SITE SPECIFIC NUTRIENT MANAGEMENT IN SOYBEAN (*GLYCINE MAX* L. MERRILL)

Divya Shah, Chandresh Kumar Chandrakar, Aparna Jaiswal, Ashish Kumar Chandrakar

Department of Agronomy, college of agriculture, J.N.K.V.V., Indore (M.P.)
Department of Agronomy, college of agriculture, I.G.K.V.V., Raipur (M.P.)
Department of rural technology, G.G.V., Bilaspur (C.G.)
Department of Agronomy, College of Agriculture, J.N.K.V.V. (M.P)

Abstract : A field experiment was conducted during *kharif* season, 2008 on medium black clay soils (Vertisols) having pH 7.80 at Research Farm, College of Agriculture Indore (M.P.). To study the "Site specific nutrient management in soybean (*Glycine max* L. Merill.)". The experiment was conducted in randomized block design having nine treatments - T_1 - Fertilizer dose as per farmers' practice (50 kg DAP/ha), T_2 - T_1 + 40 kg S/ha through gypsum + 6.25 kg Zn/ha through $ZnCl_2$, T_3 - Recommended dose of fertilizer (RDF) i.e. 23.5 kg N, 60 kg P_2O_5, 23.5 kg K_2O through DAP and MOP , T_4 - T_3 + 40 kg S/ha through gypsum + 6.25 kg Zn/ha through $ZnCl_2$, T_5 - 150% of RDF i.e. 35.2 kg N, 90 kg P_2O_5, 35.2 kg K_2O through DAP and MOP, T_6 - T_5 + 40 kg S/ha through gypsum + 6.25 kg Zn/ha through $ZnCl_2$, T_7 - Soil test based RDF for 25 q/ha yield target (28.95:74.92:9.5 N:P_2O_5:K_2O kg/ha given through DAP and MOP), T_8 - T_7 + 40 kg S/ha through gypsum + 6.25 kg Zn/ha through $ZnCl_2$, T_9 - Control. The treatments were replicated 4 times. The treatment T_6 (150% RDF + 40 kg S + 6.25 kg Zn/ha) significantly produced maximum plant growth (i.e. plant height, branches/plant, dry matter accumulation, number of nodules/plant, leaf area/plant, LAI, chlorophyll content), seed yield/plant (10.03 g), biological yield (3400kg/ha), grain yield (1673 kg/ha) and straw yield (1727 kg/ha) followed by T_5 (150% RDF). The maximum net return of Rs. 20525/ha along with highest benefit: cost ratio of 3.00 was obtained with treatment T_5 (150% RDF), while gross income was highest (Rs. 31841/ha) with treatment T_6 (150% RDF+ 40 kg S + 6.25 kg Zn/ha).

Keyword: Nutrient management, Soybean

INTRODUCTION

Soybean *(Glycine max (L.) Merrill)* is basically a leguminous crop and is gaining importance as oilseed crop of India. It is rich in protein (40-42%) and oil (20-22%), which are of paramount importance in human diet and animal nutrition. In India, soybean is grown in 65.00 lakh hectares with total annual production of 76.1 lakh tones. Soybean occupies the highest area and production amongst the oilseeds in Madhya Pradesh state. In the state it is grown in 39.5 lakh hectares with total production of 25.7 lakh tones, attaining the productivity level of 1102 kg/ha. The major concern today is the low productivity of soybean in the state i.e. around 1 t / ha. One of the major concerns of low productivity is declining soil fertility. Continuous use of imbalance fertilizers has resulted in macro and micro nutrient deficiencies and is considered as the most important factor for low productivity of soybean after water management. Thus, nutritional management is one of the important constraints identified for restricting soybean productivity. Enhancement in soybean yield and its sustainability through nutritional management has been reported. Apart from limitations offered by major nutrients, correction of deficiency of sulphur (S) and zinc (Zn) in soils of Madhya Pradesh is of equal importance. In general farmers apply only nitrogen and phosphorus, which results in total negative balance of potassium and deficiency of secondary and micronutrients in the soil. Therefore, the present investigation was carried out with objectives of to find out the effect of different nutrient management strategies on plant growth, yield attributes and yield of soybean.

