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Validation of soil test and yield target based fertilizer prescription equations developed for groundnut in Alfisols

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Abstract
Study was undertaken to validate the developed fertilizer prescription equations through field experiments in southern zone of Andhra Pradesh. The results emanated from the validation experiment proved the validity of the fertilizer prescription equations for groundnut by recording the yield targets within ± 10 variation. STCR-IPNS 30 q ha^{-1} of groundnut has proved its superiority and recorded a mean yield increase of nine percent over farmer practice. The increase in benefits: cost ratio was 1.1 times higher in STCR-IPNS model over farmer practice. Soil test based fertilization resulted in increase in yield, benefit: cost and sustenance of soil fertility with STCR-IPNS as compared to farmers practice.

Keywords: Alfisols, STCR-IPNS, groundnut, validation

Introduction
Groundnut (*Arachis hypogea* L.) is an important oilseed cum legume crop of India. Peanut seeds contain high oil (45%), protein (26-28%), carbohydrates (20%) and fiber percent (5%) (Fageria *et al*., 1997). Seeds of groundnut have high nutritive value for both of human and animal consumption and green leaves used as hay for livestock (Abdalla *et al*., 2009). In Andhra Pradesh, normal area under groundnut is 12, 46, 000 hectares with a production of 5, 82,972 MT contributing 11% of national production. YSR district is one of the districts where groundnut is being grown in rabi season under assured irrigation.
Soil testing and soil test based fertilizer recommendation plays an important role in supplying nutrients in proper amounts and in proper balance to the crops. Fertilizers are the kingpin in the present system of agriculture. Scientific use of fertilizer assumes vital importance in sustainable agriculture. The continuous use of high analysis fertilizers increased the crop yield in initial years and adversely affected the yield stability at a later stage (Virmani, 1994). The approach of general fertilizer recommendations related to soil test ratings was in common use though it has its shortcoming. Because of the changing trend in agriculture, yield target concept and fertilizer recommendations for maximum profit per hectare became more promising. Targeted yield approach was an unique one as this method indicates soil test based fertilizer requirement and levels of yield going to achieve by the farmer. The added advantage of the concept is that yield targets can be changed according to the available resources. Therefore, to promote and evaluate the improved targeted oriented prescription equation model in groundnut 15 Frontline demonstrations were conducted in YSR district of Andhra Pradesh.

Material and Methods
To validate the fertilizer prescription equations, field experiments carried out at farmer fields of Veligallu village of YSR district, Andhra Pradesh during 2018-19 followed by laboratory analysis of the soils were done at the Department of Soil Science and Agricultural Chemistry, Agricultural Research Station, Kadapa.
Initial soil samples were collected from 15 farmer fields and analyzed for pH and EC in 1:2 soil: water suspension and measured in digital PH and EC meters. The soil samples were analyzed for alkaline $KMnO_4$-N (Subbaiah and Asija, 1956), Olsen-P (Olsen *et al*., 1954), NH_4OAc-K (Hanway and Heidal, 1952). To educate and evaluate the farmers practice was compared with the improved practice as detailed.

T_1: Farmer practice
T_2: NPK application based on Soil Test Crop Response (STCR) equation at yield target of 30 q ha-1.

An interaction meeting was held with farmers to know the fertilizer application practices. The practice followed by majority farmers was considered as farmers practice. It was observed that farmers are mostly concentrating on the application of nitrogen and phosphatic fertilizers and low dose of potassium.
To suggest soil test based balanced fertilization for groundnut, fertilizer prescription equations developed following the Inductive cum Targeted yield model of Ramamoorthy *et al*., (1967) [7] under IPNS for Alfisols of YSR district were used.

$$FN = 3.69\ T - 0.36\ SN - 0.6\ ON$$
$$F\ P_2O_5 = 1.32\ T - 0.71\ SP - 0.68\ OP$$
$$F\ K_2O = 2.54\ T - 0.12\ SK - 0.24\ OK$$

Where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1} respectively T= Groundnut yield target in q ha^{-1}; SN, SP and SK are alkaline $KMnO_4$ N, Olsen-P and NH_4OAc-K in kg ha^{-1} respectively; ON,OP and OK are N, P and K supplied through FYM.
Based on the initial soil sample values of available N, P_2O_5 and K_2O, fertilizer doses (Table 1) were calculated as per the yield target (Table 2) half dose of N and full dose of P_2O_5 and K_2O were applied and remaining half dose as split after 30 DAS. Plant protection measures were adopted as and when required. Post-harvest soil samples collected from each farmer's field and analyzed for available N, P and K status. B: C Ratio, net returns per rupee invested were worked out based on the price of the produce in local market.

