



STCR based nutrient management in soybean (*Glycine max*) for higher productivity and profitability

RANJEET SINGH RAGHAV¹, Y V SINGH², MUKUL KUMAR³, PRADIP DEY⁴ and S DUBEY⁵

Krishi Vigyan Kendra, Raisen, Madhya Pradesh 464 551, India

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ABSTRACT

Farmer' Participatory On Farm Trials (FP-OFT) were conducted at 10 different locations in Raisen district of Madhya Pradesh during two consecutive years of *kharif* 2015–16 in medium black soils to study the influence of soil test crop response (STCR) approach vis-a-vis farmers' practice on productivity and economics of soybean [*Glycine max* (L.) Merr.]. Result revealed that targeted seed yield of soybean (1500 kg/ha) was achieved by adoption of STCR approach. The mean percentages of increase in grain and Stover yields of soybean under STCR were 46.7% and 46.9%, respectively over the farmers' practice (FP). The plant height, number of root nodules, pods/plant and test weight of seed increased by 11.5%, 11.1%, 29.1% and 24.0%, respectively over the farmers' practice. There was much larger negative balance in available nitrogen and available potassium levels under farmers' practice compared to STCR. The economic parameters of crop i.e. gross return, net returns and benefit-cost ratio (BCR) under the STCR approach were between ₹ 34100–38662.5/ ha, ₹ 16566–21462/ ha and ₹ 0.89–1.60 which were higher as compared to farmers' practice across the locations. STCR approach must be adopted by the farmers for higher crop productivity, profitability and soil nutrient balance.

Key words: Farmer participatory, Net return, On-farm testing, Soil Test Crop Response (STCR)

Soybean [*Glycine max* (L.) Merrill] is an important pulse as well as oilseed crop in India. It has 40–42% protein and 20–22% oil. Soybean has come forth as a potential crop and brings economic growth of the farmers of Madhya Pradesh. The ecological condition of the state are congenial for soybean production, but the productivity is low (1293 kg/ha) as compared to national productivity of 1353 kg/ha (DAC 2014). Among the factors responsible for low productivity, inadequate fertilizers use and emergence of multiple-nutrient deficiencies due to poor recycling of organic resources and unbalanced use of fertilizers is important (Chaturvedi *et al.* 2010). Soybean being rich in protein and oil contents has high nutrient requirements but its productivity is often diminished by the low availability of essential nutrients and imbalanced use of nutrition. The use of fertilizers by the farmers in the field without consideration of soil fertility status and nutrient requirement of crop causes adverse effects on soil health and crop creating nutrient toxicity and

deficiency both either by inadequate or excess use (Kaul 2004). The soil test crop response (STCR) approach for getting target yield is unique in indicating for soil test based fertilizer dose and level of yield that can be achieved with good agronomic practices (Singh *et al.* 2017). With this background STCR approach was compared with farmers' traditional method of fertilizers application in soybean crop under medium black soils of Raisen (MP).

MATERIALS AND METHODS

The Farmers' participatory On Farm Trials (FP-OFT) on soil test crop response (STCR) vis-a-vis farmers' practice were conducted during two *kharif* seasons of 2015–16 in soybean crop on 10 different locations of two villages, viz. Bhanpurgarhi and Hinotiyakhash of Gairatganj block in Raisen, Madhya Pradesh.

The soils of experimental sites were medium black. Soil samples (0–15 cm depth) were collected before sowing and dried and passed through 2 mm sieve and analyzed for physico-chemical characteristics (Jackson 1973). Soil pH was measured in (1:2) soil: water suspension. Electrical conductivity in (1:2) soil: water suspension was determined with the help of digital EC meter (Richards 1954). The collected soil samples were analyzed for organic carbon by the method of Walkley and Black (1934), available nitrogen, phosphorus and potash were analyzed by alkaline permanganate method (Subbaiah and Asija 1956, Olsen

¹Subject Matter Specialist (raghavsinghranjeet@yahoo.co.in), Soil science; ²Principal Scientist (yvsingh63@yahoo.co.in), CCUBGA, ICAR-IARI, New Delhi; ³Subject Matter Specialist (mukul0274@yahoo.co.in), Horticulture; ⁴Project Coordinator (pradipdey@yahoo.com), AICRP (STCR), ICAR-IISS Bhopal; ⁵Senior Scientist and Head (swapnildubey45@yahoo.com), Krishi Vigyan Kendra, Raisen, Madhya Pradesh.

et al. 1954), Ammonium acetate extract method (Hanway and Heidal 1952) respectively. In Bhanpurgarhi village available N, P and K varies from 112.0–132.8, 5.36–6.90 and 185.3–217.5 kg/ha, respectively and in Hinotiyakhash village 113.5–127.9, 4.25–6.75 and 190.7–223.6 kg/ha, respectively, pH and EC were normal in both the villages.

