International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 2591-2598

Received: 22-09-2018
Accepted: 26-10-2018

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Integrated effect of gliricidia green leaf manure and mineral fertilizer on soybean yield, soil fertility and nutrient balance in vertisols

Usha Satpute, VV Gabhane, MM Ganvir, NM Konde and BA Sonune

Abstract
A field study to know the effect of integrated nutrient management on soybean yield, soil fertility and nutrient balance in Vertisols was conducted during *kharif* 2013, on the long term experiment initiated during 2009-10 at Research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. 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 gliricidia green leaf manure and 50% N through inorganics, 25 kg K ha^{-1} and seed treatment with Rhizobium and PSB. The results indicated that the use of gliricidia green leaf manuring in conjunction with chemical fertilizers recorded higher soybean yield with improvement in soil fertility and nutrient balance in Vertisols.

Keywords: Green leaf manure, INM, nutrient balance, soil fertility and vertisols

Introduction
Soybean (*Glycine max* (L.) Merrill) with its 40-42% protein and 20-22% oil is the premier oilseed crop in India and it has exhibited phenomenal growth and provided resilience to oilseed and edible oil production in the country. The productivity of soybean crop has shown gradual build up from the time of its initiation of commercial cultivation, but it is hovering around 1 t/ha for more or less last one decade, mainly in view of deficit and erratic distribution of rainfall and uncertainty in onset of monsoon being experienced on account of global climatic change. Being rainfed, the productivity of oilseeds in general and soybean in particular has been far below the potential yield achievable.

Constraint analyses have indicated that unbalanced nutrition is one of the important reasons for restricted growth in productivity (Sharma *et al*., 1996 and Tiwari, 2001) [15, 21]. Soybean like most legume perform nitrogen fixation by establishing a symbiotic relationship with bacteria *Rhizobium japonicum*. Use of organic manures with optimum rate of fertilizers under intensive farming system increased the turnover of nutrients in the soil plant system. The organic fertilizers 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. Farmyard manure is an important component of integrated nutrient management for maintaining soil fertility and yield stability.

The green manures are a valuable potential source of N and organic matter. They play an important role in the reclamation of salt affected soils and improvement in physical, chemical and biological properties of soil with increase in the microbial population in soil. Integration of inorganic fertilizers, organic manures and biological sources and their efficient management has shown promise in not only sustaining the productivity and soil health but also in meeting part of crops nutrient requirement.

Materials and Methods
A field experiment 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. Akola is situated in between 22^0 41’ N latitude and 77^0 02’ longitudes at an altitude of 307.4 m above mean sea level and has a subtropical climate. Rainfall during *kharif*2013 (June- September) amounted 821.7mm which was 119.4% of the corresponding

normal rainfall (688.0 mm). Monthly rainfall during June, July, August and September amounted to 266.9, 238.6, 164.3 and, 151.9mm which was 175.9, 114.1, 76.1 and 136.7 percent of the monthly normal, respectively.

The details of various treatments undertaken in the experiment are (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} + bio fertilizes,(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}. Rhizobium and PSB were used 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 gliricidia +50% N through inorganics + biofertilizers + 25kg K ha^{-1}(T9)and it was on par(1220.8 kg ha^{-1}) with the application of 100% RDF +biofertilizers+ 25kg K ha^{-1} (T6), 100% RDF + 25kg K ha^{-1}(T_5),50% N through gliricidia + 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 gliricidia + 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 gliricidia+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 gliricidia +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) [5] observed the positive effect of Rhizobium and phosphate solubilizing microorganism in increasing the growth and yield of soybean. Similar results were also reported by Mondal *et al.* (1990) [13], Joshi and Rudradhya (1993) [9], Ved Prakash *et al.* (2002) [24], Joshi (2003) [10], Menaria and Singh (2004) [12], Singh *et al.* (2009) [19], Jadhav and Andhale (2009) [8] and Singh *et al.* (2012) [18].

Soil fertility

The data in respect of fertility status of soil at harvest of soybean are presented in Table 2.

