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Full Research Article

Impact of Various Organic, Inorganic Nutrient Sources and Bio-fertilizers on Growth, Yield, and Post Harvest Soil Status of Soybean

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Abstract

A field experiment was carried out on clayey soil at the experimental farm, AICRP on Integrated Farming Systems, VNMKV, Parbhani, India during *kharif* 2015 to evaluate the to study the effect of various organic, inorganic nutrient sources and bio fertilizers on growth yield, yield attributes and post harvest soil status of soybean. The experiment was laid down in split plot design with 18 treatment combinations comprising of two FYM levels i.e. 2.5 t FYM ha^{-1}, 5 t FYM ha^{-1}; three nutrient levels i.e. 75% RDF (22.5:45:22.5 NPK kg ha^{-1}), 100% RDF (30:60:30 NPK kg ha^{-1}) and 125% RDF (37.5:75:37.5 NPK kg ha^{-1}) as main plot treatments and three bio fertilizers i.e. Rhizobium, PSB and Rhizobium+PSB as sub-plot treatments. Application of 5 t FYM ha^{-1}, 125% RDF and Rhizobium+PSB recorded significantly higher plant growth attributing characters viz., Plant height (54.56 cm), number of functional leaves (21.37), leaf area (1323.47 cm^2), number of branches (6.46), dry matter accumulation $plant^{-1}$ (32.61 g) and as well as yield contributing characters viz., number of pods $plant^{-1}$ (34.26), no. of seeds $plant^{-1}$ (74.70), seed (1409 kg ha^{-1}), straw (1763 kg ha^{-1}) and biological yield (3172 kg ha^{-1}). The nutrient status after harvest of soybean was highest in the treatment combination of receiving 5 t FYM ha^{-1}, 125% RDF (37.5:75:37.5 NPK kg ha^{-1}), Rhizobium+PSB.

1. Introduction

In India area, production and productivity of soybean during 2015 is 11.1 mha, 8.64 mt and 781 kg ha^{-1}, respectively, in Maharashtra area, production and productivity of soybean during 2015 is 3.58 mha, 2.78 mt and 776 kg ha^{-1}, respectively. And in Marathwada area, production and productivity of soybean during 2015 is 1.3 mha, 0.69 mt and 670 kg ha^{-1}, respectively (Anonymous, 2015). Inadequate use of fertilizer is one of the most important reasons for low productivity. Nutrient interaction is one of the components of balanced nutrition, apart from nitrogen, phosphorus and some of the secondary and micronutrient are considered necessary for increase in growth and yield of Soybean. Integrated fertility management using chemical fertilizer and bio-fertilizers along with manures will facilitate restoration, enhancement and maintenance of soil productivity at high level which in turn will ensure profitable and intensive agriculture (Sikka, 2013). Application of organic manures (FYM) alone sustains the fertility of soil by improving the physical, chemical and biological condition of the soil. Use of organic manure provide good substrate for the growth of microorganisms and maintain favourable nutritional balance and soil physical property. Good yield can be achieved by balanced nutrition along with nitrogen and adequate supply of phosphate and potash is highly important.

Bio-fertilizer is considered as most important agricultural input in the context of organic farming. Bio-fertilizer do not supply nutrient directly to the crop plant but have capacity to fix atmospheric nitrogen and convert insoluble phosphate in to soluble form by using bio-agents such as *Bradyrhizobium* and Phosphate Solubilizing Bacteria (PSB), respectively. Which help in improve the productivity Co inoculation of these two bio-fertilizers has shown encouraging results in enhancing crop productivity and improving soil fertility. In view of above consideration, the present field experiment was planned and conducted during *kharif* 2015 with the objective to study the effect of organic, inorganic and bio-fertilizers on growth, yield attributes, yield of soybean and post harvest nutrient status of soil.