The experiment was laid out with two treatments, viz. farmers practice (only 50 kg di-ammonium phosphate/ha) and fertilizers application on the basis of soil test crop response (STCR) for targeted yield of 1500 kg/ha in soybean. The targeted yield of crop was ascertained as per yield potential of soybean variety. The fertilizer prescription equations were developed by the AICRP-Bhopal centre of the project on STCR for different crops under different soils. The amount of nitrogen, phosphorus and potassium for targeted yield of soybean were calculated with the help of fertilizer adjustment equations:

$$FN = 0.0519 T - 0.48 SN$$

$$FP_2O_5 = 0.0520 T - 4.10 SP$$

$$FK_2O = 0.039 T - 0.22 SK$$

where T, Yield target (kg/ha); FN, Fertilizer N (kg/ha); FP_2O_5 , Fertilizer P (kg/ha); FK_2O , Fertilizer K (kg/ha); SN, Soil available nitrogen (kg/ha); SP, Soil available phosphorus (kg/ha); SK, Soil available potassium (kg/ha).

The recommended practices for crop production techniques were followed for soybean crop. As fertilizers di-ammonium phosphate (DAP) and potash (Potassium chloride) were used as basal dressing. Data related to plant growth, yield attributes and yield parameters of soybean crop were collected from each farmer fields and analyzed by adopting the standard procedures. Harvest index was estimated by (Nichiporovich 1967).

Harvest Index (%) = $100 \times \text{Economical grain yield of}$

plot/Biological yield of plot

Plant samples (grain and stover) were collected at harvest of crop for estimation of N, P and K content. Uptake of N, P and K by crop was calculated separately by:

Uptake of nutrient (kg/ha) = nutrient content % $\times$ dry matter yield (kg/ha)/100

Benefit cost ratio (BCR) was also calculated to analyze the net returns from the soybean crop under cultivation. The equation of net income/total cost was used to calculate the BCR.

RESULTS AND DISCUSSION

Nutrient requirement for targeted crop yields: The requirements of N, P_2O_5 and K_2O for different locations for achieving yield target of 1500 kg/ha were calculated from the STCR prescription equations varied between 14.1–24.1, 49.7–60.6 and 9.3–17.7 kg/ha, respectively. Calculated amount of nutrients required for targeted yield of soybean indicated that there were wide variations in nutrient requirements at different locations within the same village also. So the common recommendation for the crop does not have much significance. Application of 50 kg DAP fertilizer/ha by farmers to soybean crop was much less to meet the N and P requirements of the crop and potassium was not applied at all sites. Therefore as per farmers' practice, they were not applying balanced dose of fertilizers. Other hand, we can say dose of fertilizers was also much less than crop requirements.

Plant growth and yield: The plant growth parameters as well yield attributes were obtained higher with STCR based nutrient management as compared to farmers' practice (Table 1). Highest plant height (44.8 cm) and number of root nodules/plant (39.7) were recorded under

Table 1 Growth parameters and yield (mean of two years) of soybean under FP-OFT on STCR vis-a-vis farmers' practices at different location in Raisen (MP)

Location	Plant height (cm)		Pods/plant		No of root nodules/plant		Test weight (g)		Grain yield (kg/ha)		Stover yield (kg/ha)		Harvest Index	
	FP	STCR	FP	STCR	FP	STCR	FP	STCR	FP	STCR	FP	STCR	FP	STCR
A	33.2	41.3	28.2	36.6	35.4	38.6	7.3	8.9	1071	1613	1498	2324	41.7	41.0
B	39.6	44.8	27.2	33.4	34.9	37.8	8.5	9.4	1223	1745	1684	2510	42.1	41.0
C	34.9	39.3	24.6	36.5	33.4	39.5	6.6	8.8	986	1417	1308	1950	43.0	42.1
D	38.8	39.5	29.7	37.5	34.3	39.7	7.8	8.3	1121	1518	1569	2184	41.7	41.0
E	38.6	40.9	27.9	38.5	33.9	38.6	7.5	9.6	974	1542	1341	2279	42.1	40.4
F	35.7	38.9	32.5	42.6	32.5	37.2	8.3	10.8	945	1429	1410	2072	40.1	40.8
G	37.8	40.7	31.2	36.5	36.5	38.7	7.9	9.7	1089	1846	1602	2648	40.5	41.1
H	34.3	43.7	28.6	37.4	34.6	37.2	8.1	9.8	871	1364	1480	1932	37.1	41.4
I	39.3	41.6	33.2	40.8	35.5	37.6	8.6	10.7	1139	1449	1670	2162	40.6	40.1
J	36.2	39.9	29.5	37.8	33.5	38.3	7.2	10.7	1121	1542	1698	2360	39.8	39.5
Mean	36.84	41.06	29.25	37.75	34.5	38.32	7.8	9.67	1054	1547	1526	2242	40.9	40.8
% Increase over FP	11.45		29.05		11.23		24.29		46.73		46.93			