Organic carbon

Organic carbon is an indication of organic carbon fraction of soil formed due to microbial decomposition of organic residue. The data (Table 2) pertaining to the organic carbon content of soil as influenced by different treatments was statistically significant and it ranged from 5.11 to 6.40 g kg^{-1} indicating that the highest (6.40 g kg^{-1}) organic carbon was recorded with the application of 50% N through gliricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1} (T_9)and it was found to be on par with 100% RDF + 25 kg K ha^{-1} + biofertilizers (T_6).The lower value of organic carbon was found in treatment T_1 i.e. control (5.11 g kg^{-1}).

The higher values of organic carbon content in treatments T_9 and T_6 may be due to higher addition of biomass into the soil as evidenced from the higher yields obtained in these treatments. Similar results were also reported by Handekar *et al.* (1991) [6], Gholve *et al.* (2005) [4], Deshmukh *et al*. (2005) [2] and Singh *et al.* (2007) [17]. The data indicate the higher organic carbon balance (1.2 g kg^{-1}) with application of 50% N through gliricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1} (T_9).

Table 2: Effect of INM on soil fertility

Treatments		OC (g kg^{-1})	Available nutrients		
			N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1	Control	5.11	189.00	11.20	312.63
T_2	100% RDF (30:75:00 NPK kg ha^{-1})	5.33	197.78	13.03	316.92
T_3	100% RDF + biofertilizers	5.47	199.03	14.80	318.83
T_4	100% N through FYM + biofertilizers	5.64	190.67	13.12	316.66
T_5	100% RDF + 25kg K ha^{-1}	5.91	209.07	13.86	347.39
T_6	100% RDF + 25kg K ha^{-1} + biofertilizers	6.21	211.16	16.99	352.65
T_7	50% N through green leaf manure + 50% N through inorganics	6.00	197.36	14.31	330.03
T_8	50% N through green leaf manure + 50% N through inorganics + biofertilizers	6.18	201.54	16.37	340.67
T_9	50% N through green leaf manure +50% N through inorganics+ biofertilizers + 25kg K ha^{-1}	6.40	215.34	17.34	357.95
	SE (m) +	0.08	4.77	0.60	3.55
	CD at 5%	0.23	14.29	1.80	10.65
	Initial(2009-10)	5.2	195	15.5	319

Available nitrogen status of soil

The results pertaining to available N status of soil was significantly influenced by different treatments. The available N in soil varied from 189.00 to 215.34 kg ha^{-1} indicating that the soil was low in available N content. The maximum available N (215.34 kg ha^{-1}) was observed with the application of 50% N through gliricidia +50% N through inorganics+ biofertilizers + 25kg K ha^{-1} (T_9) and it was found to be on par with 100% RDF + 25kg K ha^{-1} + biofertilizers(T_6), 100% RDF + 25kg K ha^{-1} (T_5), and 50% N through gliricidia + 50% N through inorganics + biofertilizers (T_8). The lower value of available N was found in treatment T_1 i.e. control (189.0 kg ha^{-1}). Raut and Ghonshikar (1971) [14] observed increase in nodulation and N content in soil due to Rhizobium inoculation. Similar results were also given by Vats *et al.* (2001) [23], Govindan and Thirumurugan (2003) [5], Gholve *et al.* (2005) [4] and Singh *et al.* (2007).

Available phosphorus status of soil

It is evident from the data in Table 2 that available P content of soil varied significantly and it ranged from 11.20 to 17.34 kg ha^{-1} indicating that the soil was low to medium in available phosphorus content. The highest (17.34 kg ha^{-1}) available P was found with the application of 50% N through gliricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1} (T_9) and it was found to be on par with the application of 100% RDF + 25 kg K ha^{-1} + biofertilizers (T_6) and 50% N through gliricidia + 50% N through inorganics + biofertilizers (T_8). The lower value of available P was found in treatment T_1 i.e. control (11.20 kg ha^{-1}). The higher values of available phosphorus in treatment T_9, T_6 and T_8 may be due to the phosphate solubilizing bacteria (PSB) which increases the availability of P in the soil by converting insoluble phosphorus into soluble P. Similar results were recorded by Singh and Singh (1993) [16], Varalakshmi *et al.* (2005) [22], Singh *et al.* (2007) [17], Chaturvedi *et al.* (2010) [1] and Thakur *et al.* (2011) [20].

