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Impact of integrated application of mineral fertilizer and glyricidia green leaf manuring on yield and nutrient uptake by soybean in Vertisols

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Abstract
A field experiment was conducted to assess the effect of mineral fertilizer and glyricidia green leaf manuring on yield and nutrient uptake by soybean in Vertisols. The soil of the experimental site was moderately alkaline in reaction, low in available nitrogen, medium in available phosphorus and high in available potassium. The nine treatments replicated thrice in randomised block design comprised of control, 100% RDF through chemical fertilizers and the combinations of 50% N through glyricidia green leaf manure and 50% N through inorganics, 25 kg K ha^{-1} and seed treatment with Rhizobium and PSB. The results revealed that the application of 50% N through glyricidia +50% N through inorganics + biofertilizers + 25 kg K ha^{-1} resulted in higher yield and nutrient uptake by soybean. Hence, it is concluded that combined application of glyricidia green manuring along with chemical fertilizers is beneficial for higher nutrient uptake and productivity of soybean in Vertisols under rainfed conditions.

Keywords: Green leaf manuring, nutrient uptake, Soybean, Vertisols

Introduction
Soybean is known as the "Golden Bean" of the twentieth century and belongs to the legume family and is native to East Asia. It grows in varied agro-climatic conditions and can be grown on a variety of soils. It has unmatched composition of 40 per cent protein and 20 per cent oil and nutritional superiority on account of containing essential amino acids, unsaturated fatty acids, carbohydrates, vitamins and minerals. In addition, it contains a good amount of minerals, salts and vitamins (thiamine and riboflavin) and its sprouting grains contain a considerable amount of Vitamin C. In the recent past, soybean cultivation has increased manifold as compared to any other oilseed crop in India and stands next only to groundnut. Soybean production is mainly confined to Madhya Pradesh (also known as soybean bowl of India), Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, Uttar Pradesh and Chhattisgarh.
Integrated nutrient management is the maintenance of soil fertility and plant nutrient supply to an optimum level for sustaining desired crop productivity through optimization of benefits from all possible sources of plant nutrients in an integrated manner. It envisages the use of chemical fertilizers in conjunction with organic manures, legumes in cropping system, biofertilizers and other locally available nutrient sources for sustaining soil health and crop productivity.
Biofertilizers are preparations containing live or latent cell of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic microorganisms used for application to seed, soil or composting areas with the objectives of increasing the population of such beneficial microorganisms and accelerate certain microbial processes to augment the extent of the availability of nutrients in a form which can be easily assimilated by the plants.

Materials and Methods
A field experiment conducted on Vertisols was initiated on the research field of AICRP for Dryland Agriculture, Dr. PDKV, Akola since 2009-10. The present study was undertaken during 2013-14 with the soybean crop.
The details of various treatments in the experiment were (T_1) Control, (T_2)100% RDF (30:75:00 NPK kg ha^{-1}), (T_3) 100% RDF + biofertilizers, (T_4)100% N through FYM + biofertilizers, (T_5) 100% RDF + 25 kg K ha^{-1}, (T_6) 100% RDF + 25 kg K ha^{-1} + biofertilizes, (T_7) 50% N through green leaf manure + 50% N through Inorganics, (T_8) 50% N through green leaf manure + 50% N through inorganics + biofertilizers, (T_9) 50% N through green leaf manure+50% N through inorganics + biofertilizers + 25 kg potassium ha^{-1} and biofertilizers used were Rhizobium and PSB as seed treatment (25 g kg^{-1} seed).

Recommended P was applied to all the treatments except T_1& T_4. N supplied through urea, P through Single super phosphate and K through Muriate of potash.

Results and Discussion

Grain and Straw Yield

The data on grain and straw yield of soybean (Table 1) was significantly influenced by various treatments. The significantly higher (1255 kg ha^{-1})grain yield was observed with application of 50% N through glyricidia +50% N through inorganics + biofertilizers + 25kg K ha^{-1}(T_9)and it was on par(1220.8 kg ha^{-1}) with the application of 100% RDF +biofertilizers+ 25kg K ha^{-1}(T_6),100% RDF + 25kg K ha^{-1}(T_5), 50% N through glyricidia + 50% N through inorganics + biofertilizers (T_8) and 100% RDF + biofertilizers (T_3). The lowest grain yield (939.6 kg ha^{-1}) was recorded in treatment T_1 *i.e.* control.

The application of 50% N through glyricidia + 50% N through inorganics + biofertilizers + 25kg K ha^{-1} (T_9) resulted in 25.13% increase in grain yield over control(T_1) and 15.29 % increase over 100% RDF (T_2). The significantly higher (2039.7 kg ha^{-1})straw yield was observed with the application of 50% N through glyricidia+50% N through inorganics+ biofertilizers + 25kg K ha^{-1} (T_9) and it was found to be on par with most of the treatments. The lowest (1352.0 kg ha^{-1}) straw yield was recorded in treatment T_1 *i.e.* control. In general, the higher grain as well as straw yield was recorded with application of 50% N through glyricidia +50% N through inorganics+ biofertilizers + 25kg K ha^{-1}.