2. Materials and Methods

The field experiment was conducted at AICRP on Integrated

Farming Systems, VNMKV, Parbhani during *kharif* 2015. The soil of the experimental field was clayey in texture, low in available N (186.42 kg ha^{-1}), medium in available P (17.18 kg ha^{-1}), and high in available K (519.18 kg ha^{-1}) with pH 7.9. The experiment was laid down in split plot design with 18 treatment combinations comprising of two FYM levels i.e. 2.5 t FYM ha^{-1} (F_1), 5 t FYM ha^{-1} (F_2); three nutrient levels i.e. (N_1) 75% RDF (22.5:45:22.5 NPK kg ha^{-1}), (N_2) 100% RDF (30:60:30 NPK kg ha^{-1}) and (N_2) and 125% RDF (37.5:75:37.5 NPK kg ha^{-1}) as main plot treatments and three bio fertilizers i.e. (B_1) Rhizobium, (B_2) PSB and (B_3) Rhizobium+PSB as sub-plot treatments. FYM was applied according to the treatments. Fertilizer viz., nitrogen, phosphorus and potassium were applied to respective plots as the treatment^{-1} by using the urea, single super phosphate and muriate of potash uniformly in the lines opened for sowing as the treatment^{-1}. The species used in bio fertilizers were Rhizobium (*Bradyrhizobium japonicum*), PSB (*Pseudomonas* spp.) (Phosphate solubulizing bacteria), Rhizobium+PSB (Phosphate solubulizing bacteria). The soil samples after harvest of the crop was analyzed for status of available N, P and K. The available N was analyzed by Kjeldhal method (Piper, 1966), available P (Olsen et al., 1954), available K by flame photometer (Hanway and Heidal, 1967). The statistical analysis was done as suggested by Panse and Sukhatme (1967).

3. Results and Discussion

3.1. *Effect on growth attributes*

Significant variations were examined with the growth and yield attributing characters as well as yield and nutrient status of soybean crop due to the different nutrient levels used in the experiment.

The data presented in Table 1 indicated that the application of FYM differed significantly regarding to the plant height. The rate of increasing plant height was highest during 30–60 DAS in both levels of FYM indicating grand growth of the crop. Application of 5 t FYM ha^{-1} recorded tallest plant height (53.38 cm), maximum number of functional leaves (21.28). The tendency of leaf area in respect of FYM was just same as that of number of functional leaves. The results are conformity with Airsing et al. (2014). They reported significant differences in plant height due to application of different levels of FYM.

The number of branches (6.29) and total dry matter accumulation plant^{-1} (32.09 g) was found maximum with the application of 5 t FYM ha^{-1} followed by 2.5 t FYM ha^{-1}. This might be due to larger leaf area in application of 5 t FYM ha^{-1}. Larger leaf area resulted in more photosynthetic activities and more accumulation of carbohydrates which is turn to increasing dry matter accumulation. Akpalu et al. (2014). also found significant variation in number of branches due to application of different levels of FYM.

In case of fertilizer levels, application of 125% RDF resulted in better results among different growth characters viz., plant height (54.56 cm), number of functional leaves (20.10), leaf area (1323.47 cm^2), number of branches (6.14) and total dry matter plant^{-1} (32.61 g) followed by 100% RDF and lower

Table 1: Growth attributes of soybean crop at harvest as influenced by different treatments

Treatment	PH	NL	LA (cm^2)	NB	DMC
FYM levels-main plot					
F_1: @ 2.5 t FYM ha^{-1}	49.81	18.26	1304.98	5.16	29.63
F_2: @ 5 t FYM ha^{-1}	53.38	21.28	1319.34	6.29	32.09
SEm±	0.71	0.44	3.03	0.15	0.60
p<0.05	2.26	1.41	9.56	0.49	1.89
Nutrient levels-main plot					
N_1: 75% RDF	48.15	17.96	1299.63	5.14	28.71
N_2: 100% RDF	52.07	20.10	1313.38	5.89	31.26
N_3: 125% RDF	54.56	21.26	1323.47	6.14	32.61
SEm±	0.88	0.55	3.71	0.19	0.73
p<0.05	2.77	1.73	11.71	0.61	2.31
Bio fertilizers-sub plot					
B_1: Rhizobium	51.36	19.17	1302.45	5.50	30.38
B_2: PSB	48.99	18.78	1302.45	5.21	29.80
B_3: Rhizobium+PSB	54.43	21.37	1322.59	6.46	32.41
SEm±	0.85	0.62	3.37	0.21	0.42
p<0.05	2.48	1.82	9.84	0.62	1.23
Interactions					
F×N					
SEm±	1.24	0.77	5.25	0.27	1.03
p<0.05	NS	NS	NS	NS	NS
F×B					
SEm±	1.20	0.88	4.76	0.30	0.59
p<0.05	NS	NS	NS	NS	NS
N×B					
SEm±	1.47	1.08	5.84	0.36	0.73
p<0.05	NS	NS	NS	NS	NS
F×N×B					
SEm±	2.08	1.53	8.26	0.52	1.03
p<0.05	NS	NS	NS	NS	NS
General mean	51.59	19.77	1312.16	5.72	30.86

PH: Plant height; NL: Number of leaves; LA: Leaf area; NB: No. of branches; DMC: Dry matter accumulation

growth attributes recorded with application of 75% RDF. Same consequence was quoted by Dhutraj (2011) on the aspect of growth characters.

