Integrated Nutrient Management for Soybean (*Glycine max* L. Merrill) in Rainfed Vertisols of Malwa Plateau in Madhya Pradesh

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ABSTRACT: A field experiment was conducted at All India Coordinated Research Project for Dryland Agriculture Centre, RVSKVV, College of Agriculture, Indore during *kharif* of 2015 and 2016 on soybean (var. JS 95-60). Nine treatments were tested viz. T_1: Control, T_2: 100% NPK, T_3: 100% NPK + Zn (20 kg ha^{-1}), T_4: 100% NPK + Zn (20 kg ha^{-1}) + S (10 kg ha^{-1}), T_5: 100% NPK + S (10 kg ha^{-1}), T_6: 10 t ha^{-1} FYM + 50% NPK, T_7: 10 t ha^{-1} FYM + (*Rhizobium* + PSB) + 50% NPK, T_8: 10 t ha^{-1} FYM + (*Rhizobium* + PSB) + 50% NPK + Zn + S, and T_9: 10 t ha^{-1} FYM + (*Rhizobium* + PSB) + 50% NPK + 5 t ha^{-1} residues + Zn + S. Treatment T_9 gave the highest soybean yield (1156 kg ha^{-1}), gross returns (Rs. 46240 ha^{-1}) and B:C ratio (2.48) compared to other treatments. The uptake of N, P, K and S by soybean was also higher in T_9 as compared to rest of the treatments. Lowest values were recorded in T_1 treatment (control).

Key words: Soybean, integrated nutrient management, nutrient uptake, vertisols

Introduction

Sustainable agriculture involves successful management of resources for increased agricultural production to satisfy changing human needs and maintaining soil and natural resources. Integrated nutrient management practices are one of the approaches for sustainable agriculture production. It involves combined application of chemical fertilizers along with organic manures, green manures, biofertilizers and other organic recyclable materials for crop production. Integrated nutrient management encourages the use of in-house organics waste; thus it saves on the cost of fertilizers for crop production and enhancing nutrient use efficiency (Thakur *et al.,* 2011). By keeping these views, the present investigation was carried out in All India Coordinated Research Project for Dryland Agriculture,College of Agriculture, Indore, Madhya Pradesh to know the effect of integrated nutrient management on soybean under rainfed condition during *kharif* seasons of 2015 and 2016.

Materials and Methods

A field experiment was conducted at All India Coordinated Research Project for Dryland Agriculture Centre, College of Agriculture, Indore during 2015 and 2016 with various treatments of inorganic fertilizers, organics and biofertilizers under rainfed condition in soybean (JS 95-60) in vertisols of Malwa Plateau. The experiment site is located at 22^o 42'10" N latitude & 75^o 54' 13" E longitude at an elevation of 555 meter above mean sea level. The climate of the area is hot dry semi-arid with an average annual rainfall ranging from 825-1100 mm. Length of growing period is 90-120 days. The mean annual value of potential evaporation (PE) and rainfall are 1781.52 mm and 919.30 mm, respectively. The treatment consisted *viz.* T_1- Control; T_2- 100% NPK; T_3-100% NPK + Zn (20 kg ha^{-1}); T_4-100% NPK + Zn + S (10 kg ha^{-1}); T_5-100% NPK + S; T_6-10 t FYM + 50% NPK; T_7-10 t FYM + (*Rhizobium* + PSB) + 50% NPK; T_8-10 t FYM + (*Rhizobium* + PSB) + 50% NPK + Zn + S and T_9-10 t FYM + (*Rhizobium* + PSB) + 50% NPK + 5 t Residues + Zn + S. The experiment was laid out in RBD with three replications in *kharif* season. The experimental soil was low in N (180 kg ha^{-1}), medium in P (12.8 kg ha^{-1}) and high in K (333 kg ha^{-1}) with EC of 0.45 dS/m, pH of 7.4 and was clayey. All the package of practices were adopted as per the recommendation for growing soybean.

Results and Discussion

Yield attributes

The mean value of yield attributes including plant height, pods per plant, total dry matter and 100 grain weight of soybean at harvest during 2015 and 2016 as influenced by various treatments are given in Table 1. The maximum plant height (30.9 cm), pods/plant (19.6) total dry matter (TDM) (14.6 g) and 100 grain weight (13.1 g) were recorded with treatment - T_9 (10 t FYM + (*Rhizobium* + PSB) + 50% NPK + 5 t Residues + Zn + S). These values were significantly higher over control. The lowest values of the above parameters were recorded in control treatment. Integrated use of chemical fertilizers, manures and biofertilizers have the capacity to produce more plant height, pods per plant, TDM and 100 grain weight as observed in treatment T_7 to T_9. Treatments T_8 and T_9 were at par with respect to all yield attributes. Increase in plant height of soybean was also observed by Neupane *et al*. (2021) through the use of biofertilizers and compost with recommended dose of fertilizer.