FP, Farmers' practice; STCR, Soil Test Crop Response. Name of locations: A, B, C, D, E, J in Bhanpurgarhi village; F, G, H, I in Hinotiyakhash village

STCR approach as compared to farmers' practice at all the locations in both the villages. Better crop growth response under STCR approach may be due to better nutrient supply to crop. The number of pods per plant ranged 33.4–42.6 in soil test based fertilizers application, i.e. STCR, whereas in farmers' practices these ranged 24.6–33.3 per plant. The seed test weight was considerable higher in STCR approach as compared to farmers' practice.

The seed and stover yields were recorded higher by 46.7% and 46.9%, respectively with STCR based fertilization as compared to farmers' practice. The seed yield with farmers' practices and STCR ranged 871–1223 kg/ha and 1417–1846 kg/ha, respectively (Table 1). Similarly the stover yield with farmers' practices and STCR ranged 1341–1698 kg/ha and 1932–2648 kg/ha, respectively. However, harvest index did not show any specific trend in both practices, i.e. Farmers practice and STCR approach. Higher yields of grain and stover under STCR based fertilization over farmers' practice was due to higher and balanced nutrient application to crop under STCR approach. Tiwari and Methew (2002) found the better partitioning of photosynthesis towards the higher seed and stover production. This meant that higher photosynthesis derived due to better supply of plant nutrients from different sources which finally resulted in to superior crop harvest.

Nutrient uptake by soybean: The soil nutrient management through STCR approach led to higher nutrient (N, P and K) uptake as compared to farmers' practice of nutrient management. The total N uptake by soybean crop (seed and stover) in farmers' practice ranged 63.3–80.2 kg/ha with mean values of 71.2 kg/ha. Whereas under STCR approach, it ranged 102.4–132.3 kg/ha with a mean of 113.9 kg/ha which showed a 60% increase in nitrogen uptake over farmers' practice. Average total P uptake by soybean was recorded higher 12.27 kg/ha with STCR approach than farmers' practice (6.65 kg/ha). The STCR based fertilizer management practice recorded higher average total potassium uptake (80.14 kg/ha) by soybean crop than farmers' practice (49.37 kg/ha) which was 62.5% higher over farmers practice. Similar results were reported by Srinivasan and Angayarkanni (2008).

Available nutrients in postharvest soil: Postharvest analysis of soil registered higher available N, P and K status in STCR approach. Available N, P and K in soil

after harvest of crop under different locations with farmers' practice of nutrient management varied 76.3–102.8, 2.2 to 3.4 and 155.6–194.3 kg/ha, respectively. Whereas with STCR based nutrient management practice the available N, P and K varied 97.60–123.57, 3.39–5.68 and 181.80–209.67 kg/ha, respectively at different locations of on farm trails conducted at farmer's field. Greater advantage consistent with maintenance of soil fertility status was realized when fertilizer applied to crop for appropriate yield targets in succession over years using STCR-INM concept (Ramamoorthy and Velayutham 2011).

Apparent nutrient balance at harvest: It was recorded that there was much higher negative balance in available nitrogen and available potassium under farmers' practice as compared to STCR (Table 2). Apparent nutrient balance for available N, P and K were found to net negative under farmers' practices to the tune of 21.51, 1.53 and 17.4 kg/ha, respectively as compared to STCR approach. However, available phosphorus levels were more or less equal in both the management systems. It was due to the higher initial P content in soil and application of 50 kg DAP could almost meet the P requirement of crop. This indicated that STCR based nutrition not only gave better nutrition to crop but left the soil in better nutrient levels.

Economics: The nutrient management through STCR based approach led to higher gross and net returns as well as benefit cost ratio as compared to farmers' practice (Table 3). However, cost of cultivation were little higher (₹ 1700/ha) with STCR compared to farmers' practice (₹ 15500/ha). The gross return in farmers' practice ranged ₹ 21775–₹ 28475/ha, whereas in STCR it ranged between ₹ 34100/ha – ₹ 46150/ha. Similarly, the net returns under farmers' practice and STCR ranged ₹ 5875/ha – ₹ 14975/ha and ₹ 16566/ha – ₹ 28390/ha, respectively. On an average there was a benefit of ₹ 10,612/ha due to the STCR over farmers' practice. Benefit cost ratio (Mean BC value of STCR) was also higher in STCR over farmers' practice (Mean BCR value of FP). Higher cost of cultivation may be due to higher amount of fertilizers and management cost. But it was compensated by higher crop productivity. Higher gross and net returns and benefit-cost ratio was due to higher crop productivity.