MATERIAL AND METHOD

The field experiment was conducted during *kharif* season of 2008 at Research Farm, College of Agriculture, Indore (M.P.). The soil of the experimental field was medium black clay (Vertisols) having pH 7.80, electrical conductivity 0.30 ds/m, organic carbon 0.45%, available N, P_2O_5, K_2O, S and Zn, 210, 13.6, 400, 9.6 kg/ha, and 0.50 mg/kg, respectively. This region belongs to sub-tropical semi-arid region having range of maximum temperature between 23º to 43º C and 6º to 25º C as minimum temperature. The average annual rainfall is 954 mm. The experiment was conducted in randomized block design having nine treatments, T_1 - Fertilizer dose as per farmers' practice (50 kg DAP/ha), T_2 - T_1 + 40 kg S/ha through gypsum + 6.25 kg Zn/ha through $ZnCl_2$, T_3 - Recommended dose of fertilizer (RDF) i.e. 23.5 kg N, 60 kg P_2O_5, 23.5 kg K_2O through DAP and MOP , T_4 - T_3 + 40 kg S/ha through gypsum + 6.25 kg Zn/ha through $ZnCl_2$, T_5 - 150% of RDF i.e. 35.2 kg N, 90 kg P_2O_5, 35.2 kg K_2O through DAP and MOP, T_6 - T_5 + 40 kg S/ha through gypsum + 6.25 kg Zn/ha through $ZnCl_2$, T_7 - Soil test based RDF for 25 q/ha yield target (28.95:74.92:9.5 N:P_2O_5:K_2O kg/ha given through DAP and MOP), T_8 - T_7 + 40 kg S/ha through gypsum + 6.25 kg Zn/ha through $ZnCl_2$, T_9 - Control. The treatments were replicated 4 times. Soybean var. 'JS.93-05' was sown @ 80 kg seed/ha in rows 45 cm apart on 20 June 2008. For analyzing the growth

pattern of the crops, five plants of uniform size were selected randomly and tagged from each treatment for recording various observations on growth and development at various growth stages.

RESULT AND DISCUSSSION

Plant height increasing progressively upto harvest, at 30, 45, 60, 75 DAS and at harvest, the maximum plant height (23.39, 42.98, 62.99, 71.68 and 68.52 cm respectively) was recorded with the application of 150% RDF + 40 kg S/ha + 6.25 kg Zn/ha (T_6) which was found significantly superior to rest of the treatments. The treatment 150 % RDF (T_5) comes next in order which was found at par with T_7 + 40 kg S/ha + 6.25 kg Zn/ha (T_8) at 60 DAS. While at 75 DAS T_6 was found at par with 150 % RDF (T_5), STCR based NPK for 25 q/ha yield target (28.95:74.92:9.5 N:P_2O_5:K_2O kg/ha) (T_7) and T_7 + 40 kg S/ha + 6.25 kg Zn/ha (T_8). At harvest T_6 was at par with T_3 + 40 kg S/ha + 6.25 kg Zn/ha (T_4), 150 % RDF (T_5), STCR based NPK for 25 q/ha yield target (28.95:74.92:9.5 N: P_2O_5:K_2O kg/ha) (T_7) and T_7 + 40 kg S/ha + 6.25 kg Zn/ha (T_8). Minimum plant height of soybean at 30, 45, 60, 75 DAS and at harvest (19.6, 33.10, 49.97, 59.76 and 56.78 cm, respectively) was found under control (T_9) which was at par with farmer's practice (50 kg DAP/ha) (T_1) at 60, 75 DAS and also with T_2 at harvest.

