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Influence of INM on nutrient uptake and quality of soybean in black cotton soil of Maharashtra

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Abstract
A field experiment was conducted on typic haplustert at Department of soil science and Agricultural Chemistry, College of Agriculture Latur during *Kharif* season of 2008-2009 on Soybean. Uptake and quality of soybean was significantly influenced by integrated nutrient management. There was a significant increase in uptake of N, P, K and S at all the critical growth stages of soybean with combined application of chemical fertilizers along with enough bulk of farm yard manure. Uptake of nutrients were significantly higher with treatment (T_9) 100 % RDF + 10 t FYM ha^{-1} + 45 kg S ha^{-1} + Biofertilizer Followed by T_8 (50%RDF+10t FYM ha^{-1} +45kg s ha^{-1} + Biofertilizer). At all the critical growth stages of soybean maximum value of 100 seed weight (14.67g) of soybean was recorded with treatment T_9 and it was at par with treatment T_8. Both protein content and protein yield were significantly improved due to treatment T_9. Treatment T_9 recorded highest protein content (40.68%) in soybean than the rest of the treatment. The treatment T_9 recorded maximum oil content (20.0%). which was significantly superior over all other treatments while highest oil yield (546.2 kg ha^{-1}) due to treatment T_9 was at par with the treatment T_8 and T_4.

Keywords: Nutrient uptake, protein content and oil yield

Introduction

Soybean (*Glycine max* L. merill) often designated as 'Golden Bean' is an important pulse as well as oilseed crop of the world. It is a legume crop belonging to family leguminaceae and subfamily papilionaceae. Being a legume plant, soybean has ability to fix atmospheric nitrogen with the help of bacteria and to add organic matter in the soil, thereby increasing the productivity of soil.

India ranks fifth in area and production of soybean the World. The total production in India was 108.02 lakh mt on an area of 9.62 million hectares with productivity of 1124 kg ha^{-1}. In Maharashtra soybean production was 36.50 lakh mt on an area of 30.70 lakh ha with productivity of 1189 kg ha^{-1}. Average consumption in India is 4812 mt giving the sixth rank in largest consumer of soybean in World (Anonymous, 2008) [1].

In last 2-3 decades there is substantial increase in command area and there by intensive cropping. It has resulted in increase in cost of fertilizer and low purchasing power of farmer has restricted the use of chemical fertilizers for increasing crop production. Under such condition it has become imperative to use all the available resources of plant nutrients in a judicious way to minimize, fertilizers use and at the same on a long term basis. The base for crop production and improvement of soil fertility is mineral nutrition. Therefore efficient management of organic and inorganic sources is a prerequisite for achieving continuous productivity of cops in an economically and ecologically sustainable manner.

Thus for maintenance of the soil fertility, productivity and soil health with the FYM, compost and other organic sources are gaining importance. Biofertilizers cannot replace chemical fertilizers, but certainly are capable of reducing their input. Seed inoculation with effective Rhizobium inoculants is recommended to ensure adequate. Nodulation and N_2 fixation for maximum growth and yield of pulse crop.

Materials and methods

The field experiment was conducted at Research farm, Department of soil science and Agril. Chemistry, College of Agriculture, Latur during *Kharif* season of 2008-2009. using soybean (MAUS-71) as a test crop and plant samples were used for its chemical analysis i.e. N,P, K and S, for this plant samples were digested with diced mixture and plant extract was prepared.