Table 1: Effect of various treatments on yield attributes of soybean (2015 and 2016)

	Treatment	Plant height (cm)	Pods/ plant	TDM/ plant (g)	100 grain wt. (g)
T_1	Control	26.9	12.7	10.2	11.4
T_2	100% NPK	29.7	15.5	11.2	11.9
T_3	100% NPK + Zn (20 kg ha^{-1})	30.4	15.8	11.9	11.9
T_4	100% NPK + Zn + S	28.4	15.6	11.7	12.7
T_5	100% NPK + S (10 kg ha^{-1})	29.7	13.8	10.5	13.0
T_6	10 t FYM + 50% NPK	30.3	16.1	11.8	12.7
T_7	10 t FYM + (*Rhizobium* + PSB)+ 50% NPK	29.4	17.6	13.2	11.9
T_8	10 t FYM+ (*Rhizobium* + PSB) + 50% NPK+Zn+S	30.5	18.2	11.2	12.2
T_9	10 t FYM + (*Rhizobium*+PSB) +50% NPK+5 t Residues+Zn+S	30.9	19.6	14.6	13.1
	SEm (±)	1.1	2.1	0.7	0.3
	CD at 5%	3.3	6.1	2.1	0.9

Seed yield

The average of two years data (2015 and 2016) presented in Table 2 indicates that the highest seed yield of soybean (1156 kg ha^{-1}) was recorded in the treatment T_9 i.e. 10 t ha^{-1} FYM+(*Rhizobium*+PSB) + 50% NPK+5t ha^{-1} residues+Zn+S followed by T_8: 10 t ha^{-1} FYM + (*Rhizobium*+PSB)+50% NPK+Zn+S (1082 kg ha^{-1}), T_7: 10 t FYM + (*Rhizobium* + PSB) + 50% NPK (1068 kg/ ha), T_6: 10 t FYM+50% NPK (1030 kg/ ha), T_4: 100% NPK+Zn + S (996 kg/ha), T_5: 100% NPK+S 10 kg ha^{-1} (957 kg/ha) and T_2: 100% NPK (923 kg/ha). The lowest seed yield of soybean was obtained in control treatment (731 kg ha^{-1}) which was significantly inferior to all other treatments.

The seed yield levels were very low (376 kg ha^{-1} to 753 kg ha^{-1}) in 2015 due to heavy rainfall during *kharif* season particularly in July (576.7 mm) and August (306.7 mm) months. The results clearly indicate that July seemed to be the most erosive month as it recorded highest erosion index of 39.27 followed by August and June 20.50, 14.36 which ultimately reflected low yield of soybean. On the other hand, soybean seed yield ranged from 1085 to 1559 kg ha^{-1} during 2016. These levels are quite good as the distribution of rainfall was good during this year.

The highest seed yield of soybean (1156 kg ha^{-1}) was recorded in the treatment T_9: 10 t ha^{-1} FYM + (*Rhizobium*+PSB) + 50% NPK+5 t ha^{-1} residues+Zn+S. Combination of Zn and S application along with 100% NPK (T_4) produced significantly higher seed yield (996 kg ha^{-1}) over control (T_1). Integrated approach of inorganic fertilizers application along with organics and biofertilizers have the capacity to produce significantly higher seed yield as obtained in T_8 (1082 kg ha^{-1}) and T_9 (1156 kg ha^{-1}). The results with significant effects of organics and chemical fertilizers are in agreement with Srinivasa Rao (2011). The present study clearly indicated that balanced nutrition through only chemical fertilizers did not sustain the seed yield of soybean as compared to integrated use of organic and chemical fertilizers. The increase in soybean yield may be attributed to improvement in yield attributing characters *viz.* plant height and pods per plant. Similar results were also obtained by Patel *et al*. (1994) and Ghodke *et al.* (2018). Chaturvedi and Chandel (2005) also obtained maximum soybean yield by supplementing the inorganic fertilizers with organic sources like FYM by improving soil environment which helped to improve soybean growth and yield contributing characters.