Results and Discussion
Initial soil available nitrogen, phosphorus and potassium of the study area are in the range of 160-234, 34-108 and 102-412 kg ha^{-1} respectively. The soils of study fall low in nitrogen and medium to high in phosphorus and potassium (Table 1). The recorded yield in farmer practice was in the range of 22.05 to 30.45 q ha^{-1} with a mean yield of 25.48 q ha^{-1} in fifteen locations while in STCR- IPNS was in the range of 24.57 to 31.98 q ha^{-1} with a mean pod yield of 27.64 q ha^{-1} (Table 3). STCR-IPNS was recorded an additional mean yield of 2.16 q ha^{-1} over farmer practice. The higher pod yield in STCR-IPNS was due to application of fertilizers according to the crop needs. Fertilizer application in yield target approach considers crop nutrient requirements and supply of nutrients from soil. Further, the nutrients supplied through straight fertilizers in right combination and in right proportion. Similar results were reported by Pradeep kumar and Parmanand (2018) [5], Reddy *et al*., (2018) [9]. On an average the farmers are investing an additional amount of Rs 3075 per hectare over STCR-IPNS on fertilizers. This was due to the indiscriminate application of complex fertilizers rather than straight fertilizers. Relative reduction in fertilizer cost is 57.86 percent in STCR –IPNS over farmer practice.
The $KMnO_4$-N, Olsen-P and NH_4OAc-K indicate the buildup and maintenance of post-harvest soil fertility in STCR-IPNS. Despite the removal of nutrients, the fertility status was maintained in improved practice as compare to farmer practice (Table 5). This will be attributed to the preventing the loss of nutrients in STCR-IPNS even after meeting the crop requirements. Greater profit consistent with maintenance of soil fertility status was realized when fertilizers were applied for appropriate yield targets in succession over years using STCR-IPNS concept (Ramammorthy and Velayutham, 2011) [6]. Application of organic manures in conjunction with chemical fertilizers will not only increase the productivity of all the crops but also sustains the soil fertility Rao and Srivastava, 2000 [8]; Santhi *et al*., (2011) [10] established the STCR-IPNS technology for beet root crop and proved that the technology sustains soil fertility.
The highest mean BCR was recorded in STCR-IPNS as 3.07 while in farmers practice as 2.83. This might be due to the better use efficiency of applied NPK fertilizers under IPNS. Similar findings were reported by Suresh and Santhi, 2018; Sellamuthu *et al*., (2015) [11]. Targetted yield equation developed from STCR-IPNS technology ensured sustainable crop production besides economizing the use of costly chemical fertilizers (Mahajan *et al*., 2013) [3]. Farmers practice recorded relatively lower yield and BCR as compared to STCR-IPNS treatments in all the farmer fields tested.

Table 1: Initial soil fertility of selected farmers of Veligallu village

S No	Name of the farmer	pH	EC (dS m^{-1})	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
1	B. Sharadamma	7.98	0.17	234	76	102
2.	M. Mutyalamma	8.04	0.26	209	43	231
3	M. Gauramma	7.93	0.28	197	34	154
4	B. Rajamma	7.91	0.10	185	75	128
5	B. Swamy Naik	7.85	0.37	209	35	205
6	B. Peeramma	7.85	0.27	209	35	205
7	B. Lakshmi Devi	8.15	0.10	160	67	269
8	B.R. Naik	7.28	0.18	197	61	282
9	B. Sonikamma	7.12	0.20	173	50	154
10	B. Mangamma	7.69	0.14	209	84	205
11	B.N. Ratnamma	8.01	0.33	176	87	304
12	B. Subbamma	8.28	0.48	188	67	152
13	B. Dhare Naik	8.28	0.48	188	67	152
14	B. Reddemma	7.90	0.25	188	108	412
15	B. Shanthamma	7.90	0.25	188	108	412
Mean			0.26	194	66	224
Range		7.12 -8.28	0.10 -0.48	160 -234	34 -108	102 -412