From this extract P Content was determined by Ammonium phosphomolybdate method by using spectrophotometer (Jackson, 1967) [6] while K content in plant estimated on flame photometer (Piper, 1966) [10]. Nitrogen and sulphur was estimated by Subbiah and Asija, 1956 [11] and Williams and Steinberg, 1959 method respectively. Uptake of N, P, K and S was concluded from their concentration in plant. The experiment was conducted in RBD comprising three replications and nine treatments *viz*. T_1 (100%RDF.), T_2 (100%RDF+10 t FYM ha^{-1}) T_3 (50%RDF +10 t FYM ha^{-1} +Biofertilizer). T_4 (100% RDF+ 10 t FYM ha^{-1} +Biofertilizer). T_5 (100%RDF+45Kg S ha^{-1}). T_6 (50%RDF+10t FYM ha^{-1} +45kg S ha^{-1}). T_7 (100%RDF+45kg s ha^{-1} +Biofertilizer). T_8 (50% RDF+10 t FYM ha^{-1} +45kg S ha^{-1} + Biofertilizer). T_9 (100%RDF+ 10 t FYM ha^{-1} +45kg S ha^{-1} + Biofertilizer). Plant samples were collected at important critical growth stages i.e. at branching, flowering, pod formation and maturity stage. After harvesting of the soybean, seed samples were analysed for protein and oil content by standard methods.

Results and discussion

Effect of INM on nutrient content and uptake:

Influence of INM on concentration and uptake of nutrients at various critical growth stages of soybean. The results on N content and uptake by soybean are presented in table 1. It is evident from the results that the concentration and uptake of nitrogen by soybean crop significantly affected due to different treatments.

The nitrogen concentration at all the critical growth stages of soybean was significantly higher with the treatment T_9 (100% RDF +10 t FYM ha^{-1} + 45 kg S ha^{-1} + Biofertilizer.) except at branching stage. At branching stage results with respect to N concentration in plant were non-significant. However, lower (4.03 %) and higher (4.40%) concentration of N was recorded due to treatment T_1 and T_9 respectively. At flowering content of N (3.90%) was highest with treatment T_9 it was at par with treatment T_8 (50%RDF+10tFYM ha^{-1} +45kg S ha^{-1}+ Biofertilizer). Content of N (3.40%) at pod formation was maximum with treatment T_9 followed by T_8, T_4, T_2, T_6 and T_3 (50%RDF +10 t FYM ha^{-1} +Biofertilizer). while at maturity N content in grain to straw was also highest with treatment T_9 followed by T_8, T_4, T_2 and T_6. At branching uptake of N was maximum with treatment T_9 which is significantly superior over rest of the treatment but it was at par with the treatment T_8, T_4, T_2 and T_6. At pod formation uptake of N (269.88 kg ha^{-1}) was significantly highest with the treatment T_9 and it was at par with treatment T_8, and T_4 However, at maturity uptake of N at maturity in grain straw varied from (122.62-177.17 kg ha^{-1}). Low content and uptake of N was recorded due to treatment T_1.

Table 1: Effect of INM on nitrogen content (%) and uptake (kg ha^{-1}) at various critical growth stages of soybean.

Treatment	Nitrogen content (%) in plant				N uptake (kg ha^{-1})			
	At Branching	At Flowering	At Pod formation	At maturity	At Branching	At Flowering	At Pod formation	At maturity
T_1 (100% RDF)	0.03	3.50	3.0	2.50	38.0	81.52	163.15	122.62
T_2 (100% RDF+10 t FYM ha^{-1})	4.25	3.76	3.25	2.76	69.42	114.3	213.34	154.22
T_3 (50% RDF +10 t FYM ha^{-1} + Biofertilizer)	4.14	6.64	3.16	2.66	56.29	99.88	201.17	140.22
T_4 (100% RDF+10 t FYM ha^{-1} + Biofertilizer)	4.29	3.80	3.29	2.81	75.26	119.24	233.25	159.98
T_5 (100% RDF+ 45 Kg S ha^{-1})	4.05	3.54	3.04	2.55	44.20	86.59	174.24	128.18
T_6 (50% RDF+10 t FYM ha^{-1} + 45 kg S ha^{-1})	4.17	3.70	3.20	2.70	61.92	105.64	209.05	144.41
T_7 (100% RDF+ 45 kg S ha^{-1} + Biofertilizer)	4.10	3.60	3.10	2.60	50.97	55.93	184.88	134.63
T_8 (50% RDF+10 t FYM ha^{-1} + 45 kg S ha^{-1} + Biofertilizer)	4.35	3.86	3.36	2.86	82.75	127.83	147.54	166.02
T_9 (100% RDF+10 t FYM ha^{-1} + 45 kg S ha^{-1} + Biofertilizer)	4.40	3.90	3.40	2.90	95.55	138.91	269.83	177.17
S.E.+	0.14	0.07	0.08	0.05	6.90	11.82	16.82	4.06
CD at 5%	Ms	0.21	0.24	0.15	20.66	35.38	50.36	12.14