Table 2: Effect of various treatments on seed yield and economics of soybean

	Treatment	Seed yield (kg ha^{-1})		Mean yield (kg ha^{-1})	Cost of cultivation (Rs. ha^{-1})	*Gross returns (Rs. ha^{-1})	B:C ratio
		2015	2016				
T_1	Control	376	1085	731	16300	29220	1.79
T_2	100% NPK	659	1186	923	20000	36900	1.85
T_3	100% NPK+Zn (20 kg ha^{-1})	634	1189	912	20200	36460	1.80
T_4	100% NPK+Zn + S	694	1298	996	20300	39840	1.96
T_5	100% NPK+S (10 kg ha^{-1})	664	1249	957	20100	38260	1.90
T_6	10 t FYM+50% NPK	692	1367	1030	18150	41180	2.27
T_7	10 t FYM + (*Rhizobium* + PSB) + 50% NPK	729	1406	1068	18350	42700	2.33
T_8	10 t ha^{-1} FYM + (*Rhizobium* + PSB) + 50% NPK+Zn+S	741	1423	1082	18650	43280	2.32
T_9	10 t ha^{-1} FYM + (*Rhizobium*+PSB) + 50% NPK+5 t ha^{-1} Residues+Zn+S	753	1559	1156	18650	46240	2.48
	SEm (±)	58	66	62	-	-	-
	CD at 5%	164	188	176	-	-	-

*Market price of soybean - Rs 40/kg

The gross returns and B:C ratio also followed the same trend as observed in case of soybean seed yield (Table 2). The maximum gross return and B:C ratio of Rs 46240 ha^{-1} and 2.48 was observed in treatment T_9 followed by T_8- Rs. 43280 ha^{-1} and 2.32. Similar results were reported earlier by Singh and Singh (2012) in wheat.

Nutrient uptake by soybean

The data with respect to nutrient uptake given in Table 3 revealed that the uptake of N, P, K and S by soybean seed and straw and total uptake of these nutrients in relation to different treatments under consideration was mainly governed by biomass yield as expected. Treatment T_9 recorded significantly higher uptake of N (104.4 kg ha^{-1}), P (15.1 kg ha^{-1}), K (43.8 kg ha^{-1}) and S (11.32 kg ha^{-1}) by soybean plant as compared to any level of application of fertilizer source. Lowest uptake of all the nutrients was recorded in the control. Thakur *et al*. (2011) also observed maximum nutrient use efficiency in soybean - wheat cropping sequence by integration of chemical and organic sources. Treatment T_6 and T_8 showed non-significant differences in respect of N, P, K and S uptake by soybean plant (Table 3). Although, these treatments showed significantly lower NPK and S uptake by soybean plant as compared to T_9.

Table 3: Effect of various treatments on nutrient uptake (kg ha^{-1}) by soybean (2015 and 2016)

	Treatment	Nutrient uptake (kg ha^{-1})			
		N	P	K	S
T_1	Control	48.4	3.4	20.4	1.02
T_2	100% NPK	62.8	4.7	23.9	2.90
T_3	100% NPK + Zn (20 kg ha^{-1})	67.8	8.0	27.9	6.53
T_4	100% NPK + Zn + S	79.9	7.0	28.6	7.00
T_5	100% NPK + S (10 kg ha^{-1})	76.9	8.4	28.8	7.00
T_6	10 t ha^{-1} FYM + 50% NPK	85.6	11.2	31.8	7.76
T_7	10 t ha^{-1} FYM + (*Rhizobium* + PSB) + 50% NPK	86.7	9.7	34.8	6.77
T_8	10 t ha^{-1} FYM + (*Rhizobium* + PSB) + 50% NPK + Zn + S	86.6	11.4	35.4	7.63
T_9	10 t ha^{-1} FYM + (*Rhizobium* + PSB) + 50% NPK + 5 t ha^{-1} residues + Zn + S	104.4	15.1	43.8	11.32
	S Em (±)	4.6	1.1	1.4	0.3
	CD at 5%	13.8	3.4	4.2	0.9

Conclusion

Based on the results of two years study, it may be concluded that seed yield and yield attributing characters of soybean can be substantially increased by integrated application of organic manure with inorganic fertilizer. The maximum seed yield (1156 kg ha^{-1}), gross return (Rs. 46240 ha^{-1}) with B:C ratio (2.48) as well as uptake of N, P, K and S by soybean was obtained with the integration of 10 t ha^{-1} FYM + (*Rhizobium*+ PSB) + 50% NPK + 20 kg Zn + 10 kg S + 5 t ha^{-1} residues (T_9). Integrated nutrient management approach may be very much remunerative and sustainable under rainfed condition of Malwa plateau for growing of soybean in vertisols.

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