Available potassium status of soil

The data (Table 2) on available K content of soil varied significantly from 312.63 to 357.95 kg ha^{-1} indicating that soil was high to very high in available K content. The highest available K (357.95 kg ha^{-1}) was observed with the application of 50% N through gliricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1}(T_9) and it was found to be on par with the application of 100% RDF + 25 kg K ha^{-1} + biofertilizers (T_6) and 100% RDF + 25 kg K ha^{-1} (T_5). The lower value of available K was found in treatment T_1 i.e. control (312.63 kg ha^{-1}).

The higher values of available potassium in treatments T_9, T_6 and T_5 may be due to application of potassium 25 kg ha^{-1} which might have increased the K content in soil. Similar results were observed by Dhonde and Bhakare (2008) [3].

Nutrient balance

The data in respect of nitrogen, phosphorus and potassium balance in soil at harvest of soybean are presented in Table 3, Table 4 and Table 5 respectively.

Nitrogen balance

The data (Table 3) indicated that the initial level of available N in soil was 195 kg ha^{-1}. The maximum nitrogen uptake (96 kg ha^{-1}) was observed in application of 50% N through gliricidia + 50% N through inorganics + biofertilizer + 25 kg K ha^{-1} (T_9).

The expected balance after the harvest of soybean was highest (162.28 kg ha^{-1}) in treatment T_4 receiving 100% N through FYM + biofertilizers, while lowest (128.96 kg ha^{-1}) expected balance was observed in treatment T_9 50% N through gliricidia + 50% N through inorganics + biofertilizer + 25 kg K ha^{-1}. However, the apparent gain or loss in the available nitrogen to extent of 74 kg ha^{-1} was observed in treatment T_6 receiving 100% RDF + 25 kg K ha^{-1} while lowest (28.39 kg ha^{-1}) apparent gain was observed in treatment T_4 receiving 100% N through FYM + biofertilizers. The final status of available N in soil after harvest of soybean (Actual fertility status) was considerably increased (211.16 to 215.34 kg ha^{-1}) in all the treatments except control over initial fertility status of soil which indicated the beneficial effect of the legumes cropping which helped in increasing the available N in soil.

The data in respect of actual gain or loss, further revealed that there was a maximum gain (20.34 kg ha^{-1}) of nitrogen in treatment T_9 50% N through gliricidia + 50% N through inorganics + biofertilizers + 25 kg K ha^{-1} and loss was observed in treatment T_1(-6 kg ha^{-1}) *i.e.* control which might be due to no addition of organic or inorganic fertilizer to it and nutrient uptake (52.79 kg ha^{-1}). These results are in conformity with the finding of Malewar *et al.* (1999) [11].

2013 (June- September) amounted 821.7mm which was 119.4% of the corresponding normal rainfall (688.0 mm).

Monthly rainfall during June, July, August and September amounted to 266.9, 238.6, 164.3 and, 151.9mm which was 175.9, 114.1, 76.1 and 136.7 percent of the monthly normal, respectively.

The details of various treatments undertaken in the experiment are (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}. Rhizobium and PSB were used 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 3) was significantly influenced by various treatments. The significantly higher (1255 kg ha^{-1}) grain yield was observed with application of 50% N through gliricidia +50% N through inorganics + biofertilizers + 25kg K ha^{-1}(T9) and it was on par (1220.8 kg ha^{-1}) with the application of 100% RDF +biofertilizers+ 25kg K ha^{-1}(T6),100% RDF + 25kg K ha^{-1}(T_5), 50% N through gliricidia + 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 gliricidia + 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 gliricidia+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 gliricidia +50% N through inorganics+ biofertilizers + 25kg K ha^{-1}.

Table 3: 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) [5] observed the positive effect of Rhizobium and phosphate solubilizing microorganism in increasing the growth and yield of soybean. Similar results were also reported by Mondal *et al.* (1990) [13], Joshi and Rudradhya (1993) [9], Ved Prakash *et al.* (2002), Joshi (2003) [10], Menaria and Singh (2004) [12], Jadhav and Andhale (2009) [8] and Singh *et al.* (2012) [18].