The combined application of chemical fertilizers along with enough bulk of FYM has always stimulated the uptake of N and partly because of stimulated microbes flush and improved root growth due to congenial soil physical condition reacted by addition of heavy bulk of FYM. Kachot *et al.* (2001) [7] showed that increase in uptake of nutrients might be the outcome of increased availability of nutrients to the plant by decomposition of applied FYM application of N fixing biofertilizers enhanced the organic acids which may partly be responsible for quick release of nutrients resulting in more content of nutrients. These results substantiated the findings of Chawale *et al*. (1995) [4]. Data indicating concentration and uptake of phosphorus recorded at branching, flowering, pod formation and maturity is presented in Table 2. From the data it is observed that the concentration and uptake of phosphorus were significantly influenced. Higher concentration and uptake of P was recorded with treatment T_9 (100% RDF +10 t FYM ha^{-1} + 45kg S ha^{-1} + Biofertilizer.) than the rest of the treatments at all the growh stages of soybean. But at branching stage of soybean the treatment T_9 was at par with the treatments T_8 (50% RDF+10t FYM ha^{-1} +45 kg S ha^{-1}+ Biofertilizer).

T_4 (100 % RDF+10t FYM ha^{-1} +Biofertilizer) than the rest of the treatments at all the growth stages of soybean the treatment T_9 (100% RDF +10 t FYM h^{-1} + 45 kg S ha^{-1}+ Biofertilizer.) At pod formation and maturity stage of soybean phosphorus content (0.33%) was highest with treatment T_9 but in most of treatments *viz*. T_8, T_4, T_2, T_6, T_3 and T_7 (100% RDF+45 kg S ha^{-1} +Biofertilizer).

With respect to uptake of P it was maximum due to treatment T_9 at all the critical growth stages of soybean. Treatment T_9 was found statistically at par with the treatment T_4 and T_8 at all the growth stages of soybean.

Table 2: Effect of INM on phosphorus content (%) and uptake (kg ha^{-1}) at various critical growth stages of soybean.

Treatment	Phosphorus content (%) in plant				P uptake (kg ha-^{1})			
	At Branching	At Flowering	At Pod formation	At Branching	At Flowering	At Pod formation	At Branching	At Flowering
T_1 (100% RDF)	0.400	0.340	0.290	0.230	3.790	7.916	15.85	11.27
T_2 (100% RDF+10 t FYM ha $^{-1}$)	0.425	0.367	0.314	0.256	6.913	10.99	21.43	14.07
T_3 (50% RDF +10 t FYM ha $^{-1}$ +Biofertilizer)	0.415	0.355	0.305	0.245	5.670	9.693	19.02	13.00
T_4 (100% RDF +10 t FYM ha^{-1} +Biofertilizer)	0.431	0.372	0.320	0.261	7.600	11.63	22.7	14.85
T_5 (100% RDF + 45 Kg S ha^{-1})	0.405	0.345	0296	0.235	4.390	8.56	16.9	11.81
T_6 (50% RDF + 10 t FYM ha^{-1} +45 kg S ha $^{-1}$)	0.420	0.360	0.310	0.250	6.263	10.31	20.31	13.36
T_7 (100% RDF + 45 kg S ha^{-1} +Biofertilizer)	0.409	0.351	0.300	0.241	5.033	9.103	17.94	12.47
T_8 (50% RDF+10 t FYM ha $^{-1}$ +45 kg S ha^{-1} + Biofertilizer)	0.436	0.376	0.326	0.266	8.276	12.49	23.94	15.38
T_9 (100 % RDF+10tFYM ha $^{-1}$ +45 kg S ha^{-1} + Biofertilizer)	0.440	0.380	0.330	0.270	9.560	13.05	26.24	16.47
S.E.+	0.009	0.006	0.010	0.10	0.724	1.163	1.778	0.556
CD at 5%	0.27	0.019	0.031	0.30	2.168	3.483	5.322	1.66

It was also at par with T_2 and T_4 treatment at flowering and pod formation stage of soybean crop.

