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Productivity and profitability of soybean (*Glycine max*) as influenced by site-specific nutrient management

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Soybean (*Glycine max* L.) is an important oilseed crop in Indian sub-continent. It is cultivated under a wide range of agro-ecological conditions in different cropping systems. The United States, Brazil and Argentina are the world's largest soybean producers and represent more than 80% of global soybean production (Anonymous, 2016a). In India, it is grown on an area of 11.18 million ha with production and productivity of 13.15 million tonnes and 1235 kg/ha, respectively (Anonymous 2016b). Soybean is a potential rainy season crop of mid-hills zone of Himachal Pradesh. It is grown as a sole as well as an intercrop with maize. The area under crop in the state is 0.6 thousand ha with an average production of 980 kg/ha (Anonymous, 2016c). Among the legumes, soybean is valued for its high protein (38-45%) as well as its high oil content (20 %). It supplies approximately 65% world meal and 22% of the world edible oil. It is soil building crop and requires less water as compared to other crops (Imran *et al.* 2017). Soybean has several advantages over other oilseed crops. It performs nitrogen fixation by establishing a symbiotic relationship with the bacterium *Bradyrhizobium japonicum.* It is also highly adaptable to varying soil and climatic conditions, giving high yields compared to other pulse crops. The growing concern about impaired soil health, declining productivity and nutrient use efficiency are compelling the farmers to use higher doses of fertilizers during last two decades. The low nutrient use efficiency and associated environmental pollution and global warming problems have raised serious concerns about the existing nutrient management practices. As such, it is high time to develop site-specific nutrient management technologies which are able to synergic crop-soil nutrient dynamics. It is an approach to feed crops with nutrients as and when needed. The application and management of nutrients are dynamically adjusted to crop needs of the location and season.

The field experiment was conducted during rainy season of 2018 at the Research Farm, Department of Agronomy, Forages and Grassland Management, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The soil of the experimental site was silty clay loam with 5.41 pH, 0.55 % OC, 130.08 kg/ha available nitrogen, 13.08 kg/ha available phosphorus and 256.3 kg/ha available potassium.The meteorological data recorded during the crop season revealed that the weekly maximum and minimum temperature ranged from 23.57ºC to 32.89 ºC and 10.14 ºC to 20.64 ºC, respectively. The mean relative humidity ranged from 24.07 to 94.93% and total of 2619.4 mm rainfall was received during the crop season.

The experiment was laid out in randomized block design comprising of seven treatments [T_1 - $N_{43}P_{43}K_{50}$ (SSNM), T_2 - $N_{43}P_{43}K_0$ (K omission), T_3 - $N_{43}P_0K_{50}$ (P omission), T_4 - $N_0P_{43}K_{50}$ (N omission), T_5 - $N_{20}P_{60}K_{40}$ (RDF), T_6 - FYM@5 t/ha (Farmer's practice) and T_7 -$N_0P_0K_0$ (control)]. Treated seeds with bavistin were used. Different doses of nitrogen, phosphorus and potassium, and farmyard manure were applied as per the respective treatment. Other package of practices recommended for the region was also followed. Data were recorded on yield attributes, yields and economics of soybean and subjected to analysis of variance with mean comparison of 5% level of significance.

Primary branches/plant, seeds per pod and test weight remained unaffected. However, numerically the highest values were noted in T_1 ($N_{43}P_{43}K_{50}$) and the lowest was in control. Similar results were also reported by Patil *et al.* (2018) in groundnut. Different treatments significantly affected number of pods per plant (Table 1). Significantly higher number of pods per plant was recordedinT_1 ($N_{43}P_{43}K_{50}$) which was statistically at par with T_5 (RDF). The lowest number of pods was recorded in absolute control. T_5 resulted in higher number of pods as compared to T_6 (farmer's practice). This might be due to fact that number of pods depends on number of branches per plant and number of flowering nodes per plant and its retention, greater photosynthesis enhanced by more nutrient uptake resulted in more flowering buds which ultimately produced more pods per plant. Chaturvedi and Chandel (2005) reported similar results in soybean.

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Table 1 Effect of different treatments on number of primary branchesper plant,pods per plant, seeds per podand test weight

Treatment	Primary branches/ plant	Pods/plant	Seeds/pod	Test weight (g)
T_1 - N_{43} P_{43} K_{50} (SSNM)	6.5	70.9	3.0	193.0
T_2 - N_{43} P_{43} K_0 (T_1- K omission)	5.8	62.4	2.83	187.3
T_3 - N_{43} P_0 K_{50} (T_1- P omission)	5.8	61.2	2.67	188.6
T_4 - N_0 P_{43} K_{50} (T_1- N omission)	5.8	60.9	2.83	190.3
T_5 - N_{20} P_{60} K_{40}(RDF)	6.5	66.8	3.0	193.0
T_6 - FYM@5t/ha(Farmer's Practice)	6.3	65.7	2.83	191.0
T_7 - N_0 P_0 K_0 (control)	5.1	58.2	2.83	186.6
SEm±	0.3	1.6	0.2	2.5
CD (P=0.05)	NS	4.9	NS	NS