Table 1: Effect of INM on soybean yield

Treatments		Grain (kg ha^{-1})	Straw (kg ha^{-1})
T_1	Control	939.6	1352.0
T_2	100% RDF (30:75:00 NPK kg ha^{-1})	1063.1	1707.2
T_3	100% RDF + biofertilizers	1083.7	1819.3
T_4	100% N through FYM + biofertilizers	1028.8	1574.3
T_5	100% RDF + 25kg K ha^{-1}	1193.4	1871.0
T_6	100% RDF + 25kg K ha^{-1} + biofertilizers	1220.8	1894.4
T_7	50% N through green leaf manure + 50% N through inorganics	1042.5	1662.1
T_8	50% N through green leaf manure + 50% N through inorganics + biofertilizers	1179.7	1870.5
T_9	50% N through green leaf manure +50% N through inorganics+ biofertilizers + 25kg K ha^{-1}	1255.1	2039.7
	SE (m) ±	61.6	114.9
	CD at 5%	184.8	344.6

This may be due to beneficial role of potassium which increases nodulation of legumes and biofertilizers also perform better when soil is well supplied with nutrients particularly nitrogen and phosphorus by fixing atmospheric nitrogen. Govindan and Thirrumurugan (2003) [3] observed the positive effect of Rhizobium and phosphate solubilizing microorganism in increasing the growth and yield of soybean. Similar results were also reported by Singh *et al*. (2009) [9], Jadhav and Andhale (2009) [4] and Singh *et al*. (2012) [10].

Nutrient uptake by soybean

Nitrogen uptake

The data in respect of N uptake by grain and straw and total N uptake by soybean were significantly influenced by various treatments (Table 2).

Table 2: Effect of INM on nitrogen uptake by soybean (kg ha^{-1})

Treatments		Grain	Straw	Total
T_1	Control	32.86	19.93	52.79
T_2	100% RDF (30:75:00 NPK kg ha^{-1})	43.63	28.71	72.35
T_3	100% RDF + biofertilizers	45.86	31.43	77.29
T_4	100% N through FYM + biofertilizers	38.13	24.59	62.72
T_5	100% RDF + 25kg K ha^{-1}	52.34	31.87	84.21
T_6	100% RDF + 25kg K ha^{-1} + biofertilizers	54.17	33.67	87.84
T_7	50% N through green leaf manure + 50% N through inorganics	41.94	26.73	68.67
T_8	50% N through green leaf manure + 50% N through inorganics + biofertilizers	51.74	33.21	84.95
T_9	50% N through green leaf manure +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1}	57.98	38.06	96.04
	SE (m) ±	2.87	2.18	3.55
	CD at 5%	8.61	6.54	10.64

The data indicated that the significantly higher N uptake(57.98 kg ha^{-1}) by grain was observed with the application of 50% N through glyricidia +50% N through inorganics+ biofertilizers + 25kg K ha^{-1} (T_9)and it was found to be on par with the application of 100% RDF + 25kg K ha^{-1}+ biofertilizers (T_6), 100% RDF + 25kg K ha^{-1}(T_5) and 50% N through glyricidia + 50% N through inorganics + biofertilizers (T_8). The lowest N uptake by grain was observed in treatment T_1 *i.e.* control (32.86 kg ha^{-1}).The significantly higher N uptake (38.06 kg ha^{-1}) by straw was observed with the application of 50% N through glyricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1}(T_9) and it was also found to be on par with the treatments T5, T6 and T8. The lowest N uptake by straw was observed in treatment T_1 *i.e.* control (19.93 kg ha^{-1}).

The uptake of N increased due to the combined application of N, P, K + 25 kg K + biofertilizers which increase the concentration of N in grain and straw. Moreover, potassium is reported to have a beneficial effect on symbiotic nitrogen fixation by leguminous crops. The results are in conformity with finding of Akbari *et al. (*2001) [1], Talati (2004) [11] and Singh *et al*. (2007) [8].

Phosphorus uptake

The data in respect of P uptake by grain and straw and total P uptake by soybean were significantly influenced by various treatments (Table 3).

Table 3: Effect of INM on phosphorus uptake by soybean (kg ha^{-1})

Treatments		Grain	Straw	Total
T_1	Control	5.12	5.03	10.15
T_2	100% RDF (30:75:00 NPK kg ha^{-1})	6.43	7.07	13.50
T_3	100% RDF + biofertilizers	7.20	8.73	15.93
T_4	100% N through FYM + biofertilizers	6.12	6.52	12.64
T_5	100% RDF + 25kg K ha^{-1}	8.07	9.22	17.29
T_6	100% RDF + 25kg K ha^{-1} + biofertilizers	9.15	10.33	19.48
T_7	50% N through green leaf manure + 50% N through inorganics	6.91	8.36	15.27
T_8	50% N through green leaf manure + 50% N through inorganics + biofertilizers	8.54	9.98	18.52
T_9	50% N through green leaf manure +50% N through inorganics+ biofertilizers + 25kg K ha^{-1}	9.60	11.59	21.19
	SE (m) ±	0.39	0.54	0.64
	CD at 5%	1.18	1.61	1.91

The data indicated that the significantly higher P uptake (9.60 kg ha^{-1}) by grain was observed with the application of 50% N through glyricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1}(T_9) and it was on par with the application of 100% RDF + 25kg K ha^{-1} + biofertilizers (T_6) and 50% N through glyricidia + 50% N through inorganics + biofertilizers (T8). The lowest P uptake by grain was observed in treatment T_1 *i.e.* control (5.12 kg ha^{-1}).