Further data reveals that the uptake of P by soybean was lowest with the treatment T1 at all the growth stages. Among the different stages of the crop higher uptake was recorded at pod formation stages.

Chaturvedi and Chandel (2005.) [5] found that highest uptake of N, P and K were observed with recommended dose of N,P, K + FYM @ 10 tones ha^{-1} resulted in higher uptake than recommended dose of NPK alone, This might be owing to increased supply of nutrient sources to the crop as well as due to the indirect effect resulting from reduced loss of organically supplied nutrients. Rao and Shaktawat (2002) [12] observe that application of FYM @ 10 tonnes ha^{-1} increased uptake of P significantly over the control. The magnitude of increase in mean uptake of p due to FYM was 17.2 % over the control. It appears that availability of those nutrients increased in soil under organic manure application as reflected by higher pod and higher yields that have resulted into more uptakes of these nutrients. The results on K content and uptake by soybean are presented in table 3.

The K content was significantly higher with the treatment T_9 at all the growth stages of soybean crop, but it was at par with the treatment T_9 at all the growth stages of soybean crop, but it was at par with the treatment T_2 (100% RDF+10t FYM ha^{-1}), T_4 (100% RDF+ 10 t FYM ha^{-1} + Biofertilizer), and T_8 (50% RDF+10t FYM ha^{-1} + 45kg S ha^{-1} + Biofertilizer). At branching, flowering and maturity stage of soybean crop. At pod formation stage the treatment T_9 was at par with the treatment T_8 only. The treatment T_1 (control) recorded

Table 3: Effect of INM on potassium content (%) & uptake (kg ha^{-1}) at various critical growth stages of soybean.

Treatment	Pota#ssium content (%) in plant				Potassium uptake (kgha-1)			
	At Branching	At Flowering	At Pod formation	At maturity	At Branching	At Flowering	At Branching	At maturity
T_1 (100% RDF)	1.95	1.60	1.10	0.60	18.62	36.92	60.00	29.46
T_2 (100% RDF+10 t FYM ha $^{-1}$)	2.20	1.86	1.37	1.08	36.18	55.84	93.44	60.37
T_3 (50% RDF +10 t FYM ha $^{-1}$ +Biofertilizer)	2.10	1.75	1.26	0.90	29.95	47.65	79.47	47.73
T_4 (100% RDF+10 t FYM ha^{-1} +Biofertilizer)	2.25	`1.90	1.40	1.10	39.41	60.12	99.77	62.62
T_5 (100% RDF+45 Kg S ha^{-1})	2.0	1.66	1.17	0.70	21.97	40.98`	66.98	35.11
T_6 (50% RDF+10 t FYM ha^{-1} +45 kg S ha $^{-1}$)	2.15	1.80	1.30	0.95	32.17	50.49	84.89	50.79
T_7 (100 % RDF+ 45 kg S ha^{-1} +Biofertilizer)	2.06	1.70	1.20	1.81	25.23	44.15	71.66	41.89
T_8 (50% RDF+10 t FYM ha $^{-1}$ +45 kg S ha^{-1} + Biofertilizer)	2.31	1.97	1.46	1.16	44.42	65.10	160.51	67.49
T_9 (100% RDF+10 t FYM ha $^{-1}$ + 45 kg S ha^{-1} + Biofertilizer)	2.35	2.0	1.50	1.20	51.21	70.36`	18.99	7338
S.E.+	0.05	0.07	0.05	0.07	3.88	5.55	8.05	4.55
CD at 5%	0.19	0.21	0.17	0.21	11.63	16.62	24.11	13.62

significantly lower concentration of k at all the growth stages of soybean crop.

