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Field validation of soil test and yield target based fertiliser prescription equation for soybean on vertisol

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Abstract
The validity of the soil test crop response (STCR) equation was tested by conducting ten follow up trials of soybean across three villages of Nizamabad district of Telangana state during *Kharif* 2016 on Vertisols. The treatments include Farmers fertiliser practice and STCR based fertilizer recommendations for an yield target of 25 q ha^{-1}. The N, P and K fertilizers for yield target was calculated based on the initial soil test values of the respective locations. The results showed that, against the soybean yield target of 25 q ha^{-1}, the seed yield at ten locations varied from 18.22 to 22.78 q ha^{-1}, with a mean of 21.04 q ha^{-1}. The variation in yield obtained from the targeted ones ranged from -8.88 to -27.12. Except for one location, the measured yields were above 10 % variation of the yield targets. The fertiliser application as per the STCR equation not achieved the targeted yield. With respect to Farmers practice of fertiliser recommendations, the yield at ten locations varied from 18.24 to 22.75 q ha^{-1} with a mean yield of 20.79 q ha^{-1}. The seed yield recorded with Farmers practice of fertiliser recommendations were more or less similar in producing seed yield as compared to STCR recommendations. The higher benefit cost ratio obtained under Farmers practice of fertiliser recommendations over STCR recommendations. Thus, fertilizer prescription equation for soybean has failed to achieve the target yield of 25 q ha^{-1}.

Keywords: STCR equation, validation, soybean, fallow up trails

Introduction
Soybean is an important global crop and has very high nutritional value containing 40-45 % protein and 18-22% oil. This crop is gaining popularity on account of its unique characteristics and adaptability to various agro climatic conditions of the Indian soils. In India, Soybean is grown in an area of 11.67 million hectare with an annual production of about 8.59 million tonnes and productivity of 737 kg ha^{-1} (Agricultural Statistics at a Glance 2016) [1]. Soybean has become an important oilseed crop in Northern Telangana Zone of Telangana State in a very short period with approximately 1.5 lakh ha area under its cultivation. There has been an unprecedented growth in soybean.

Fertilizer is one of the costliest inputs in agriculture and the use of the right amount of fertilizer is fundamental for farm profitability and environmental protection. Soil test based fertilizer prescription eliminates over or under usage of fertilizer inputs there by increasing the fertilizer use efficiency and yield of crops. Soil testing becomes one of the vital tools in increasing the yield of crops by optimum prescription of fertilizers to crops and maintenance of soil fertility. Soil test based application of plant nutrients helps to realize higher response ratio and benefit: cost ratio as the nutrients are applied in proportion to the magnitude of the deficiency of a particular nutrient and the correction of the nutrients imbalance in soil helps to harness the synergistic effects of balanced fertilization (Rao and Srivastava, 2000) [6].

Hence, the present study was carried out for soybean on Vertisols of Nizamabad (Telangana) which is neutral to slightly alkaline in nature. Extrapolation of the results emanated from the study is possible if it is test verified at farmer's holdings. Therefore, to enhance the production of soybean and to sustain soil health, verification of suitable fertilizer prescription model is highly essential.

Materials and Methods
Field experiments were conducted at ten different locations across three villages in Nizamabad district of Telangana during *Kharif* 2016 to validate the fertiliser prescription developed from soil test crop response correlation for soybean on Vertisols. The fertilizer prescription equations developed for desired yield target of soybean for Northern Telangana soil series are are furnished below.

STCR Equation for soybean

FN = 15.91 T - 2.11 SN

FP_2O_5 = 7.54 T - 4.37 SP

F K_2O = 12.16 T - 0.85 SK

Where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O and K_2O in kg ha^{-1} respectively. T is the yield targeted in q ha^{-1}; SN, SP and SK are soil available N, P and K in kg ha^{-1} respectively. The treatments include Farmers fertiliser practice and soil test crop response (STCR) based fertilizer dose for an yield target of 25 q ha^{-1}.

Initial soil samples were collected in each location and analysed for alkaline $KMnO_4$-N (Subbiah and Asija, 1956) [11], Olsen-P (Olsen *et al.,* 1954) [5] and NH4OAc-K (Hanway and Heidal, 1952) [4]. Initial determination of native fertility revealed that, soils across 10 locations were neutral in reaction to non-saline in nature. Available N, P_2O_5 and K_2O were low, medium to high and medium to high in status ranging from 172 to 242, 44 to 97 and 255 to 375 kg ha^{-1}, respectively (Table 1). The test crop soybean variety JS 335 was raised during *Kharif* 2016 and the seed and stover yield was recorded at harvest. BCR (B: C ratio) was worked out based on the standard procedure (Gittinger, 1982) [3]. The cultivation practices were carried out periodically and the seed and stover yield was recorded at harvest.