The dry matter accumulation per plant at different growth stages of the crop is presented in Table 2 and. It is revealed from the data that dry matter accumulation per plant continuously increased up to 75 DAS under all the treatments and rate of increase in dry matter accumulation per plant was more between 60 to 75 DAS as compared to 45 to 60 DAS, but slight reduction in dry matter accumulation per plant was noted at harvesting stage. Application of 150% of RDF along with 40 kg S and 6.25 kg Zn/ha (T_6) produced significantly more dry matter accumulation of 45.47, 67.55, 92.20 and 89.95 g per plant over rest of the treatments at 45, 60, 75 DAS and harvest, respectively but being at par with 150% of RDF (T_5), T_7 + 40 kg S/ha + 6.25 kg Zn/ha (T_8) and STCR based NPK for 25 q/ha yield target (28.95:74.92:9.5 N:P_2O_5:K_2O kg/ha) (T_7) at 45, 75 DAS and at harvest and with 150 % RDF (T_5) at 60. The minimum dry matter accumulation by soybean plant (34.67, 47.55, 59.27 and 58.87 g per plant, respectively, at each stage) was recorded under control (T_9).

Table 1. Effect of various treatments on plant height at successive growth stages

Treatments		Plant height (cm) at				
		30 DAS	**45 DAS**	**60 DAS**	**75 DAS**	**Harvest**
T_1	Fertilizer dose as per farmers' practice (50 kg DAP/ha, i.e. 9:23 N:P_2O_5 kg/ha)	19.71	33.85	50.19	61.05	58.76
T_2	T_1 + 40 kg S/ha + 6.25 kg Zn/ha	20.60	35.16	52.38	64.79	60.37
T_3	RDF(23.5:60:23.5 N:P_2O_5:K_2O kg/ha)	20.68	38.96	53.55	66.15	62.40
T_4	T_3 + 40 kg S/ha + 6.25 kg Zn/ha	20.90	38.99	54.48	69.31	65.94
T_5	150% of RDF	22.80	42.05	57.46	71.43	67.93
T_6	T_5 + 40 kg S/ha + 6.25 kg Zn/ha	23.39	42.98	62.99	71.68	68.52
T_7	STCR based NPK for 25 q/ha yield target (28.95:74.92:9.5 N:P_2O_5:K_2O kg/ha)	21.14	39.42	54.79	70.03	66.39
T_8	T_7 + 40 kg S/ha + 6.25 kg Zn/ha	22.16	40.20	57.33	70.62	67.69
T_9	Control	19.65	33.10	49.97	59.76	56.78
	SE (m) ±	0.16	0.19	0.13	0.58	1.41
	CD (at 5%)	0.47	0.56	0.38	1.70	4.12

The number of nodules per plant at different growth stages of the crop is presented in Table 2. It is revealed from the data that the number of nodules per plant continuously increased upto 60 DAS under all the treatments. Slight reduction in number of nodules per plant was noted after 60 days stage of the crop growth. Significant differences amongst the various treatments were observed at all crop growth stages. At 45, 60 and 75 DAS, the maximum number of root nodules per plant (67.19, 83.24 and 81.21, respectively) were recorded in treatment T_5 + 40 kg S/ha + 6.25 kg Zn/ha (T_6), which was statistically at par with 150% of RDF (T_5) at 45 and 60 DAS and with 150 % RDF (T_5) and T_7 + 40 kg S/ha + 6.25 kg Zn/ha (T_8) at 75 DAS and all these treatments were significantly superior to rest of the treatments. The control (T_9) resulted in significantly lowest number of root nodules per plant (37.12, 46.35 and 44.21,

respectively). Such enhancement effect might be attributed to the favorable influence of these nutrients on metabolism and biological activity and its stimulating effect on photosynthetic pigments and enzyme activity which in turn encourage vegetative growth of plant it is also supported by Agarwal *et al.* (1996), Dwivedi *et al.* (1999), Singh *et al.* (2001) and Paliwal *et al.* (2003).

Table 2. Effect of various treatments on dry matter accumulation and number of nodules per plant at successive growth stages.

