YIELD AND PROFIT OF SOYBEAN (*GLYCINE MAX* L. MERRILL) AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT UNDER *VERTISOLS* OF CHHATTISGARH PLAINS

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Abstract: A field experiment was conducted in *kharif* season of 2009 at the Instructional Farm, Indira Gandhi Krishi Vishwavidyalya, Raipur to study the "Productivity and profitability of soybean (*Glycine max* L. Merrill) as influenced by integrated nutrient management practices under *Vertisols* of Chhattisgarh plains". The application of recommended level of organic and inorganic fertilizers with biofertilizer showed the superiority for plant height, number of leaves, number of branches, dry matter accumulation, leaf area and yield attributes viz. pods per plant, seeds per pods, seeds per plant and 100 seed weight. The combine application of 20:60:40 kg NPK ha^{-1} + 5 t FYM ha^{-1} + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} + *Rhizobium* + PSB were recorded highest yield (21.41 q ha^{-1}) and economic net return (15226.89 Rs ha^{-1}) however the benefit: cost ratio (1.55%) was recorded maximum with the application of recommended dose of NPK (20:60:40 kg ha^{-1}, respectively). Soil physico-chemical and biological properties as well as nutrient status in the soil were also improved. The Nutrient content in soil after harvest of the crop was found 260:20:320 kg NPK ha^{-1} respectively and 0.75% organic content higher over control.

Keywords: Yield, Soyabean, Crops, Chhattisgarh

INTTRODUCTION

Soybean is an important legume and oilseed crops of the world. It has the cheapest source of protein amongst vegetable and animal protein. Hence, it called 'poor mans meat' and miracle bean it contains 40% protein and 20% of excellent quality of edible oil. The protein quality of soybean is equivalent to that of meat, milk products and eggs. It is generally grown as a rainy season crop under rainfed situation predominantly in *Vertisols* and associated soils. It has ability to fix atmospheric nitrogen with the help of *Rhizobium* symbiotically, thus help in enrichment of soil nutrient status. Fertilizer is an important input for successful crop production. Soybean utilized high quantities of nutrients from soil and if not fertilized properly, it causes mining of soil nutrients. Application of inorganic fertilizers alone increases the production cost besides affecting the soil properties negatively in long run. Therefore, it is necessary to maintain soil fertility for sustainable production of soybean through judicious use of fertilizers. Supplementation of zinc and magnesium also enhance the productivity of soybean and soybean based cropping system. In present scenario of sustainability, farmers need more yield with optimum resources without disturbance of physical condition of soil. Therefore, to attain higher production, it is necessary to apply optimum and integrated use of the nutrients with proper combination of organic, inorganic and micronutrients as well as inoculation with bio-fertilizer to soybean.

MATERIAL AND METHOD

The field experiment was conducted at Block No.3 in the Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh in *Kharif* season- 2009. The soil of the experiment was clayey in texture (*Vertisols*) and was low, medium and high in available N, P and K, respectively. The experiment was laid out in Randomized Block Design with thrice replicated. The treatment consist 10 integrated nutrient management *viz.* T_1- Control (no fertilizers), T_2-100% RDF (20:60:40 kg NPK ha^{-1}), T_3- FYM 10 t ha^{-1}, T_4-50% RDF (12.5:40:30 kg NPK ha^{-1}) + FYM 10 t ha^{-1}, T_5- 50% RDF (12.5:40:30 kg NPK ha^{-1}.) + FYM 5 t ha^{-1} +*Rhizobium* + PSB, T_6- T_2 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}, T_7- T_3 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}, T_8- T_4 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}, T_9- T_5 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}, T_{10}- 100% RDF (20:60:40 kg NPK ha^{-1}) + FYM 10 t ha^{-1} + Zinc 5 kg + Mg 5kg ha^{-1} + *Rhizobium* + PSB. Soybean variety 'JS- 335' was sown in rows with spacing of 30 cm and plant tp plant spacing of 10 cm on Jully 11, 2009 using seed rate 75 kg/ha and was harvested on October 27, 2009.

Climate of this region is sub- humid with an average annual rainfall of about 1200-1400 mm and the crop received 1009.9 mm of rainfall during its crop growth. The maximum temperature during its period varied between 28^0C in the third week of July to 33.7^0C in the second week of October, whereas, minimum temperature varies between 18.8^0C in the third week of October to 26.0^0C in the second week of July.