Among the bio fertilizers, Application of different bio-fertilizers exerted significant effect on Plant height, number of functional leaves plant^{-1}, leaf area expansion plant^{-1}, number of branches plant^{-1}. Application of Rhizobium+PSB in combination recorded tallest plant height (54.43 cm), Maximum numbers of functional leaves plant^{-1} (21.37), leaf area expansion plant^{-1} (1322.59), number of branches plant^{-1} (6.46) over Rhizobium and PSB alone at all growth stages of crop. Maruthi et al. (2014); Ahsan et al. (2012) reported the same results.

Increase in dry matter accumulation plant^{-1} was cumulative effect of increase in various growth characters viz., number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}. The mean total dry matter accumulation plant^{-1} was influenced due to different bio-fertilizer. Significantly higher dry matter plant^{-1} (32.41 g) was recorded with the application of Rhizobium+PSB in combination which was significantly superior over Application of Rhizobium and PSB alone at all stages of crop growth. Bodake et al. (2014) reported similar kind of findings.

3.2. *Effect on yield attributes*

In soybean the yield contributing characters are viz., number of pods plant^{-1}, pods weight plant^{-1}, seed weight plant^{-1}, number of seeds pod^{-1} and number of seeds plant^{-1} were recorded and showed in Table 2.

The yield contributing characters viz., pod weight plant^{-1} (8.04 g), seed weight plant^{-1} (5.86 g), number of seed pod^{-1} (2.15), number of pods plant^{-1} (34.00), number of seeds plant^{-1} (72.46) and 1000 seeds weight (80.97 g) were higher with application of 5 t FYM ha^{-1} followed by 2.5 t FYM ha^{-1}. Chaturvedi et al. (2012) found significant differences in yield attributing characters due to application of different levels of FYM ha^{-1}.

Similarly, among the fertility levels the yield attributing characters viz., pod weight plant^{-1} (8.21 g), seed weight plant^{-1} (5.93 g), number of seeds pod^{-1} (2.16), number of pods plant^{-1} (34.77), number of seeds plant^{-1} (74.75) and 1000 seeds weight (81.03 g) were registered higher with application of 125% RDF followed by 100% RDF and lowest with 75% RDF. The same result was observed by Kang et al. (2012).

In case of bio-fertilizers yield attributing characters were differed significantly. The performance of application of Rhizobium+PSB as regard to number of pods plant^{-1} (34.26), pod weight plant^{-1} (8.25 g), seed weight plant^{-1} (5.97 g), number of seed pod^{-1} (2.17), number of seeds plant^{-1} (74.70) was superior as compare to use of Rhizobium and PSB alone. Similar results were recorded by Kang et al. (2012).

3.3. *Effect on yield*

Seed yield was a function of yield attributes. Similarly biological yield of crop plant has a close relationship with its economical yield. Straw yield was an augmenting effect of

Table 2: No. of pods plant^{-1}, No. of seeds pod^{-1}, Pod weight plant^{-1} (g), No. seeds plant^{-1}, Seed weight plant^{-1} (g) and Test weight (g) as influenced by different treatments

Treatment	NPH	NSP	PWP	NSP	SWP	TW
FYM levels-main plot						
F_1: @ 2.5 t FYM ha^{-1}	30.18	2.13	7.41	64.13	5.20	79.70
F_2: @ 5 t FYM ha^{-1}	34.00	2.15	8.04	72.46	5.86	80.97
SEm±	0.62	0.01	0.16	1.69	0.14	0.89
p<0.05	1.95	NS	0.51	5.34	0.46	NS
Nutrient levels-main plot						
N_1: 75% RDF	28.86	2.12	7.13	60.86	4.97	79.49
N_2: 100% RDF	32.64	2.14	7.84	69.27	5.69	80.49
N_3: 125% RDF	34.77	2.16	8.21	74.75	5.93	81.03
SEm±	0.76	0.01	0.19	2.07	0.17	1.09
p<0.05	2.39	NS	0.62	6.55	0.56	NS
Bio fertilizers-sub plot						
B_1: Rhizobium	31.71	2.13	7.66	67.54	5.40	80.27
B_2: PSB	30.31	2.12	7.27	62.65	5.22	79.78
B_3: Rhizobium+PSB	34.26	2.17	8.25	74.70	5.97	80.96
SEm±	0.82	0.02	0.14	2.02	0.15	1.10
p<0.05	2.40	NS	0.43	5.91	0.43	NS
Interactions						
F×N						
SEm±	1.07	0.02	0.28	2.94	0.25	1.54
p<0.05	NS	NS	NS	NS	NS	NS
F×B						
SEm±	1.16	0.02	0.20	2.86	0.21	1.55
p<0.05	NS	NS	NS	NS	NS	NS
N×B						
SEm±	1.42	0.03	0.25	3.50	0.26	1.90
p<0.05	NS	NS	NS	NS	NS	NS
F×N×B						
SEm±	2.01	0.05	0.36	4.96	0.36	2.69
p<0.05	NS	NS	NS	NS	NS	NS
General mean	32.09	2.14	7.73	68.30	5.53	80.34