Table 2: Fertilizers applied in farmer and STCR model

S No	Name of the farmer	Farmer's fertilizer practice (kg ha^{-1})			Fertilizer application in STCR practice (kg ha^{-1})		
		UREA	DAP	MOP	UREA	SSP	MOP
1	B. Sharadamma	100	150	50	57	00	107
2.	M. Mutyalamma	100	150	50	77	57	81
3	M. Gauramma	100	150	50	86	97	96
4	B. Rajamma	100	150	50	96	00	102
5	B. Swamy Naik	100	150	50	77	92	86
6	B. Peeramma	100	150	50	77	92	86
7	B. Lakshmi Devi	100	150	50	115	00	73
8	B.R. Naik	100	150	50	86	00	71
9	B. Sonikamma	100	150	50	105	26	96
10	B. Mangamma	100	150	50	77	00	86
11	B.N. Ratnamma	100	150	50	103	00	66
12	B. Subbamma	100	150	50	93	00	97
13	B. Dhare Naik	100	150	50	93	00	97
14	B. Reddemma	100	150	50	93	00	45
15	B. Shanthamma	100	150	50	93	00	45

Table 3: Economics of fertilizer usage in farmer and STCR model

S No	Name of the farmer	Farmers practice (kg ha^{-1})	STCR practice (kg ha^{-1})	% increment in yield over Farmer's practice	Amount spent on fertilizers in control (Rs)	Amount incurred as per STCR equation (Rs)	Difference amount (Rs)	% decrease in fertilizers cost
1	B.Sharadamma	2615	2772	6	5315	2191	3124	58.78
2	M.Mutyalamma	2392	2694	13	5315	2376	2939	55.30
3	M.Gauramma	2541	2646	4	5315	2995	2320	43.65
4	B.Rajamma	2667	2772	4	5315	2438	2877	54.13
5	B.Swamy Naik	2266	2568	13	5315	2722	2593	48.79
6	B.Peeramma	2843	3198	12	5315	2722	2593	48.79
7	B.Lakshmi Devi	3045	3150	3	5315	2134	3181	59.85
8	B.R. Naik	2205	2520	14	5315	1858	3457	65.04
9	B.Sonikamma	2392	2694	13	5315	2616	2699	50.78
10	B.Mangamma	2417	2772	15	5315	2023	3292	61.94
11	B.N. Ratnamma	2793	2898	4	5315	1855	3460	65.10
12	B.Subbamma	2636	2898	10	5315	2333	2982	56.11
13	B. Dhare Naik	2436	2646	9	5315	2333	2982	56.11
14	B.Reddemma	2667	2772	4	5315	1501	3814	71.76
15	B.Shanthamma	2300	2457	7	5315	1501	3814	71.76
	Range	2205-3045	2457-3198	3-15	5315	1501-2995	2320-3814	43.65-71.46
	Mean	2548	2764	9	5315	2240	3075	58

Table 4: Economics of verification trails for groundnut in Veligallu village

	Name of the farmer	Farmers practice			Net returns /rupee invested	Improved practice (STCR Equation)			Net returns /rupee invested	Additional yield Over farmers practice Kg/ha	Value of additional yield
		Pod yield kg/ha	Cost of cultivation	B: C Ratio		Pod yield kg/ha	Cost of cultivation (Rs)	B: C Ratio			
1	B.Sharadamma	2615	45000	2.91	1.91	2772	36405	3.08	2.08	157	7850
2	M.Mutyalamma	2392	45000	2.66	1.66	2694	37200	2.99	1.99	302	15100
3	M.Gauramma	2541	45000	2.82	1.82	2646	36990	2.94	1.94	105	5250
4	B.Rajamma	2667	45000	2.96	1.96	2772	37160	3.08	2.08	105	5250
5	B.Swamy Naik	2266	45000	2.52	1.52	2568	37138	2.85	1.85	302	15100
6	B.Peeramma	2843	45000	3.16	2.16	3198	38385	3.55	2.55	355	17750
7	B.Lakshmi Devi	3045	45000	3.38	2.38	3150	37595	3.50	2.50	105	5250
8	B.R. Naik	2205	45000	2.45	1.45	2520	37818	2.80	1.80	315	15750
9	B.Sonikamma	2392	45000	2.66	1.66	2694	38098	2.99	1.99	302	15100
10	B.Mangamma	2417	45000	2.69	1.69	2772	37565	3.08	2.08	355	17750
11	B.N. Ratnamma	2793	45000	3.10	2.10	2898	38385	3.22	2.22	105	5250
12	B.Subbamma	2636	45000	2.93	1.93	2898	36660	3.22	2.22	262	13100
13	B. Dhare Naik	2436	45000	2.71	1.71	2646	37138	2.94	1.94	210	10500
14	B.Reddemma	2667	45000	2.96	1.96	2772	37240	3.08	2.08	105	5250
15	B.Shanthamma	2300	45000	2.56	1.56	2457	37413	2.73	1.73	157	7850
		2548	45000	2.83	1.83	2764	37413	3.07	2.07	216	10807