It was concluded that in soybean crop growth, yield attributes and yields of seed and stover were considerably

Table 2 Apparent nutrient balance (kg/ha) at crop harvest under STCR vis-a-vis farmers' Practice's at different location in Raisen (MP)

Particulars	Farmers' practice (FP)			Soil Test Crop Response (STCR)		
	Initial	At crop harvest	Apparent nutrient balance	Initial	At crop harvest	Apparent nutrient balance
Available nitrogen (kg/ha)	112-132.8 (121.9)	76.28-102.8 (87.96)	-33.94	112-132.8 (121.9)	97.25-123.57 (109.47)	-12.43
Available phosphorus (kg/ha)	4.25-6.9 (5.90)	2.31-3.27 (2.96)	-2.94	4.25-6.9 (5.90)	3.39-5.68 (4.49)	-1.41
Available potassium (kg/ha)	185.3-223.6 (204.2)	155.63-194.30 (175.80)	-28.4	185.3-223.6 (204.2)	179.21-209.3 (193.20)	-11.0

Table 3 Economic analysis under FP-OFT on STCR vis-a-vis farmers' practices at different locations in Raisen (MP)

Location	Cost of cultivation (₹/ha)		Gross return (₹/ha)		Net return (₹/ha)		Benefit-cost ratio	
	FP	STCR	FP	STCR	FP	STCR	FP	STCR
A	14700	16235	26775	40325	12075	24090	0.82	1.48
B	15600	17074	30575	43625	14975	26551	0.96	1.56
C	13500	15170	24650	35425	11150	20255	0.83	1.34
D	16900	18733	28025	37950	11125	19217	0.66	1.03
E	14600	16350	24350	38550	9750	22200	0.67	1.36
F	14700	16771	23625	35725	8925	18954	0.61	1.13
G	16200	17760	27225	46150	11025	28390	0.68	1.60
H	15900	17534	21775	34100	5875	16566	0.37	0.94
I	17400	19141	28475	36225	11075	17084	0.64	0.89
J	15500	17233	28025	38550	12525	21317	0.81	1.24
Mean	15500	17200	26350	38662.5	10850	21462	0.70	1.25

(Benefit-cost ratio = Net return/Cost cultivation)

higher under STCR approach over farmers' practice. Soil available nutrients in postharvest soil were also higher under STCR. Net return and benefit cost ratio also were considerably higher under STCR approach over farmers' practice. Thus, STCR approach may be used by the farmers for higher crop productivity, profitability and improvement in soil fertility.

REFERENCES

- Chaturvedi S, Chandel A S, Dhyani A S and Singh A P. 2010. Productivity, profitability and quality of soybean (*Glycine max*) and residual soil fertility as influenced by integrated nutrient management. *Indian Journal of Agronomy* **55**(2): 133–7.
- DAC. 2014. Economic Survey of Maharashtra, Directorate of Economic of soybean. Department of Agricultural and cooperation. www.sopa.org/crop.po.doc.
- Hanway J J and Heidel H. 1952. Soil analysis method as used in Iowa state college soil testing Laboratory. *Iowa State College of Agriculture Bulletin* **57**: 1–3.
- Jackson M L. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt Ltd, New Delhi.
- Kaul D. 2004. 'Effect of different levels of nitrogen, phosphorus and potassium on growth, yield and quality of soybean'. M Sc (Ag) thesis, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.
- Olsen S R, Cole C V, Watanabe F S and Dean L A. 1954. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. Circular US Dept. of Agriculture, Washington DC: 939.
- Ramamoorthy B and Velayutham M. 2011. The Law of optimum and soil test based fertiliser use for targeted yield of crops and soil fertility management for sustainable agriculture. *Madras Agricultural Journal* **98**(10-12): 295–307.
- Richards L A. 1954. *Diagnosis and Improvement of Saline and Alkali Soils*. Agriculture Handbook 60, USDA, USA.
- Singh M, Singh Y V, Singh S K, Dey Pradip, Jat L K and Ram R L. 2017. Validation of soil test and yield target based fertilizer prescription model for rice on Inceptisol of Eastern Zone of Uttar Pradesh, India. *International Journal of Current Microbiology and Applied Sciences* **6**(2): 406–15.
- Srinivasan S and Angayarkanni A. 2008. Effect of INM on yield and nutrient uptake by rice in STCR experiment. *Agricultural Science Digest* **28** (2): 130–2.
- Subbiah B V and Asija G I. 1956. A rapid procedure for determination of available nitrogen in soils. *Current Science* **31**: 196–98.
- Tiwari B K and Methew, Roby. 2002. Influence of post-emergence herbicides on growth and yield of soybean. *JNKVV Research Journal* **36**(1&2): 17–21.
- Walkley A and Black C A. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science* **37**: 29–38.