (Table 2). The higher protein content and protein yield in the present study could be due to the fact that nitrogen is the basic constituent of protein and with increase in rates of N application. These findings are in conformity with the findings of Sumit Chaturvedi and Chandel (2005) [10].

Nutrient uptake: Significantly higher uptake of N, P and K were registered with application of 125% RDF (75% N through fertilizer + 25% through compost) + TMI (T_{12}) (Table 3). Higher nitrogen uptake (178.54 kg ha^{-1}) was due to higher mineralization of nitrogen from applied organic and inorganic source. P increases root growth and its deficiency reduce overall plant growth. Higher phosphorus uptake (29.84 kg ha^{-1}) was due to higher P application through inorganic fertilizer and organic source (FYM), this has created surplus P in the soil. FYM application reduced the loss of nutrients through leaching and made available significant amount of plant nutrients, which created a balancing effect on supply of nitrogen, phosphorus and potassium (Bijay Singh *et al*. 1979) [3] Higher potassium uptake (143.75 kg ha^{-1}) also could be due to application of biofertilizers such as *Brady rhizobium japonicum* has enormous potential to fix atmospheric nitrogen while, PSB and VAM have capacity to solubilize and mobilize P and micronutrients present in non available form in the soil under soybean cultivation. The results of present investigation are in conformity with results of Tiwari (2007) [11], Singh *et al*. (2006) [9].

Available nutrients: The residual available nitrogen, phosphorus and potassium were significantly higher with application of 125% RDF (50% N through fertilizer + 50% through compost) + TMI (T_9) Addition of increased dose of RDF and FYM increased the available NPK content of soil. FYM application reduced the loss of nutrients through leaching and provided a significant amount of plant nutrients, which created a balancing effect on supply of nitrogen, phosphorus and potassium. Similar results were reported earlier by Babalad (2000) [1], Khatic and Dixshit (2001) [5], Tiwari *et al*. (2007) [11].

Microbial population: Microbial populations (Bacteria, fungi and actinimycetes) in soil differ significantly due to different integrated nutrient management practices. Significantly higher microbial population was registered with application of 125% RDF (50% N through fertilizer + 50% through compost) + Triple microbial inoculations (T_9) and it was on par with 125% RDF (75% N through fertilizer + 25% through compost) + Triple microbial inoculations (T_{12}) represented in Table 5. The organic manure and biofertilizers led to a significant increase in microbial population, because it creates favorable environment for better growth and development of soil organisms, mainly due to the increase in soil organic carbon status. The current finding concerning earlier response of soil microbial population to mixed treatment was also reported by Balakrishnan *et al.* 2007 [2].

Table 1: Vegetable pod yield (q ha^{-1}), haulm yield (q ha^{-1}) and harvest index of vegetable soybean as influenced by integrated nutrient management

Treatments	Vegetable pod yield (q ha^{-1})	Haulm Yield (q ha^{-1})	Harvest index
T_1: 100% RDF	82.73	254.47	0.33
T_2: 75% RDF	73.03	226.87	0.32
T_3: 125% RDF	83.67	264.27	0.32
T_4: T_1 + TMI	85.10	270.53	0.31
T_5: T_2 + TMI	78.68	244.33	0.32
T_6: T_3 + TMI	88.63	278.97	0.32
T_7: T_1 (50% N through fertilizer + 50% through compost) + TMI	80.21	255.77	0.31
T_8: T_2 (50% N through fertilizer + 50% through compost) + TMI	77.87	229.37	0.34
T_9: T_3 (50% N through fertilizer + 50% through compost) + TMI	81.83	258.83	0.32
T_{10}: T_1 (75% N through fertilizer + 25% through compost) + TMI	90.98	281.57	0.32
T_{11}: T_2 (75% N through fertilizer + 25% through compost) + TMI	79.20	247.80	0.32
T_{12}: T_3 (75% N through fertilizer + 25% through compost) + TMI	95.30	294.80	0.32
S. Em. ±	2.77	7.67	0.01
C. D. at 5%	8.34	23.08	NS

Note: DAS = Days after sowing, NS = Non-significant
RDF= Recommended dose of fertilizer (30:80:37.5 kg ha^{-1})
TMI= Triple microbial inoculations (*Rhizobium* + PSB + VAM)

Table 2: Total plant N, P, K and protein content and protein yield of vegetable soybean as influenced by integrated nutrient management

Treatments	N (%)	P (%)	K (%)	Protein content (%)	Protein yield (kg ha^{-1})
T_1: 100% RDF	5.97	0.78	4.14	33.19	686.97
T_2: 75% RDF	5.81	0.75	3.94	32.52	594.56
T_3: 125% RDF	6.22	0.81	4.24	34.27	716.67
T_4: T_1 + TMI	6.24	0.83	4.27	34.25	728.52
T_5: T_2 + TMI	6.15	0.80	4.11	34.15	672.36
T_6: T_3 + TMI	6.46	0.90	4.66	35.56	786.60
T_7: T_1 (50% N through fertilizer + 50% through compost) + TMI	6.28	0.83	4.54	34.67	694.31
T_8: T_2 (50% N through fertilizer + 50% through compost) + TMI	6.20	0.79	4.45	34.25	666.80
T_9: T_3 (50% N through fertilizer + 50% through compost) + TMI	6.51	0.89	4.75	36.00	738.05
T_{10}: T_1 (75% N through fertilizer + 25% through compost) + TMI	6.64	0.95	4.95	36.42	827.61
T_{11}: T_2 (75% N through fertilizer + 25% through compost) + TMI	6.22	0.83	4.55	34.33	680.15
T_{12}: T_3 (75% N through fertilizer + 25% through compost) + TMI	6.77	1.00	5.16	36.94	879.59
S. Em. ±	0.14	0.03	0.12	0.85	26.95
C. D. at 5%	0.41	0.10	0.36	2.54	80.91