In respect to uptake of k at different growth stages the treatment T_9 recorded significantly higher uptake of k over rest of the treatments at all the critical growth stages of soybean however the treatment T_9 was at par with the treatments T_8 and T_4 at branching and pod formation stage. It was also at par with $T_{8,}$ T_4 and T_2 at flowering and maturity stage, of soybean crop. Further data revealed that the uptake of k was lowest due to treatment T_1 (control). It was 18.62, 36.92 60.0 and 29.46 kg ha^{-1} at branching, flowering, pod formation and maturity stage of crop respectively.

This increase in concentration and uptake of k by soybean crop might be due to combined application of organic, inorganic and biofertilizers resulted into greater availability of nutrients in soil (Rao and Shaktawat, 2002) [12].

The results on sulphur content and uptake by soybean are presented in table 4. Content and uptake of sulphur was maximum with treatment T_9 (100% RDF +10 t FYM ha^{-1} + 45 kg S ha^{-1}+ Biofertilizer.) at various critical growth stages of soybean.

The sulphur concentration in soybean plant due to treatment was T_9 2.00, 1.8, 1.4 and 1.2 percent at branching, flowering, pod formation and maturity stage of respectively. This was significantly higher than the rest of the treatments. However, the treatment T_9 was at par with T_8 (50%RDF+10 t FYM ha^{-1} + 45kg S ha^{-1} + Biofertilizer), and T_7 (100%RDF+45kg S ha^{-1} + Biofertilizer). At all the growth stages of the crop.

Table 4: Effect of INM on sulphur content (%) and uptake (kg ha^{-1}) at various critical growth stages of soybean.

Treatments	Sulphur Content (%) in Plant				Sulphur Uptake (Kg ha^{-1})			
	At Branching	At Flowering	At Pod formation	At minority	At Branching	At Flowering	At Pod formation	At minority
T_1 (100% RDF)	1.60	1.20	1.10	0.80	15.25	27.28	60.17	43.48
T_2 (100% RDF+10 t FYM ha $^{-1}$)	1.70	1.35	1.17	1.90	27.95	40.63	80.02	52.0
T_3 (50% RDF +10 t FYM ha $^{-1}$ +Biofertilizer)	1.64	1.26	1.14	0.84	22.069	34.03	71.80	44.61
T_4 (100% RDF+10 t FYM ha^{-1} +Biofertilizer)	1.74	1.44	1.21	0.84	30.93	45.23	86.10	53.46
T_5 (100% RDF+45 Kg S ha^{-1})	1.86	1.62	1.29	1.05	20.77	39.58	73.70	52.73
T_6 (50% RDF+10 t FYM ha^{-1} +45 kg S ha $^{-1}$)	1.80	1.55	1.25	1.0	28.72	44.62	81.66	53.50
T_7 (100 % RDF+ 45 kg S ha^{-1} +Biofertilizer)	1.90	1.70	1.33	1.11	23.33	44.15	79.63	57.44
T_8 (50% RDF+10 t FYM ha $^{-1}$ +45 kg S ha^{-1} + Biofertilizer)	1.96	1.76	1.36	1.16	37.34	58.15	100.20	67.20
T_9 (100% RDF+10 t FYM ha $^{-1}$ + 45 kg S ha^{-1} + Biofertilizer)	2.00	1.80	1.40	1.20	44.55	64.22	110.76	73.24
S.E.+	0.076	0.069	0.042	0.053	3.602	5.070	7.10	3.14
CD at 5%	0.229	0.208	0.125	0.1613	10.78	15.17	21.25	9.14

It was at par withT_8 (50%RDF + 10 t FYM ha^{-1} + 45kg S ha^{-1} + Biofertilizer), at branching. flowering, pod formation and maturity stage of soybean crop. Further data revealed that the treatment T_1 (control) recorded lower concentration of soybean with respect to uptake of S by soybean crop, it was observed from the treatment T_9 recorded significantly higher uptake of S at all the critical growth stages of soybean crop. It was 44.55, 64.22, 110.7 and 73.24 kg ha^{-1} at branching, flowering, pod formation and maturity stage of soybean. These values of S uptake due to T_9 treatment were at par with the values observed due to T_8 treatment. Treatment T_1 (control) recorded significantly lower uptake of s than the rest of treatments at all the critical growth stages of soybean crop might be due to higher concentration of S in plant and increased dry matter yield of soybean crop. Singh *et al.* (2004) also found that S content both in seed and straw and uptake of S was increased significantly up to 40 kg S ha^{-1} over control and 20 kg S ha^{-1}higher content of sulphur in seed and straw together with increased seed and straw yield might be the result of greater uptake of sulphur.