Energetic was estimated in Mega Jules (MJ ha^{-1}) with reference to the standard values suggested by Mittal *et al.* (1985) are taken for energy estimation. Statistical analysis of data was carried out using standard analysis of variance technique as described in "Statistical Procedure for Agricultural Research" by Gomez and Gomez (1984) for significant treatment effects, standard error of means (SEm$\pm$) and critical differences were calculated at 5 per cent level of significance.

RESULT AND DISCUSSION

Discussion on soybean growth parameters

A progressive increase in number of leaves (76.46 at 60 DAS), number of branches (5.20), plant height (47.26 cm) and total dry matter(18.31 g plant^{-1}) production was observed with the combined application of 20:60:40 kg NPK ha^{-1} + 5 t FYM ha^{-1} + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} + *Rhizobium* + PSB followed by the application of 25: 80: 60 kg NPK ha^{-1} + 5 t FYM ha^{-1} + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} and minimum growth attributes were recorded under control (Table 1). The increase in plant height, plant dry weight with *Rhizobium* and PSB could be due to the better nodulation and greater availability of phosphorus. 100% NPK ha^{-1} with bio-fertilizer was responsible for increased number of leaves plant^{-1}, resulting in higher production photosynthesis and assimilation rate, metabolic activities and cell division which consequently increased the growth characters like- plant height and stem girth.

The increased in plant height may be due to the regular availability of different organic and inorganic sources and bio-fertilizer which helped in acceleration of various metabolic process (Kumar *et al*. 2005). The Biological N fixation by *Rhizobium*, greater release of P by phosphate solublizing bacteria and synthesis of growth promoting hormones and vitamins by these microbes might have favored the plant growth characters. The higher dry matter leading to the more of photosynthesis translocated towards roots, the root colonization by *Rhizobium* and PSB and also enhanced nodulation of soybean roots due to favorable rhizosphere created by the addition of FYM in addition to the adequate supply of essential plant nutrients might be the factor responsible for higher dry weight (Singh and Rai, 2004).

Discussion on yield attributes and yield of soybean

Beneficial effect of the combined application of 20:60:40 kg NPK ha^{-1} + 5 t FYM ha^{-1} + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} + *Rhizobium* + PSB seen as an increase the yield attributes and yield of soybean (Table 2). The combined application of 20:60:40 kg NPK ha^{-1} + 5 t FYM ha^{-1} + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} + *Rhizobium* + PSB gave the greater yield attributes like- pods per plant (47.3), seeds per pods (2.80), seeds per plant (113.13), 100 seed weight (12.62 g) which ultimately gave the highest yield 21.41 q ha^{-1} which was 65.07% more over untreated control and grain yield also increases 43.3% and 51.4% with the application of 100% RDF and 100% RDF Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1} respectively. The higher yield in above treatment might be due to improvement in growth and yield component. Looking into the result of seed and stover yields of soybean crop, it was observed that these characters were influenced significantly due to different integrated nutrient management. The variation in seed yield could be attributed to the variation in yield components *viz.* number of pods plant^{-1}, number of seeds pod^{-1}, number of seeds plant^{-1} and 100 seed weight.

Combine use of manures and inorganic fertilizer played a significant role in increasing the above and below ground dry matter, water use efficiency, pod number and weight resulting in higher seed and oil yield of soybean (Ghosh *et al.*, 2005). The higher yield response might be due to synergistic effect of phosphorus and biofertilizer and involved transformation of energy in higher value of growth and yield attributes (Bhaskar *et al.*, 2000 and Thanki *et al.*, 2005). Higher yield attributes may be due to the favorable effect of PSB on root growth and there by increase root activity.

Discussion on economics and energetic

Economics of the present study revealed that among the all integrated nutrient management treatments, application of 20:60:40 kg NPK ha^{-1} + 5 t FYM ha^{-1} + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} + *Rhizobium* + PSB gave the highest net return (15226.89 Rs ha^{-1}), however the benefit: cost ratio (1.55%) was found to be highest with the application recommended dose of NPK (20:60:40 kg ha^{-1}) (Table 2). The results corroborate the finding of Deshmukh *et al.* (2005) and Vyas *et al.* (2009). The highest gross and net returns were due to highest seed and stover yield. The benefit: cost ratio was highest due to the sustainability in increased yield and decrease cost of cultivation. The high cost due to the higher quantity of fertilizer and its unit cost.

The data show that the maximum energy input (9.099 MJ ha^{-1}) with maximum energy output (65.59 MJ ha^{-1}) were registered with the application of 20:60:40 kg NPK ha^{-1} + 5 t FYM ha^{-1} + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} + *Rhizobium* + PSB, whereas the energy output: input ratio (12.6%) as well as energy use efficiency (5.33 MJ× 10^{-3} ha^{-1}) registered under control (Table 3).