Soil fertility

The data in respect of fertility status of soil at harvest of soybean are presented in Table 4.

Organic carbon

Organic carbon is an indication of organic carbon fraction of soil formed due to microbial decomposition of organic residue. The data (Table 4) pertaining to the organic carbon content of soil as influenced by different treatments was statistically significant and it ranged from 5.11 to 6.40 g kg^{-1} indicating that the highest (6.40 g kg^{-1}) organic carbon was recorded with the application of 50% N through gliricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1} (T_9)and it was found to be on par with 100% RDF + 25 kg K ha^{-1} + biofertilizers (T_6).The lower value of organic carbon was found in treatment T_1 i.e. control (5.11 g kg^{-1}).

The higher values of organic carbon content in treatments T_9 and T_6 may be due to higher addition of biomass into the soil as evidenced from the higher yields obtained in these treatments. Similar results were also reported by Handekar *et al.* (1991), Gholve *et al.* (2005) [4], Deshmukh *et al.* (2005) [2] and Singh *et al.* (2007). The data indicate the higher organic carbon balance (1.2 g kg^{-1}) with application of 50% N through gliricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1} (T_9).

Table 4: Effect of INM on soil fertility

Treatments		OC (g kg^{-1})	Available nutrients		
			N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1	Control	5.11	189.00	11.20	312.63
T_2	100% RDF (30:75:00 NPK kg ha^{-1})	5.33	197.78	13.03	316.92
T_3	100% RDF + biofertilizers	5.47	199.03	14.80	318.83
T_4	100% N through FYM + biofertilizers	5.64	190.67	13.12	316.66
T_5	100% RDF + 25kg K ha^{-1}	5.91	209.07	13.86	347.39
T_6	100% RDF + 25kg K ha^{-1} + biofertilizers	6.21	211.16	16.99	352.65
T_7	50% N through green leaf manure + 50% N through inorganics	6.00	197.36	14.31	330.03
T_8	50% N through green leaf manure + 50% N through inorganics + biofertilizers	6.18	201.54	16.37	340.67
T_9	50% N through green leaf manure +50% N through inorganics+ biofertilizers + 25kg K ha^{-1}	6.40	215.34	17.34	357.95
	SE (m) +	0.08	4.77	0.60	3.55
	CD at 5%	0.23	14.29	1.80	10.65
	Initial(2009-10)	5.2	195	15.5	319

Available nitrogen status of soil

The results pertaining to available N status of soil was significantly influenced by different treatments. The available N in soil varied from 189.00 to 215.34 kg ha^{-1} indicating that the soil was low in available N content. The maximum available N (215.34 kg ha^{-1}) was observed with the application of 50% N through gliricidia +50% N through inorganics+ biofertilizers + 25kg K ha^{-1} (T_9) and it was found to be on par with 100% RDF + 25kg K ha^{-1} + biofertilizers(T_6), 100% RDF + 25kg K ha^{-1} (T_5),and 50% N through gliricidia + 50% N through inorganics + biofertilizers (T_8). The lower value of available N was found in treatment T_1 i.e. control (189.0 kg ha^{-1}). Raut and Ghonshikar (1971) [14] observed increase in nodulation and N content in soil due to Rhizobium inoculation. Similar results were also given by Vats *et al.* (2001) [23], Govindan and Thirumurugan (2003) [5], Gholve *et al.* (2005) [4] and Singh *et al.* (2007) [17].

Available phosphorus status of soil

It is evident from the data in Table 4 that available P content of soil varied significantly and it ranged from 11.20 to 17.34 kg ha^{-1} indicating that the soil was low to medium in available phosphorus content. The highest (17.34 kg ha^{-1}) available P was found with the application of 50% N through gliricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1} (T_9) and it was found to be on par with the application of 100% RDF + 25 kg K ha^{-1} + biofertilizers (T_6) and 50% N through gliricidia + 50% N through inorganics + biofertilizers (T_8). The lower value of available P was found in treatment T_1 i.e. control (11.20 kg ha^{-1}). The higher values of available phosphorus in treatment T_9, T_6 and T_8 may be due to the phosphate solubilizing bacteria (PSB) which increases the availability of P in the soil by converting insoluble phosphorus into soluble P. Similar results were recorded by Singh and Singh (1993) [16], Varalakshmi *et al.* (2005) [22], Singh *et al.* (2007) [17], Chaturvedi *et al.* (2010) [1] and Thakur *et al.* (2011) [20].