NPH: No. of pods at harvest; NSP: No. of seeds pod^{-1}; PWP: Pod weight plant^{-1} (g); NSP: No. of seeds plant^{-1}; SWP: Seed weight plant^{-1} (g); TW: Test weight (g)

increased growth through plant height, number of branches and number of leaves plant^{-1}. Data presented in Table 3 indicated that the higher seed (1402 kg ha^{-1}), straw (1761 kg ha^{-1}) and biological yield (3163 kg ha^{-1}) of soybean crop was recorded with the application of 5 t FYM ha^{-1} followed by 2.5 t FYM ha^{-1} (1194, 1526 and 2721 kg ha^{-1} respectively).

Whereas in the level of fertilizers higher seed yield (1402 kg ha^{-1}), straw yield (1747 kg ha^{-1}) and biological yield (3149 kg ha^{-1}) were produced with the application of 125% RDF followed by 100% RDF and lower with application of 75% RDF. Maruthi et al. (2014) reported same results.

Among the bio-fertilizer treatments application of Rhizobium+PSB recorded profound effect on seed yield (1409 kg ha^{-1}), straw yield (1763 kg ha^{-1}) and biological yield (3172 kg ha^{-1}) which was significantly superior over the application of Rhizobium and PSB alone. Similar results were reported by Dhage and Kachhave et al. (2010).

Table 3: Seed, straw, biological yields (kg ha^{-1}) and harvest index (%) as influenced by different treatments

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
FYM levels-main plot				
F_1: @ 2.5 t FYM ha^{-1}	1194	1526	2721	43.88
F_2: @ 5 t FYM ha^{-1}	1402	1761	3163	44.32
SEm±	28.42	34.18	56.97	---
p<0.05	89.55	107.72	179.53	---
Nutrient levels-main plot				
N_1: 75% RDF	1183	1521	2704	43.75
N_2: 100% RDF	1309	1669	2978	43.95
N_3: 125% RDF	1402	1747	3149	44.52
SEm±	34.81	41.87	69.78	---
p<0.05	109.68	131.93	219.88	---
Bio fertilizers-sub plot				
B_1: Rhizobium	1258	1605	2863	43.93
B_2: PSB	1227	1571	2798	43.85
B_3: Rhizobium+PSB	1409	1763	3172	44.41
SEm±	26.12	38.45	56.71	---
p<0.05	76.26	112.25	165.53	---
Interactions				
F×N				
SEm±	49.22	59.21	98.69	---
p<0.05	NS	NS	NS	---
F×B				
SEm±	36.94	54.38	80.20	---
p<0.05	NS	NS	NS	---
N×B				
SEm±	45.25	66.61	98.22	---
p<0.05	NS	NS	NS	---
F×N×B				
SEm±	63.99	94.20	138.91	---
p<0.05	NS	NS	NS	---
General mean	1298	1645	2943	44.07

3.4. *Effect on chemical studies*

The soil characteristics viz., available nitrogen, phosphorus and potassium differed from preliminary portions. The results which were gained after harvest were positive. Very slight increase in available nitrogen, phosphorus and potassium with the application of different levels of FYM, nutrients and bio fertilizers are observed.

The data in Table 4 revealed that the differences in available nitrogen of the soil were found significant. The amount of available nitrogen is more with the application of 5 t FYM ha^{-1} (214.13 kg ha^{-1}). The available nitrogen significantly increased with increasing nutrient levels. The higher amount of nitrogen available in soil (214.33 kg ha^{-1}) was observed with application of 125% RDF followed by 100% RDF and 75% RDF. The available nitrogen significantly influenced by application of different bio-fertilizers. Application of Rhizobium+PSB was recorded higher amount of available nitrogen (224.50 kg ha^{-1}) and found significantly superior over rest of the treatments.