The available status of nutrients was used to compute fertiliser doses for soybean through adjustment equations using basic data that had earlier been generated from fertility gradient field experiments for soybean. The detailed procedure has been described by Valayutham *et al* (1985) [14]. The range of N, P_2O_5 and K_2O application rates under different treatments across 10 locations indicated that, N, P_2O_5 and K_2O recommendations by farmers practice were lower than STCR recommendations. Across all sites, farmers practice of N, P_2O_5 and K_2O recommendations ranged from 0 to 50, 0 to 60 and 0 to 40 with a mean of 21, 39 and 13, respectively where as STCR practice of N, P_2O_5 and K_2O recommendations ranged from 6 to 51, 30 to 104 and 38 to 109 kg ha^{-1} with a mean of 26, 69 and 75 kg ha^{-1}, respectively (Table 2). Recommended dose of fertilizer application for soybean in Telangana region is 60-60-40 kg N- P_2O_5-K_2O ha^{-1}.

Table 1: Initial available soil nutrient status of selected farmers

S. No.	Name of the Farmer	pH	EC (dSm^{-1})	Available Soil Nutrient Status (kg ha^{-1})		
				N	P_2O_5	K_2O
1	M. Ranga Rao	7.74	0.249	185.6	75.52	346.4
2	S. Prasad	7.92	0.552	208.6	52.42	363.4
3	N. Madhan Krishna	7.24	0.624	192.8	60.82	290.0
4	V. Srinivasa Rao	7.82	0.491	172.8	66.16	303.2
5	B. Ranga Babu	8.12	0.324	232.7	96.78	274.7
6	S. Bosu Babu	7.74	0.296	202.4	49.37	349.9
7	T. Dayakar	8.08	0.784	172.4	89.13	375.2
8	N. Prasad	7.54	0.426	241.8	44.33	329.5
9	R. Venkata Rao	7.76	0.927	202.7	60.57	255.2
10	J. Suresh	7.94	0.328	178.2	48.71	347.5
Mean		7.79	0.501	199.0	64.38	323.5

Table 2: Fertilisers recommendations under different treatments

S. No	Name of the Farmer	Village	Farmers Fertiliser Practice (kg ha^{-1})			STCR Recommendation (kg ha^{-1})		
			N	P_2O_5	K_2O	N	P_2O_5	K_2O
1	M. Ranga Rao	Ethonda	18	46	0	6	44	59
2	S. Prasad	Ethonda	0	0	0	25	88	47
3	N. Madhan Krishna	Ethonda	12	32	16	25	72	99
4	V. Srinivasa Rao	Ethonda	12	32	16	33	62	89
5	B. Ranga Babu	Karegam	20	20	0	25	30	109
6	S. Bosu Babu	Karegam	29	46	0	25	94	56
7	T. Dayakar	Karegam	18	46	0	51	30	38
8	N. Prasad	Karegam	18	46	15	25	104	71
9	R. Venkata Rao	Ranam palli	30	60	40	25	73	123
10	J. Suresh	Ranam Palli	50	60	40	22	96	58
Mean			21	39	13	26	69	75

Results and Discussion

The results showed that, against the soybean yield target of 25 q ha^{-1}, the seed yield at ten locations varied from 18.22 to 22.78 q ha^{-1} with a mean of 21.04 25 q ha^{-1}. The variation in yield obtained from the targeted ones ranged from -8.88 to -27.12. Except for one location, the measured yields were above 10 % variation of the yield targets. The fertiliser application as per the STCR equation with yield target 25 q ha^{-1} to soybean crop for validation were not achieved the targeted yield. With respect to Farmers practice of fertiliser recommendations, the yield at ten locations varied from 18.24 to 22.75 q ha^{-1} with a mean yield of 20.79 q ha^{-1}. The seed yield recorded with Farmers practice of fertiliser recommendations were more or less similar in producing seed yield as compared STCR recommendations (Table 3).