Available potassium status of soil

The data (Table 5) on available K content of soil varied significantly from 312.63 to 357.95 kg ha^{-1} indicating that soil was high to very high in available K content. The highest available K (357.95 kg ha^{-1}) was observed with the application of 50% N through gliricidia +50% N through inorganics+ biofertilizers + 25 kg K ha^{-1}(T_9) and it was found to be on par with the application of 100% RDF + 25 kg K ha^{-1} + biofertilizers (T_6) and 100% RDF + 25 kg K ha^{-1} (T_5). The lower value of available K was found in treatment T_1 i.e. control (312.63 kg ha^{-1}).

The higher values of available potassium in treatments T_9, T_6 and T_5 may be due to application of potassium 25 kg ha^{-1} which might have increased the K content in soil. Similar results were observed by Dhonde and Bhakare (2008) [3].

Nutrient balance

The data in respect of nitrogen, phosphorus and potassium balance in soil at harvest of soybean are presented in Table 3, Table 4 and Table 5 respectively.

Nitrogen balance

The data (Table 3) indicated that the initial level of available N in soil was 195 kg ha^{-1}. The maximum nitrogen uptake (96 kg ha^{-1}) was observed in application of 50% N through gliricidia + 50% N through inorganics + biofertilizer + 25 kg K ha^{-1} (T_9).

The expected balance after the harvest of soybean was highest (162.28 kg ha^{-1}) in treatment T_4 receiving 100% N through FYM + biofertilizers, while lowest (128.96 kg ha^{-1}) expected balance was observed in treatment T_9 50% N through gliricidia + 50% N through inorganics + biofertilizer + 25 kg K ha^{-1}. However, the apparent gain or loss in the available nitrogen to extent of 74 kg ha^{-1} was observed in treatment T_6 receiving 100% RDF + 25 kg K ha^{-1} while lowest (28.39 kg ha^{-1}) apparent gain was observed in treatment T_4 receiving 100% N through FYM + biofertilizers. The final status of available N in soil after harvest of soybean (Actual fertility status) was considerably increased (211.16 to 215.34 kg ha^{-1}) in all the treatments except control over initial fertility status of soil which indicated the beneficial effect of the legumes cropping which helped in increasing the available N in soil.

The data in respect of actual gain or loss, further revealed that there was a maximum gain (20.34 kg ha^{-1}) of nitrogen in treatment T_9 50% N through gliricidia + 50% N through inorganics + biofertilizers + 25 kg K ha^{-1} and loss was observed in treatment T_1 (-6 kg ha^{-1}) *i.e.* control which might be due to no addition of organic or inorganic fertilizer to it and nutrient uptake (52.79 kg ha^{-1}). These results are in conformity with the finding of Malewar *et al.* (1999) [11].