Note: DAS = Days after sowing
RDF= Recommended dose of fertilizer (30:80:37.5 kg ha^{-1})
TMI= Triple microbial inoculations (*Rhizobium* + PSB + VAM)

Table 3: Uptake and availability of major nutrients (kg ha^{-1}) of vegetable soybean as influenced by integrated nutrient management

Treatments	Nutrient uptake (kg ha^{-1})			Available nutrients (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
T_1: 100% RDF	135.33	19.52	95.62	266.17	42.10	163.96
T_2: 75% RDF	115.61	16.73	80.13	261.43	38.36	160.05
T_3: 125% RDF	143.85	20.79	100.42	269.80	42.51	170.07
T_4: T_1 + TMI	147.26	21.81	103.50	278.43	45.60	172.09
T_5: T_2 + TMI	132.79	19.35	90.76	273.80	41.83	169.89
T_6: T_3 + TMI	158.22	24.69	119.39	282.13	44.67	176.26
T_7: T_1 (50% N through fertilizer + 50% through compost) + TMI	139.38	20.70	107.46	287.93	51.10	180.14
T_8: T_2 (50% N through fertilizer + 50% through compost) + TMI	131.43	18.54	99.23	283.93	45.59	176.19
T_9: T_3 (50% N through fertilizer + 50% through compost) + TMI	147.32	23.00	114.40	294.63	56.76	189.40
T_{10}: T_1 (75% N through fertilizer + 25% through compost) + TMI	166.63	26.93	131.02	284.07	41.42	174.84
T_{11}: T_2 (75% N through fertilizer + 25% through compost) + TMI	135.78	20.65	105.15	281.03	46.16	173.65
T_{12}: T_3 (75% N through fertilizer + 25% through compost) + TMI	178.54	29.84	143.75	286.27	47.32	183.59
S. Em. ±	4.71	1.02	3.90	4.97	2.55	4.19
C. D. at 5%	14.11	3.06	11.73	14.92	7.66	12.58

Note: DAS = Days after sowing
RDF= Recommended dose of fertilizer (30:80:37.5 kg ha^{-1})
TMI= Triple microbial inoculations (*Rhizobium* + PSB + VAM)

Table 4: Soil pH, electrical conductivity (dSm^{-1}) and Organic carbon (%) as influenced by integrated nutrient management in vegetable soybean

Treatments	pH	Electrical conductivity (dSm^{-1})	Organic carbon (%)
T_1: 100% RDF	5.55	0.16	0.38
T_2: 75% RDF	5.63	0.15	0.41
T_3: 125% RDF	5.64	0.15	0.42
T_4: T_1 + TMI	5.70	0.14	0.41
T_5: T_2 + TMI	5.65	0.13	0.44
T_6: T_3 + TMI	5.70	0.16	0.43
T_7: T_1 (50% N through fertilizer + 50% through compost) + TMI	5.74	0.13	0.48
T_8: T_2 (50% N through fertilizer + 50% through compost) + TMI	5.66	0.14	0.46
T_9: T_3 (50% N through fertilizer + 50% through compost) + TMI	5.67	0.12	0.52
T_{10}: T_1 (75% N through fertilizer + 25% through compost) + TMI	5.68	0.14	0.46
T_{11}: T_2 (75% N through fertilizer + 25% through compost) + TMI	5.69	0.14	0.46
T_{12}: T_3 (75% N through fertilizer + 25% through compost) + TMI	5.73	0.14	0.47
S. Em. ±	0.55	0.01	0.03
C. D. at 5%	NS	NS	NS

Note: DAS = Days after sowing
RDF= Recommended dose of fertilizer (30:80:37.5 kg ha^{-1})
TMI= Triple microbial inoculations (*Rhizobium* + PSB + VAM)
NS = Non-significant

Table 5: Total microbial population as influenced by integrated nutrient management in vegetable soybean

Treatments	Microbial population		
	Total Bacteria (No. × 10^6)	Total Fungi (No. × 10^3)	Total Actinomycetes (No. × 10^4)
T_1: 100% RDF	37.95	13.18	11.68
T_2: 75% RDF	36.86	14.75	11.34
T_3: 125% RDF	36.08	14.03	11.33
T_4: T_1 + TMI	41.00	16.12	12.40
T_5: T_2 + TMI	39.33	15.73	12.10
T_6: T_3 + TMI	43.06	16.56	12.73
T_7: T_1 (50% N through fertilizer + 50% through compost) + TMI	46.46	18.32	14.09
T_8: T_2 (50% N through fertilizer + 50% through compost) + TMI	42.56	17.02	13.09
T_9: T_3 (50% N through fertilizer + 50% through compost) + TMI	49.40	19.76	15.20
T_{10}: T_1 (75% N through fertilizer + 25% through compost) + TMI	43.68	17.47	13.44
T_{11}: T_2 (75% N through fertilizer + 25% through compost) + TMI	40.49	16.20	12.46
T_{12}: T_3 (75% N through fertilizer + 25% through compost) + TMI	47.08	18.83	14.49
Initial population	39.32	15.21	11.9
S. Em. ±	1.77	0.75	0.60
C. D. at 5%	5.30	2.27	1.75

Note: DAS = Days after sowing
RDF= Recommended dose of fertilizer (30:80:37.5 kg ha^{-1})
TMI= Triple microbial inoculations (*Rhizobium* + PSB + VAM)

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