Effect of INM on Protein content and yield

The results regarding protein content and protein Yields are presented in table 5. The data presented in table 5 indicated that treatment T_9 (100% RDF) +10 t FYM ha^{-1} + 45 kg S ha^{-1} + Biofertilizer.) recorded highest protein content (40.68) in soybean than the rest of the treatments, but it was at par with the treatment T_8(50% RDF +10 t FYM ha^{-1} +45kg S ha^{-1} + Biofertilizer), With respect to protein yield the treatment T_9 was significantly superior over rest of the treatments. Both protein content and protein yield was recorded lower due to T_1. Oil and protein content of the soybean grains increased significantly with increasing doses of fertilizer.

Soybean responded more to sulphur in increasing oil and protein content (Nagar *et al* 1993) [9].

Table 5: Effect of INM on quality and oil yield of soybean

Treatment details	Hundred seed weight	Protein content (%)	Protein yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
T_1 (100% RDF)	12.2	38.2	842.7	18.0	398.0
T_2 (100% RDF+10+ FYM ha $^{-1}$)	13.0	40.1	1024.2	19.3	492.7
T_3 (50% RDF +10+ FYM ha $^{-1}$ + Biofertilizer)	12.9	38.9	939.8	18.8	455.8
T_4 (100% RDF+10+ FYM ha^{-1} + Biofertilizer)	13.5	40.2	1033.4	19.6	504.5
T_5 (100% RDF+45 Kg S ha^{-1})	12.3	38.4	891.2	18.4	427.2
T_6 (50% RDF+10t FYM ha^{-1} + 45 kg S ha $^{-1}$)	13.1	40.2	991.1	19.2	474.9
T_7 (100% RDF+ 45 kg S ha^{-1} + Biofertilizer)	12.7	38.6	919.1	18.6	444.1
T_8 (50% RDF+10 t FYM ha $^{-1}$ + 45 kg S ha^{-1} + Biofertilizer)	14.0	40.3	1066.9	19.8	524.8
T_9 (100% RDF+10 t FYM ha $^{-1}$ +45 kg S ha^{-1} + Biofertilizer)	14.6	40.6	1111.1	20.0	546.2
S.E.+	0.2	0.19	1.56	0.04	13.90
CD at 5%	0.6	0.57	4.68	0.13	41.90

Bacchav and Sabale (1996) [3] found that the application of 50 kg N ha^{-1} half through urea and half through FYM produced maximum protein and oil content of soybean, which was significantly superior over fertilizers or organic sources.

Effect of INM on Oil content and yield

The data presented in table 5 indicated that both oil content and oil yield in soybean was significantly influenced by different treatments, it is evident from the results that the treatment. T_9 (100% RDF + 10 t FYM ha^{-1} + 45kg S ha^{-1}+ Biofertilizer.) recorded maximum oil content (20.00) which was significantly, superior over all other treatments oil yield was significantly highest with the treatments T_9 and was at par with treatment T_8 (50% RDF+10t FYM ha^{-1} + 45kg S ha^{-1} + Biofertilizer). According to Aulakh *et al* (1990) [2] synthesis of phospholipids and oil storage organs are proteinacious in nature. Sulphur addition accelerated the metabolic pathway of protein thus increasing protein and oil content in seeds. Majumdar *et al* (2001) [8] observed that the maximum protein and oil content were recorded with a treatment combination of 60 kg P_2O_5 and 40 kg S ha $^{-1}$ this increase in oil content with p application could be due to the fact that p helped in synthesis of fatty acids and their etherification by accelerating biochemical reactions in glyoxalate cycle and the increase in oil content with S application might be due to the fact that S helped in oil synthesis by enhancing the level of thioglucosides.

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