Table 5: Post-harvest soil fertility in the farmer and STCR treated fields of Veligallu village

S No	Name of the farmer	Available Nitrogen (kg ha^{-1})			Available Phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
		Initial	Final		Initial	Final		Initial	Final	
			FP	STCR		FP	STCR		FP	STCR
1	B.Sharadamma	234	213	226	76	67	67	102	99	108
2	M.Mutyalamma	209	188	201	43	36	45	231	215	228
3	M.Gauramma	197	188	201	34	31	45	154	134	161
4	B.Rajamma	185	188	188	75	67	67	128	121	134
5	B.Swamy Naik	209	201	213	35	31	31	205	188	202
6	B.Peeramma	209	188	213	35	31	31	205	188	202
7	B.Lakshmi Devi	160	151	163	67	54	58	269	255	276
8	B.R. Naik	197	188	201	61	54	67	282	269	282
9	B.Sonikamma	173	163	176	50	45	54	154	148	161
10	B.Mangamma	209	201	213	84	90	90	205	188	215
11	B.N. Ratnamma	176	176	201	87	76	90	304	282	309
12	B.Subbamma	188	176	188	67	63	67	152	134	161
13	B. Dhare Naik	188	176	188	67	63	69	152	134	161
14	B.Reddemma	188	176	188	108	90	112	412	403	417
15	B.Shanthamma	188	176	188	108	90	112	412	390	417
		160-234	151-213	163-226	34-108	31-90	31-112	102-412	99-403	108-417
		194	183	197	66	59	67	224	210	229