NPK uptake and nutrient content in soil

The plants were analyzed for NPK uptake and soils were analyzed for the NPK and organic carbon (Table 4). It was noticed that the NPK uptake by soybean crop was found to be highest 175.5:15.2:155.25 kg NPK ha^{-1}, which is 103.7, 80.5, and 159.1% respectively more over control due to combined application of 20:60:40 kg NPK ha^{-1} + 5 t FYM ha^{-1} + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} + *Rhizobium* + PSB (Table-3). Similar results were found by Wandhekar *et al.* (2005). The increase in nodulation might have resulted in higher amount of nitrogen and phosphorus uptake by plants and there by resulted in better vegetative growth. Higher uptake of N and P due to the co-inoculation of bio-fertilizers which enhance the nitrogenase and nitrate- reductase enzyme activity in the soil leading to more nitrogen fixation by *Rhizobium* and increased the availability of phosphorus in soil due to greater solublization.

The NPK and organic content in soil after harvest of the crop was found 20.8, 97.8, 14.3 and 38.8% respectively higher over control with the application of 20:60:40 kg NPK ha^{-1} + 5 t FYM ha^{-1} + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} + *Rhizobium* + PSB. The N content in soil increased due to the all treatments except control. The response of soybean to FYM application may be attributed to better nutrient availability enhanced inherent nutrient supply capacity of the soil and its favorable effect of soil physical and biological properties (Hati *et al.*, 2005). Improved nodulation, nitrogenase and nitrarte–reductase enzymes activity and N fixation by *Rhizobium* and improved solublization of P through secretion of organic acids and activity of phosphatase enzyme by PSB (Pal, 1997) and their combine influence might have resulted in improved soil N and P status at harvest.

In summary, it can be stated that combine application of 20:60:40 kg NPK ha^{-1} + 5 t FYM ha^{-1} + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} + *Rhizobium* + PSB produced significantly maximum seed yield of soybean followed by 100% RDF + Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} The treatment T4-50% RDF (12.5:40:30 kg NPK ha^{-1}) + 5 t FYM ha^{-1} and 50% RDF + 5 t FYM ha^{-1}+ Zn 5 kg ha^{-1} + Mg 5kg ha^{-1} produced statistically similar yield with former treatment, which is clearly indicated that even 50% of organic and 50% of inorganic with micronutrient and biofertilizer gave higher yield as good as application 100% of all nutrients.

Table 1: Effect of integrated nutrient management on growth attributes of soybean

Treatments	Plant height At harvest	No of Leaves (60DAS)	No of branches	Dry Matter (g $plant^{-1}$)	Leaf area cm^{-2} $plant^{-1}$	Chlorophyll content in leaves (SPAD)
T_1 - Control (no fertilizers)	36.97	60.38	4.06	12.25	902.20	40.41
T_2 - 100% RDF (20:60:40 kg NPK ha^{-1})	44.96	70.73	4.53	17.47	1422.89	44.16
T_3 - FYM 10 t ha^{-1}	39.70	64.43	4.13	13.89	1010.21	40.87
T_4 - 50% RDF + FYM 10 t ha^{-1}	40.06	69.03	4.40	15.57	1259.01	42.66
T_5 - T_4 + *Rhizobium* + PSB	42.96	64.93	4.33	14.07	1134.19	41.44
T_6 - T_2 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	46.06	74.16	4.60	17.97	1593.22	45.65
T_7 - T_3 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	40.46	65.33	4.26	14.32	1022.83	41.47
T_8 - T_4 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	43.56	66.60	4.53	16.44	1291.59	43.21
T_9 - T_5 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	42.87	67.00	4.46	15.10	1256.64	43.09
T_{10} - T_2 + T_7 + *Rhizobium* + PSB	47.26	76.46	5.20	18.31	1775.76	49.88
SEm$\pm$	**1.05**	**2.87**	**0.18**	**1.23**	**54.11**	**1.61**
CD (P = 0.05)	**3.12**	**8.52**	**0.55**	**3.65**	**160.71**	**4.80**

Table 2: Effect of integrated nutrient management on yield attributes and yields of soybean