Suresh and Santhi (2018) [12] validated STCR equation for hybrid maize and reported that, STCR based fertiliser recommendations with the targeted yield has been achieved within +/- 10 per cent variation proving the validity of the equations. Similar results were reported by Santhi *et al.,* (2011) [7] for beetroot, Sharma *et al.,* (2015) [8] for pearl millet, Singh *et al*., (2017) [10] for rice, Dhinesh *et al.,* (2017) [2] for Brinjal. According to Velayutham *et al.* (1984) [13], if the targeted yield was achieved within ± 10 per cent variation, then the equations are found to be valid. The results of the validation experiment on soybean clearly indicated that the per cent achievement was above 10 per cent (72 - 91 %)

variation at all the locations for validation was not achieved the targeted yield of soybean crop.

The benefit cost ratio of the treatments was estimated using the cost of input and value of output. Economics of fertiliser application based on targeted concept gave benefit cost ratio varying from 1.09 to 1.72 with a mean value of 1.48. The corresponding value for farmers fertiliser practice ranged from 1.39 to 2.07 with a mean value of 1.76 (Table 3). The results are confirming that, the higher benefit cost ratio recorded through Farmers practice of fertiliser recommendations comparison to targeted yield approach. However, the treatment of targeted yield found most economic treatment as compare to farmer practices and general recommendation reported by Singh *et al.,* (2015) [9].

Table 3: Seed and Stover yields of soybean under different treatments

S. No	Name of the Farmer	Farmers Fertiliser Practice		STCR Recommendation		Variation in seed yield from the target yield (%)	Benefit - Cost Ratio	
		Seed Yield (q ha^{-1})	Stover Yield (q ha^{-1})	Seed Yield (q ha^{-1})	Stover Yield (q ha^{-1})		Farmers Practice	STCR recommendation
1	M. Ranga Rao	19.53	21.24	20.26	21.56	18.96	1.60	1.54
2	S. Prasad	19.28	22.21	18.22	20.45	27.12	1.81	1.14
3	N. Madhan Krishna	22.26	23.85	22.08	24.37	11.68	1.99	1.52
4	V. Srinivasa Rao	20.62	23.78	22.78	24.12	8.88	1.77	1.66
5	B. Ranga Babu	22.09	25.02	21.82	24.27	12.72	2.07	1.63
6	S. Bosu Babu	21.48	23.59	20.86	23.44	16.56	1.84	1.41
7	T. Dayakar	21.08	23.88	21.08	25.12	15.68	1.81	1.72
8	N. Prasad	18.24	20.12	18.62	20.46	25.52	1.39	1.09
9	R. Venkata Rao	20.61	22.64	22.26	23.45	10.96	1.55	1.48
10	J. Suresh	22.75	25.78	22.42	24.11	10.32	1.79	1.58
Mean		20.79	23.21	21.04	23.14	15.84	1.76	1.48

Cost of seed per kg = Rs.34 Cost of phosphorus per kg = Rs.44.0
Cost of nitrogen per kg = Rs.12.26 Cost of potassium per kg = Rs.30.0

Post-harvest soil nutrient status

In general the pH of soil slightly decreases from initial mean value (7.79) at all ten sites. The pH of soil of all ten locations ranged from 7.24 to 8.14 with a mean of 7.60 and 7.38 to 8.12 with a mean of 7.75 in farmers practice and STCR recommendations, respectively. The lowet mean soil pH value was observed in Farmers practice of fertiliser recommendations as compared to STCR recommendations. This may be due to the fact that the application of higher amount of nitrogenous fertilizer (urea) for obtaining higher targeted yield. The Electrical Conductivity (EC) ranged between 0.289 to 0.781 dS m^{-1} with a mean value of 0.424 and 0.278 to 0.678 with a mean value of 0.436 in farmers practice and STCR recommendations, respectively. The EC of soil is result of soluble salts present in soil at any particular temperature. The application of fertilizer increases soluble salts in soil resulted electrical conductivity rises.

The data on $KMnO_4$-N, Olsen-P and NH_4OAc-K indicated the build-up and maintenance of post-harvest soil fertility due to soil test based fertilizer recommendation. Despite higher removal of nutrients, the fertility status was maintained in STCR recommendations as compared to the farmer practice. This might be attributed to the prevention of losses of nutrients under soil test based balanced fertilisation, even after meeting the crop needs. Santhi *et al.,* (2011) [7] established that soil-test-based fertilizer prescription for beet root was found to be useful in increasing yield and also maintained soil fertility.

Fig 1: Overall view of the experimental site at Karegam village

Conclusion

The STCR equation developed for soybean has failed to achieve the target yield of 25 q ha^{-1} and did not found suitable for black soils of Nizamabada District for fertilizer application to harvest the targeted yield of soybean. It is recommended to develop new STCR equation for soybean crop for black soils of Nizamabad District.

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