Table 3: Nitrogen balance (kg ha^{-1}) after harvest of soybean

	Treatments	Initial N status (A) (kg ha^{-1})	Nitrogen added (B) (kg ha^{-1})				Nitrogen uptake (C) (kg ha^{-1})	Expected Balance (D)= (A+B)-C (kg ha^{-1})	Actual nitrogen after harvest (E) (kg ha^{-1})	Apparent gain /loss (F)= (E-D) (kg ha^{-1})	Actual gain / loss (G)= (E-A) (kg ha^{-1})
			Fertilizer	FYM	*Gliricidia*	Total					
T_1	Control	195	-	-	-	-	52.79	142.21	189	46.79	-6
T_2	100% RDF (30:75:00 kg ha^{-1})	195	30	-	-	30	72.35	152.65	197.78	45.13	2.78
T_3	100% RDF + biofertilizers	195	30	-	-	30	77.29	147.71	199.03	51.32	4.03
T_4	100%N through FYM + biofertilizers	195	-	30	-	30	62.72	162.28	190.67	28.39	-4.33
T_5	100%RDF + 25 kg K ha^{-1}	195	30	-	-	30	84.21	140.79	209.07	68.28	14.07
T_6	100%RDF + 25 kg K ha^{-1}+ biofertilizers	195	30	-	-	30	87.84	137.16	211.16	74	16.16
T_7	50% N through green leaf manure + 50% N through inorganics	195	15	-	15	30	68.67	156.33	197.36	41.03	2.36
T_8	50% N through green leaf manure + 50% N through inorganics + biofertilizers	195	15	-	15	30	84.95	140.05	201.54	61.49	6.54
T_9	50% N through green leaf manure + 50% N through inorganics + biofertilizers + 25 kg K ha^{-1}	195	15	-	15	30	96.04	128.96	215.34	86.38	20.34

Phosphorus balance

The results pertaining to the balance of available phosphorus in soil are presented in Table 4. The initial available phosphorus in soil was 15.5 kg ha^{-1}.The maximum uptake of phosphorus (21.19 kg ha^{-1}) was observed in treatment T_9 50% N through gliricidia + 50% N through inorganics + biofertilizers + 25 kg K ha^{-1}.The expected phosphorus balance after the harvest of soybean was highest (75.23 kg ha^{-1}) in treatment T_7 *i.e.* 50% N through gliricidia +50% N through inorganics, while lowest (2.86 kg ha^{-1}) expected balance was observed in treatment T_4 receiving 100% N through FYM + biofertilizers. The data in respect of apparent gain or loss of phosphorus revealed that there was gain of 10.26 kg ha-1 phosphorus in 100% N through FYM + biofertilizers i.e.T4 and the apparent loss of phosphorus was highest (-60.92 kg ha-1) in treatment T7 receiving 50% N through gliricidia +50% N through inorganics after the harvest of soybean.

The final status of available phosphorus in soil was considerably increased in all treatments over control, clearly indicating the beneficial effect due to the legume which absorb more soil P from subsurface and a part of which left in the surface layer and subsurface soil with roots. The data in respect of actual gain or loss revealed that there was maximum gain (1.84 kg ha^{-1}) of phosphorus with application of 50% N through gliricidia + 50% N through inorganics + biofertilizers + 25 kg K ha^{-1}(T_9) followed by 1.49 kg ha^{-1} with application of 100% RDF + 25 kg K ha^{-1}+ biofertilizers(T_6). The highest actual loss (-4.3 kg ha^{-1}) was observed in treatment T_1 *i.e.* control.

Similar results on increase in available phosphorus balance with INM were also given by Malewar *et al.* (1999) [11] and Singh *et al*. (2007) [17].

Potassium balance

The data in Table 5 revealed that the initial status of available potassium in soil was 319 kg ha^{-1} which was increased up to 357.95 kg ha^{-1} after the harvest of soybean crop. The maximum uptake (33.5 kg ha^{-1}) of potassium by crop was observed in treatment T_9 50% N through gliricidia + 50% N through inorganics + biofertilizers + 25 kg K ha^{-1}.

The expected potassium balance after harvest of soybean was highest (314.55 kg ha^{-1}) in treatment T_5 100% RDF + 25 kg K ha^{-1}, while lowest (289.03 kg ha^{-1}) expected balance was observed in treatment T_8 *i.e.* 50% N through gliricidia + 50% N through inorganics + biofertilizers. The data in respect of apparent gain or loss revealed that there was a highest gain (47.45 kg ha^{-1}) in treatment 50% N through gliricidia + 50% N through inorganics + biofertilizers +25 kg K ha^{-1} and apparent gain was lowest in (12.02 kg ha^{-1}) in treatment T_1 *i.e.* control.

The final status of available potassium *i.e.* actual fertility status of soil considerably increased in all treatments. This may be due to major K bearing and crystal lattices of silicate minerals which on weathering, gradually release K to the soil. The higher actual gain (38.95 kg ha^{-1}) of potassium in treatment T_9 50% N through gliricidia + 50% N through inorganics + biofertilizer + 25 kg K ha^{-1}, may be due to addition of potassic fertilizer to soil and the lowest actual gain was observed in treatment T_1 *i.e.* control.