Treatments	Pods $plant^{-1}$	Seeds pod^{-1}	Seeds $plant^{-1}$	100 seed weight (g)	Seed yield (q/ha)	Yield increases over control	Production (kg ha^{-1} day^{-1})
T_1 - Control (no fertilizers)	31.80	2.31	80.20	10.40	12.97		12.00
T_2 - 100% RDF (20:60:40 kg NPK ha^{-1})	40.66	2.65	104.60	11.76	18.60	43.4%	17.16
T_3 - FYM 10 t ha^{-1}	33.13	2.39	81.20	11.13	15.43	18.9%	14.25
T_4 - 50% RDF + FYM 10 t ha^{-1}	36.00	2.60	91.26	11.39	17.62	35.8%	16.30
T_5 - T_4 + *Rhizobium* + PSB	33.60	2.53	85.96	11.53	17.03	31.3%	15.70
T_6 - T_2 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	42.80	2.66	106.20	11.83	19.64	51.4%	18.15
T_7 - T_3 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	33.20	2.57	84.33	11.36	16.80	29.5%	15.50
T_8 - T_4 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	38.60	2.64	94.80	11.60	18.50	42.6%	17.03

T_9 - T_5 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	37.60	2.62	93.33	11.46	18.37	41.6%	16.90
T_{10} - T_2 + T_7 + *Rhizobium* + PSB	45.73	2.80	113.13	12.36	21.41	65.07%	19.7
SEm±	2.82	0.08	6.35	0.30	1.34		1.24
CD (P = 0.05)	8.40	0.26	18.86	0.90	3.98		3.69

Table 3: Effect of integrated nutrient management on an energy input and output relationship of soybean

Treatments	Net return (Rs ha^{-1})	Benefit: Cost ratio	Energy output: input ratio	Energy use efficiency (MJ× 10^{-3} ha^{-1})	
				Seed	Stover
T_1 (Control -no fertilizers)	9614.39	1.29	12.86	4.21	5.33
T_2 (100% RDF, 20:60:40 kg NPK ha^{-1})	14779.39	1.55	9.05	3.13	3.56
T_3 (FYM 10 t ha^{-1})	10866.86	1.15	7.83	2.54	3.28
T_4 (50% RDF + FYM 10 t ha^{-1})	12648.14	1.20	7.10	2.34	2.92
T_5 (50% RDF + FYM 5 t ha^{-1} + *Rhizobium* + PSB)	12784.64	1.34	8.35	2.83	3.36
T_6 (T_2 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1})	14874.89	1.37	9.44	3.22	3.76
T_7 (T_3 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1})	11287.89	1.05	7.97	2.69	3.20
T_8 (T_4 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1})	12419.64	1.05	7.01	2.41	2.76
T_9 (T_5 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1})	13136.14	1.22	6.48	2.39	2.45
T_{10} (T_2 + T_3+ Zinc 5 kg + Mg 5kg ha^{-1} + *Rhizobium* + PSB)	15226.89	1.18	7.16	2.35	2.91
SEm±	-	-	0.69	0.27	0.29
CD (P = 0.05)	-	-	2.06	0.82	0.86

Table 4: Effect of integrated nutrient management on nutrient status of the soil and nutrient uptake.

Treatments	Concentration of nutrients in soil				Total uptake of nutrients (kg ha^{-1})		
	Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})	Organic carbon (%)	N	P	K
T_1 - Control (no fertilizers)	225.6	11.40	282.60	0.54	97.63	8.71	61.86
T_2 - 100% RDF (20:60:40 kg NPK ha^{-1})	260.3	18.10	306.36	0.64	185.30	13.99	145.80
T_3 - FYM 10 t ha^{-1}	242.66	16.03	287.16	0.66	155.60	10.96	110.40
T_4 - 50% RDF + FYM 10 t ha^{-1}	252.33	16.76	291.80	0.71	158.26	11.36	121.96
T_5 - T_4 + *Rhizobium* + PSB	267.00	19.66	316.70	0.67	168.03	14.83	148.73
T_6 - T_2 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	264.66	19.40	312.80	0.66	187.23	14.43	144.40
T_7 - T_3 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	248.33	17.93	308.46	0.65	160.73	11.73	105.3
T_8 - T_4 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	259.16	19.56	306.33	0.70	165.23	11.56	138.43
T_9 - T_5 + Zinc 5 kg ha^{-1} + Mg 5kg ha^{-1}	266.66	19.80	318.40	0.67	183.96	13.26	145.61
T_{10} - T_2 + T_7 + *Rhizobium* + PSB	272.66	22.56	323.23	0.75	198.96	15.73	160.30
SEm±	3.81	0.85	2.10	0.01	2.81	0.84	3.33
CD (P = 0.05)	11.33	2.54	6.24	0.04	7.47	2.51	9.90

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