SSNM-Site specific nutrient management, RDF - Recommended dose of fertilizers

Table 2 Effect of different treatments on yield, productivity, harvest index, returns, benefit cost ratio and profitability

Treatment	Yield (t/ha)		Productivity (kg/ha/day)	Harvest Index (%)	Gross return (₹ ×10³/ha)	Net return (₹ ×10³/ha)	B:C	Profitability (₹/ha/day)
	Seed	Straw						
T_1 - N_{43} P_{43} K_{50} (SSNM)	2.0	3.3	15.9	37.8	82.7	45.9	2.25	366.9
T_2 - N_{43} P_{43} K_0 (T_1-K omission)	1.5	2.8	11.9	34.4	63.1	27.2	1.76	217.8
T_3 - N_{43} P_0 K_{50} (T_1- P omission)	1.4	2.7	11.0	34.1	58.9	25.1	1.74	200.5
T_4 - N_0 P_{43} K_{50} (T_1- N omission)	1.4	2.5	11.5	35.6	60.3	24.1	1.66	192.6
T_5 - N_{20} P_{60} K_{40}(RDF)	1.8	3.0	14.3	36.9	74.2	36.7	1.98	293.4
T_6- FYM@5t/ha(Farmer's Practice)	1.7	2.9	13.3	36.6	70.0	27.6	1.65	221.1
T_7 -N_0 P_0 K_0 (control)	0.8	1.7	6.7	33.1	36.3	3.9	1.12	31.2
SEm±	0.04	0.13	0.33	1.02	1.75	1.75	0.05	14.06
CD (P = 0.05)	0.13	0.41	1.03	3.14	5.41	5.41	0.15	43.32

SSNM-Site specific nutrient management, RDF - Recommended dose of fertilizers

Seed and straw yields were significantly affected by different treatments (Table 2). T_1 ($N_{43}P_{43}K_{50}$) resulted in the highest seed yield which was equal to the targeted yield (2 t/ha).The lowest seed yield was recorded in T_7. This shows that if nutrients are applied according to site specific needs targeted yield can be easily achieved. This might be due to fulfilment of nutritional needs of crop on that site. Kauraw *et al.* (2007) reported similar results in soybean. Similar results have also been reported by Patil *et al.* (2016) in soybean.Straw yield was significantly higher in T_1 which was at par withT_5 (RDF) and T_6 (Farmer's practice). The lowest straw yield was observed in control treatment. Similar results were also reported by Rana and Badiyala (2014) in soybean. The highest productivity and harvest index was also observed in T_1 while the lowest was in absolute control. This might be due to reason that balanced application of nutrients resulted in increasing the productivity of land area increasing its efficiency. Similar results have also been reported by Swati and Singh (2018) in soybean.

Gross return, net return, benefit cost ratio and profitability were significantly influenced by different treatments (Table 2). Significantly higher gross and net returns were observed in T_1. The lowest returnswas noted in control treatment. This might be due to higher yields at higher nutrient level. Hellal and Abdelhamid (2013), Patil *et al.* (2018) and Billore and Srivastava (2015) reported similar results. Significantly higher B:C was observed in T_1 while the lowest was in control. Singh *et al.* (2013) also reported similar results in soybean. Significantly higher profitability was also recorded in T_1. Thelowest profitability was recorded in control.This might be due to higher net return in T_1 resulted in higher profitability. Swati and Singh (2018) also reported similar results in soybean.

SUMMARY

A field experiment was conducted during the rainy season of 2018 at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur to study the effect of site-specific nutrient management on yield attributes, productivity and profitability of soybean. The experiment was laid out in randomized block design comprising of seven treatments ($N_{43}P_{43}K_{50}$, $N_{43}P_{43}K_0$, $N_{43}P_0K_{50}$, $N_0P_{43}K_{50}$, $N_{20}P_{60}K_{40}$, FYM@5t/ha and $N_0P_0K_0$). Experimental site was silty clay loam in texture, acidic in reaction, low in available nitrogen, and medium in available phosphorus and potassium.The highest number of pods (71/plant), seed yield (2 t/ha), net return (45.9×10³ ₹//ha), benefit cost ratio (2.25) and profitability (366.9 ₹//ha/day) was recorded at $N_{43}P_{43}K_{50}$. Omission of nutrients significantly reduced productivityand

profitability of soybean. The lowest number of pods, seed yield, net return,benefit cost ratio and profitability was recorded in control treatment ($N_0P_0K_0$). Site specific nutrient management (N_{43} P_{43} K_{50}) proved to be the best treatment in enhancing the yield and profitability of soybean.The recommended dose of fertilizers ($N_{20}P_{60}K_{40}$) and farmer's practice (FYM@5t/ha) proved to be the second and third best treatment, respectively.

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