The data revealed that the differences in available of the soil were found significant. The amount of available phosphorus is more with the application of 5 t FYM ha^{-1} (20.15 kg ha^{-1}). The available phosphorus significantly increased with increasing nutrient levels. The higher amount of phosphorus available in soil was observed with application of 125% RDF (20.27 kg ha^{-1}) and it was found significantly superior over application of 100% RDF and 75% RDF. The data on available phosphorus was influence significantly by application of different bio-fertilizers. Application of Rhizobium+PSB was recorded higher amount of available phosphorus (20.70 kg ha^{-1}) and found significantly superior over rest of the treatments.

As far as available potassium is concerned, it was influenced significantly with application of different levels of FYM. The higher amount of available potassium in soil was found with the application of 5 t FYM ha^{-1} (513.66 kg ha^{-1}). The data furnished in Table 4 indicated that the available potassium was influenced significantly by application of different nutrient levels. The higher amount of available potassium in soil (576.50 kg ha^{-1}) was found with the application of 125% RDF and it was found significantly superior over application of 100% RDF and 75%

Table 4: Available NPK (kg ha^{-1}) status in soil as influenced by different treatments after harvest of the crop

Treatment	N	P	K
FYM levels-main plot			
F_1: @ 2.5 t FYM ha^{-1}	210.03	19.10	509.00
F_2: @ 5 t FYM ha^{-1}	214.13	20.15	513.66
SEm±	0.56	0.24	1.45
p<0.05	1.77	0.76	4.58
Nutrient levels-main plot			
N_1: 75% RDF	209.72	18.88	505.83
N_2: 100% RDF	212.20	19.73	511.66
N_3: 125% RDF	214.33	20.27	516.50
SEm±	0.69	0.29	1.78
p<0.05	2.17	0.93	5.62
Bio fertilizers-sub plot			
B_1: Rhizobium	209.05	18.50	507.00
B_2: PSB	202.70	19.69	504.66
B_3: Rhizobium+PSB	224.50	20.70	522.33
SEm±	0.78	0.40	1.54
p<0.05	2.30	1.19	4.52
Interactions			
F×N			
SEm±	0.97	0.41	2.52
p<0.05	NS	NS	NS
F×B			
SEm±	1.11	0.57	2.19
p<0.05	NS	NS	NS
N×B			
SEm±	1.36	0.70	2.68
p<0.05	NS	NS	NS
F×N×B			
SEm±	1.93	0.99	3.79
p<0.05	NS	NS	NS
General mean	212.08	19.63	511.33

RDF. The amount of available potassium found more with the application of Rhizobium+PSB (522.33 kg ha^{-1}) which was significantly superior over the application of Rhizobium and PSB alone.

3.5. *Effect on quality studies*

The data presented in Table 5 revealed that the oil content of soybean was not influenced significantly due to the different treatments and their interaction. The mean oil content was 19.77%. The data on protein content was found non-significant by various treatments and their interactions. The mean protein content of soybean was recorded 39.63%.

3.6. *Interaction effect*

The interaction effect of all treatment viz., F×N, F×B, N×B, F×N×B on influence of any trait were found to be non-significant.

Table 5: Oil content and protein content of soybean as influenced by different treatments

Treatment	Oil content (%)	Protein content (%)
FYM levels-main plot		
F_1: @ 2.5 t FYM ha^{-1}	19.41	39.28
F_2: @ 5 t FYM ha^{-1}	20.13	39.97
SEm±	0.27	0.22
p<0.05	NS	NS
Nutrient levels-main plot		
N_1: 75% RDF	19.25	38.98
N_2: 100% RDF	19.97	39.89
N_3: 125% RDF	20.09	40.01
SEm±	0.33	0.27
p<0.05	NS	NS
Bio fertilizers-sub plot		
B_1: Rhizobium	19.61	39.58
B_2: PSB	19.54	39.21
B_3: Rhizobium+PSB	20.16	40.10
SEm±	0.21	0.48
p<0.05	NS	NS
Interactions		
F×N		
SEm±	0.47	0.39
p<0.05	NS	NS
F×B		
SEm±	0.29	0.69
p<0.05	NS	NS
N×B		
SEm±	0.36	0.84
p<0.05	NS	NS
F×N×B		
SEm±	0.51	1.19
p<0.05	NS	NS
General mean	19.77	39.63

4. Conclusion

Maximum growth, yield attributes, yield and post harvest nutrient status could be achieved by judicious application of

5 t FYM ha^{-1}, 125% RDF and Rhizobium+PSB. Therefore, it was concluded that increasing dose of FYM ha^{-1}, RDF and use of Rhizobium+PSB may result in the better performance of soybean crop.

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