The significantly higher P uptake (11.59 kg ha^{-1}) by straw was observed with the application of 50% N through green leaf manure +50% N through inorganics+ biofertilizers + 25kg K ha^{-1}(T_9) and it was also found to be on par with treatments T_6 and T_8. The lowest P uptake by straw was observed in treatment T_1 *i.e.* control (5.03 kg ha^{-1}). Similar results were also reported by Dubey (2000) [2] and Joshi (2003) [7].

Potassium uptake

The data (Table 4) in respect of K uptake by grain and straw and total K uptake by soybean were significantly influenced by various treatments. The data indicated that the significantly higher K uptake(10.21 kg ha^{-1}) by grain was observed with the application of 50% N through glyricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1} (T_9) and it was found to be on par with application of 100% RDF + 25 kg K ha^{-1} + biofertilizers (T_6), 50% N through glyricidia + 50% N through inorganics + biofertilizers (T_8) and 100% RDF + 25 kg K ha^{-1} (T_5). The lowest K uptake by grain was observed in treatment T_1 *i.e.* control (5.01 kg ha^{-1}).

Table 4: Effect of INM on potassium uptake by soybean (kg ha^{-1})

Treatments		Grain	Straw	Total
T_1	Control	5.01	13.38	18.39
T_2	100% RDF (30:75:00 NPK kg ha^{-1})	6.78	17.78	24.56
T_3	100% RDF + biofertilizers	7.35	19.56	26.91
T_4	100% N through FYM + biofertilizers	6.23	16.19	22.43
T_5	100% RDF + 25kg K ha^{-1}	9.07	20.38	29.45
T_6	100% RDF + 25kg K ha^{-1} + biofertilizers	9.65	21.27	30.92
T_7	50% N through green leaf manure + 50% N through inorganics	7.75	17.99	25.74
T_8	50% N through green leaf manure + 50% N through inorganics + biofertilizers	9.22	20.76	29.97
T_9	50% N through green leaf manure +50% N through inorganics+ biofertilizers + 25kg K ha^{-1}	10.21	23.29	33.50
	SE (m) ±	0.51	1.32	1.37
	CD at 5%	1.52	3.97	4.12

The significantly higher K uptake (23.29 kg ha^{-1}) by straw was observed with the application of 50% N through glyricidia +50% N through inorganics+ biofertilizers + 25kg K ha^{-1}(T_9) and it was found to be on par with treatments T_3, T_5, T_6 and T_8. The lowest K uptake by straw was observed in treatment T_1 *i.e.* control (13.38 kg ha^{-1}). Similar results were also recorded by Ved Prakash *et al*. (2002) [12] and Singh *et.al*. (2007) [8].

Sulphur uptake

The data indicated that the significantly higher S uptake (6.39 kg ha^{-1}) by grain was observed with the application of 50% N through glyricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1}(T_9) and it was found to be on par with application of 100% RDF + 25 kg K ha^{-1} + biofertilizers(T_6), (T_8). The lowest S uptake by grain was observed in treatment T_1 *i.e.* control (4.26 kg ha^{-1}).

Table 5: Effect of INM on sulphur uptake by soybean (kg ha^{-1})

Treatments		Grain	Straw	Total
T_1	Control	4.26	2.34	6.61
T_2	100% RDF (30:75:00 NPK kg ha^{-1})	4.95	3.24	8.19
T_3	100% RDF + biofertilizers	5.10	3.45	8.55
T_4	100% N through FYM + biofertilizers	4.73	3.20	7.92
T_5	100% RDF + 25kg K ha^{-1}	5.81	3.81	9.61
T_6	100% RDF + 25kg K ha^{-1} + biofertilizers	6.14	4.17	10.32
T_7	50% N through green leaf manure + 50% N through inorganics	5.15	3.44	8.59
T_8	50% N through green leaf manure + 50% N through inorganics + biofertilizers	5.89	4.12	10.01
T_9	50% N through green leaf manure +50% N through inorganics+ biofertilizers + 25kg K ha^{-1}	6.39	4.62	11.02
	SE (m) ±	0.29	0.28	0.39
	CD at 5%	0.87	0.83	1.17

The significantly higher S uptake (4.62 kg ha^{-1}) by straw was observed with the application of 50% N through glyricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1} (T_9) and it was also found to be on par with the treatments T_5, T_6 and T_8. The lowest S uptake by straw was observed in treatment T_1 *i.e.* control (2.34 kg ha^{-1}). The similar results were reported by Jadhav *et.al*. (2007) [5] and Jeevan Rao and Rama Lakshmi (2009).

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