Treatments		Dry matter accumulation (g/plant)				Number of nodules/plant		
		45 DAS	60 DAS	75 DAS	Harvest	45 DAS	60 DAS	75 DAS
T_1	Fertilizer dose as per farmers' practice (50 kg DAP/ha, i.e 9:23 N:P_2O_5 kg/ha)	35.50	48.85	63.87	62.40	37.35	48.47	47.09
T_2	T_1 + 40 kg S/ha + 6.25 kg Zn/ha	35.77	50.22	65.57	64.12	41.62	50.34	47.44
T_3	RDF (23.5:60:23.5 N:P_2O_5:K_2O kg/ha)	36.90	52.82	72.97	71.72	45.73	62.79	55.00
T_4	T_3 + 40 kg S/ha + 6.25 kg Zn/ha	37.90	54.45	74.12	72.47	57.28	67.55	64.06
T_5	150% of RDF	44.77	58.25	78.52	77.05	67.15	82.56	78.34
T_6	T_5 + 40 kg S/ha + 6.25 kg Zn/ha	45.47	67.55	92.20	89.95	67.19	83.24	81.21
T_7	STCR based NPK for 25 q/ha yield target (28.95:74.92:9.5 N:P_2O_5:K_2O kg/ha)	39.62	55.17	75.50	73.92	57.89	76.38	74.93
T_8	T_7 + 40 kg S/ha + 6.25 kg Zn/ha	40.85	55.30	78.10	76.07	64.14	76.40	76.66
T_9	Control	34.67	47.55	59.27	58.87	37.12	46.35	44.21
	SE (m) ±	1.97	3.46	5.47	5.29	0.61	0.62	1.92
	CD(at 5%)	5.76	10.11	15.95	15.47	1.77	1.80	5.60

Yield Attributes and yields

The number of pods per plant of soybean was significantly influenced by various treatments as presented in Table 3. Significantly higher number of pods (32.10/plant) was recorded under treatment T_5 + 40 kg S/ha + 6.25 kg Zn/ha (T_6) which was statistically at par with 150 % RDF (T_5), T_7 + 40 kg S/ha + 6.25 kg Zn/ha (T_8), T_3 + 40 kg S/ha+ 6.25 kg Zn/ha (T_4) and STCR based NPK for 25 q/ha yield target (28.95:74.92:9.5 N:P_2O_5:K_2O kg/ha) (T_7). Significantly lowest number of pods (22.00/plant) was recorded under control (T_9).

The seed yield per plant of soybean was significantly influenced by various treatments as presented in Table 3. Maximum seed yield (10.03 g/plant) was obtained with treatment T_5 + 40 kg S/ha + 6.25 kg Zn/ha (T_6) which was found at par with150% of RDF (T_5). The control (T_9) being at par with 50 kg DAP/ha (T_1), T_1 + 40 kg S/ha + 6.25 kg Zn/ha (T_2) and RDF (23.5:60:23.5 N:P_2O_5:K_2O kg/ha) (T_3) resulted in significantly lower seed yield of 5.94 g/plant.

The maximum seed index (8.50 g) of soybean was obtained in treatment 150% RDF + 40 kg S/ha + 6.25 Zn/ha (T_6) and minimum seed index (7.75 g) of soybean was obtained under control (T_9), but variation in seed index under all the treatments did not touch the level of significance (Table 3). Different treatments did not cause marked variation on seeds per pod in soybean as the statistical variations among the treatments were found to be non-significant

Biological and seed yield per hectare was significantly influenced by various treatments as presented in Table 4. Application of 150% of RDF along with 40 kg S and 6.25 kg Zn/ha (T_6) was influential in recording maximum biological (3400.50 kg/ha) and seed yield (1673.25 kg/ha) followed by 150% of RDF (T_5), T_7 + 40 kg S/ha + 6.25 kg Zn/ha (T_8) and STCR based NPK for 25 q/ha yield target (28.95:74.92:9.5 N:P_2O_5:K_2O kg/ha) (T_7). The minimum biological (2105 kg/ha) and seed yield (935.75 kg/ha) of was recorded under control (T_9).