Similar results were recorded by Malewar *et al.* (1999) [11] and Singh e*t al.* (2007) [17].

Table 4: Phosphorus balance (kg ha^{-1}) after harvest of soybean

Treatments		Initial P status (A) (kg ha^{-1})	Phosphorus added (B) (kg ha^{-1})				P uptake (C) (kg ha^{-1})	Expected Balance (D)= (A+B)-C (kg ha^{-1})	Actual phosphorus after harvest (E) (kg ha^{-1})	Apparent gain /loss (F)= (E-D) (kg ha^{-1})	Actual gain / loss (G)= (E-A) (kg ha^{-1})
			Fertilizer	FYM	*Gliricidia*	Total					
T_1	Control	15.5	_	-	-	-	10.15	5.35	11.2	5.85	-4.3
T_2	100% RDF (30:75:00 kg ha^{-1})	15.5	75	-	-	75	13.5	77	13.03	-63.97	-2.47
T_3	100% RDF + biofertilizers	15.5	75	-	-	75	15.93	74.57	14.8	-59.77	-0.7
T_4	100%N through FYM + biofertilizers	15.5	_	10	-	10	12.64	12.86	13.12	0.26	-2.38
T_5	100%RDF + 25 kg K ha^{-1}	15.5	75	-	-	75	17.29	73.21	13.86	-59.35	-1.64
T_6	100%RDF + 25 kg K ha^{-1}+ biofertilizers	15.5	75	-	-	75	19.48	71.02	16.99	-54.03	1.49
T_7	50% N through green leaf manure + 50% N through inorganics	15.5	75	-	2.6	77.6	15.27	77.83	14.31	-63.52	-1.19
T_8	50% N through green leaf manure + 50% N through inorganics + biofertilizers	15.5	75	-	2.6	77.6	18.52	74.58	16.37	-58.21	0.87
T_9	50% N through green leaf manure + 50% N through inorganics + biofertilizers + 25 kg K ha^{-1}	15.5	75	-	2.6	77.6	21.19	71.91	17.34	-54.57	1.84

Table 5: Potassium balance (kg ha^{-1}) after harvest of soybean

Treatments		Initial K status (kg ha^{-1})	Potassium added (B) (kg ha^{-1})				K uptake (C) (kg ha^{-1})	Expected Balance (D)= (A+B)-C (kg ha^{-1})	Actual potassium after harvest (E) (kg ha^{-1})	Apparent gain/loss (F)= (E-D) (kg ha^{-1})	Actual gain / loss (G)= (E-A) (kg ha^{-1})
			Fertilizer	FYM	*Gliricidia*	Total					
T_1	Control	319	-	-	-	-	18.39	300.61	312.63	12.02	-6.37
T_2	100% RDF (30:75:00 kg ha^{-1})	319	-	-	-	-	24.56	294.44	316.92	22.48	-2.08
T_3	100% RDF + biofertilizers	319	-	-	-	-	26.91	292.09	318.83	26.74	-0.17
T_4	100%N through FYM + biofertilizers	319	-	33	-	33	22.43	329.57	316.66	-12.91	-2.34
T_5	100%RDF + 25 kg K ha^{-1}	319	25	-	-	25	29.45	314.55	347.39	32.84	28.39
T_6	100%RDF + 25 kg K ha^{-1}+ biofertilizers	319	25	-	-	25	30.92	313.08	352.65	39.57	33.65
T_7	50% N through green leaf manure + 50% N through inorganics	319	-	-	16.66	16.66	25.74	309.92	330.03	20.11	11.03
T_8	50% N through green leaf manure + 50% N through inorganics + biofertilizers	319	-	-	16.66	16.66	29.97	305.69	340.67	34.98	21.67
T_9	50% N through green leaf manure + 50% N through inorganics + biofertilizers + 25 kg K ha^{-1}	319	25	-	16.66	41.66	33.5	327.16	357.95	30.79	38.95

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