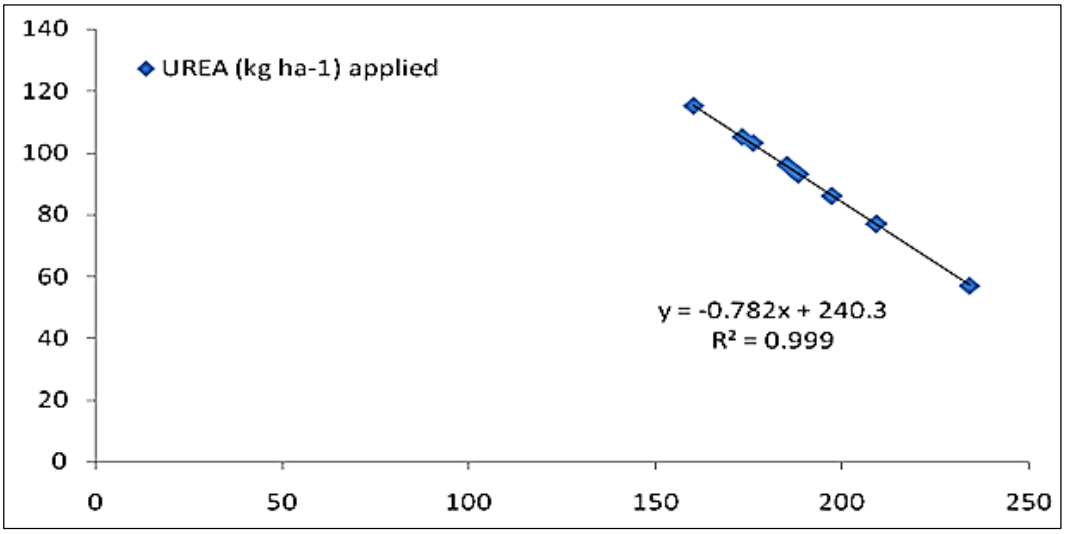

Fig 1: Available nitrogen and Urea (kg ha^{-1}) applied in STCR - IPNS

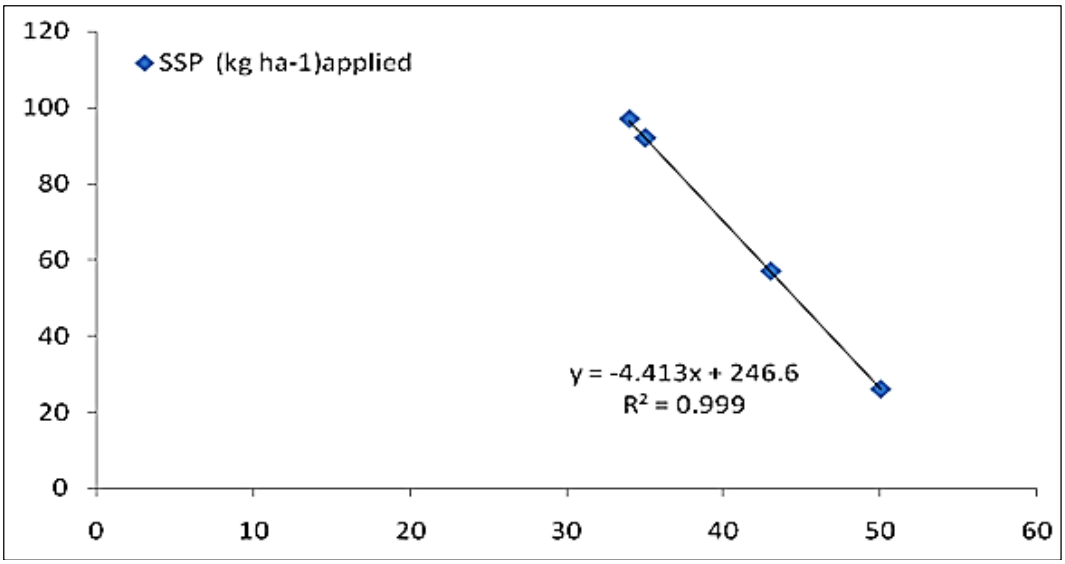

Fig 2: Available phosphorus and Single Super Phosphate (kg ha-1) applied in STCR-IPNS

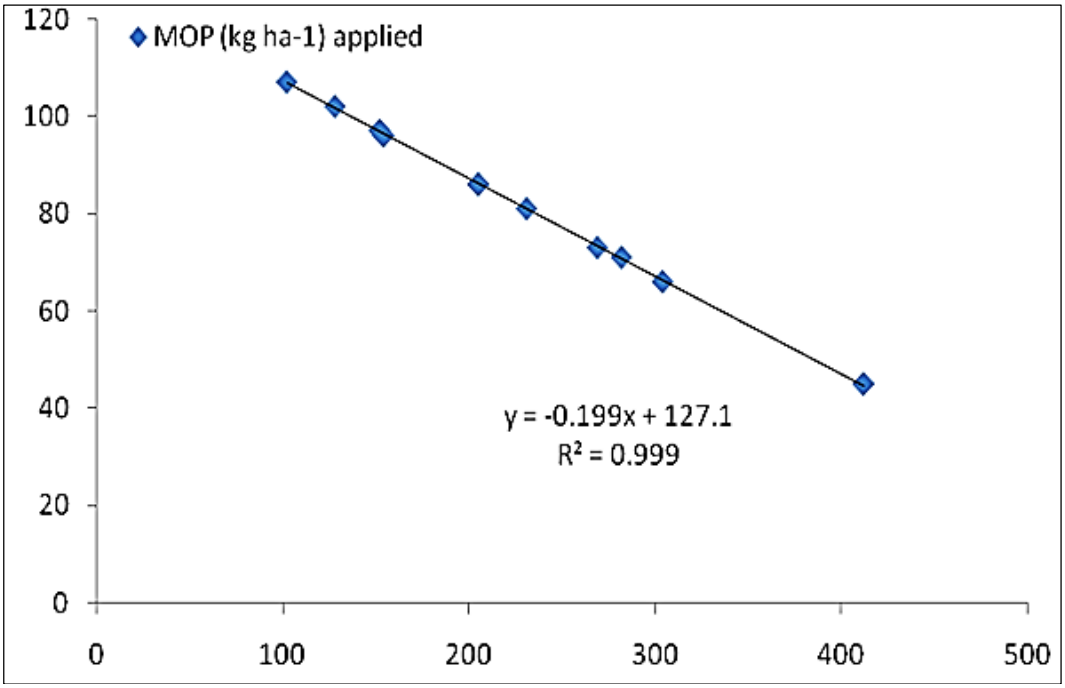

Fig 3: Available potassium and Muriate of Potash (kg ha-1) applied in STCR-IPNS

Conclusion

The results emanated from all the 15 farmer fields tested reveals that the yield target model was achieved yield targets within +/- 10 percent variation proving the validity of the fertilizer prescription equation to prescribe fertilizer doses for groundnut in Alfisols. The mean grain yield of groundnut from fifteen validation experiments indicated that STCR-IPNS 30 q ha^{-1} was found to record higher grain yield over farmer practice. This model found effective in increasing the use efficiency of fertilizers and sustaining the soil fertility.

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