The maximum straw yield (1727.25 kg/ha) was recorded with the application of 150% of RDF along with 40 kg S/ha and 6.25 kg Zn/ha (T_6) which was found at par with 150% of RDF (T_5). The minimum straw yield (1169.25 kg/ha) was recorded under control (T_9).

The harvest index is the economic (seed) yield expressed as the percentage of total biological (seed + straw) yield in terms of dry matter. The harvest index was significantly influenced by various treatments as presented in Table 4. However, the harvest index varied from 44.45 to 49.94 per cent. The maximum and minimum values of harvest index were registered with the treatment 50 kg DAP/ha (T_1) and control (T_9), respectively. This might be due to application of critical nutrients like sulphur and zinc along with NPK to soybean. The improvement in yield components might have resulted from favorable influence of fertilizers on the growth attributes. Pattanashetti *et al.* (2002), Singh *et al.* (2002), Srimathi *et al.* (2002) and Abraham and Lal (2003) also reported similar findings.

Table 3. Effect of various treatments on yield attributing characters

Treatments		Pods/ plant	Seeds/ pod	Seed yield (g/ plant)	Seed index (g)
T_1	Fertilizer dose as per farmers' practice (50 kg DAP/ha, i.e 9:23 N:P_2O_5 kg/ha)	24.62	3.18	6.30	7.76
T_2	T_1 + 40 kg S/ha + 6.25 kg Zn/ha	24.72	3.18	7.13	8.12
T_3	RDF (23.5:60:23.5 N:P_2O_5:K_2O kg/ha)	27.15	3.30	7.17	8.19
T_4	T_3 + 40 kg S/ha + 6.25 kg Zn/ha	29.35	3.40	7.96	8.37
T_5	150% of RDF	31.75	3.32	8.92	8.49
T_6	T_5 + 40 kg S/ha + 6.25 kg Zn/ha	32.10	3.33	10.03	8.50
T_7	STCR based NPK for 25 q/ha yield target (28.95:74.92:9.5 N:P_2O_5:K_2O kg/ha)	28.60	3.35	8.05	8.22
T_8	T_7 + 40 kg S/ha + 6.25 kg Zn/ha	29.72	3.36	8.12	8.45
T_9	Control	22.00	3.15	5.94	7.75
	SE (m) ±	1.61	0.06	0.50	0.19
	CD (at 5%)	4.69	NS	1.47	NS

Table 4. Effect of various treatments on biological, seed, straw yield and harvest index

Treatments		Biological yield (kg/ha)	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest Index
T_1	Fertilizer dose as per farmers' practice (50 kg DAP/ha, i.e 9:23 N:P_2O_5 kg/ha)	2705	1343.75	1369.25	49.94
T_2	T_1 + 40 kg S/ha + 6.25 kg Zn/ha	2854.5	1413.50	1441	49.38
T_3	RDF (23.5:60:23.5 N:P_2O_5:K_2O kg/ha)	3060.75	1501.50	1532	49.52
T_4	T_3 + 40 kg S/ha + 6.25 kg Zn/ha	3064.25	1528.75	1562.75	49.88
T_5	150% of RDF	3330.50	1615.25	1717.75	48.50
T_6	T_5 + 40 kg S/ha + 6.25 kg Zn/ha	3400.50	1673.25	1727.25	49.20
T_7	STCR based NPK for 25 q/ha yield target (28.95:74.92:9.5 N:P_2O_5:K_2O kg/ha)	3153	1573.25	1579.75	49.90
T_8	T_7 + 40 kg S/ha + 6.25 kg Zn/ha	3293	1596.75	1696.25	49.01
T_9	Control	2105	935.75	1169.25	44.45
	SE (m) ±	14.69	8.92	8.74	0.16
	CD (at 5%)	42.89	26.03	25.50	0.47

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