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Validation of soil test crop response based fertilizer recommendations for targeted yields of *Bt* cotton in semi arid south western zone of Haryana

V. GOYAL* AND MOHINDER SINGH

Department of Soil Science, CCS Haryana Agricultural University, Hisar-125004

**E mail: vishal_goyal11@rediffmail.com*

ABSTRACT : The suitability of soil test crop response (STCR) based fertilizer prescription equations under integrated plant nutrient supply (IPNS) for targeted yields of *Bt* cotton were validated at eight farmers' fields in cotton growing areas of Haryana during 2013-2014 and 2015-2016. Seven fertilizer treatments were employed which included control; farmers practice (FP); generalised package recommendations (PR), STCR recommendations for 28 and 32 q/ha (TY 28 and TY 32) seed cotton yield target with fertilizers alone; and with fertilizer and FYM (TY 28 FYM and TY32 FYM). The highest mean seed cotton yield was recorded in TY 32 FYM which decreased in the following order: TY 32 FYM > TY 32 > PR > TY 28 FYM > TY 28 > FP > control. The response to fertilizer application also followed the same trend. The mean response yardstick was 5.30, 5.08, 6.31, 5.32, 6.66 and 5.43 kg of seed cotton/kg of applied nutrients. The mean response yardstick was higher in TY 28/TY28 FYM (6.49) followed by TY 32 / TY32 FYM (5.38) as compared to PR (5.08) and FP (5.30). The yield targets of 28 and 32 q/ha was achieved within deviations of -8.9 to +5.5 and -7.8 to +1.9 per cent, respectively, at different locations indicating the validity of STCR-IPNS fertilizer prescription for *Bt.* cotton.

The mean benefit of Rs 74602/- and 72862/ha was in TY 32 FYM and TY 32 treatments, respectively. Similarly, the mean net profit of Rs 66746/ ha was the highest in targeted yield of 32 q/ha, followed by PR (Rs 58387/-), 28 q/ha yield target (Rs 55892/-) and FP (Rs 41723/-)/ha. Similarly, the mean marginal B:C ratio was higher under targeted yield treatments of STCR/ STCR-IPNS than other treatments. The results clearly revealed that the STCR based fertilizer recommendations for 32 q/ha yield targets under irrigated conditions in cotton growing area of Haryana proved superior over generalised package recommendations due to higher productivity, response yardstick and benefit to farmers.

Key words : Conductivity, integrated, nurtrient, recommondations, target, validation

Cotton (*Gossypium* spp.) is an important cash crop playing key role in the agriculture and textile sector of the country. The area under cotton has increased by1.47 times from 87.3 lakh ha in 2001-2002 to 128.2 lakh ha during 2014-2015 (Cotton Corporation of India, 2016) and about 95 per cent of the area is under *Bt.* cotton which was evenly distributed among the major cotton growing states (Chaudhary and Gaur, 2014). During this period, the production of cotton has increased by about 2.40 times from 158 lakh bales (170 kg per bale) in 2001-2002 to 380 lakh bales in 2014-2015. However, the current productivity of 504 kg/ha of lint of India and 538 kg/ha of lint of Haryana is much lower than the seed cotton yield of 2803 kg/ha (about 930 kg/ha lint) and 3392 kg/ha (about 1130 kg/ha lint) obtained under experimental research stations

(Katherine *et al.*, 2013 and Manjunatha *et al.*, 2014).

The sustainability of cotton productivity has been hampered and the production of cotton has been adversely affected mainly due its high cost of production because of heavy infestation of whitefly and indiscriminate use of insecticides as well as imbalanced use of fertilizers. The fertilizer prices have escalated steeply in recent past and necessity of judicious application of appropriate quantity of nutrients through fertilizers and manures based on soil test and crop requirement is fundamental to sustain farm productivity and to improve economy of the farmers. Several approaches of fertilizer recommendations have been followed world over of which soil test crop response based fertilizer recommendation for specific yield target of crops is unique as it not only indicates soil test based balanced fertilizer recommendations but also the level of the yield which farmers' can obtain with optimum crop management under favourable climatic conditions. Under STCR approach, the fertilizer dose varies for each unit change in soil test value and higher doses are recommended for higher targets.

The systematic study on the effect of soil test crop response based fertilizer recommendations for specific yield targets of *Bt* cotton in Haryana is lacking. The present study was under taken to verify the soil test based fertilizer prescription equations for targeted yields under integrated nutrient supply and to compare the response and economics with farmers' practices and package recommendation of fertilizers for *Bt* cotton under irrigated conditions at farmers' fields in parts of semi arid south western zone in major cotton growing districts of Haryana.

MATERIALS AND METHODS

The soil test based fertilizer prescription equations for targeted yield of *Bt* cotton under integrated plant nutrient supply were tested at four farmers' fields each during 2013-2014 and 2015-2016 in cotton growing districts of Hisar, Fatehabad and Sirsa. Before laying out the experiment, composite surface (0-15 cm) soil samples were drawn from the field, processed in the laboratory and analyzed for texture, pH and electrical conductivity using standard methods. The samples were also analysed for organic carbon and available N, phosphorous and potassium using standard methods. Seven fertilizers and FYM treatments were applied in each field comprising of control, farmers' practice (FP), general package recommendations of fertilizers (PR), soil test based fertilizer dose for 28 q/ha (TY 28) and 32 q/ha (TY 32) seed cotton yield. In addition, there were two treatments in which fetilizers along with 15 t FYM/ ha were applied for 28 q/ha (TY 28 FYM) ad 32 q/ha (TY 32FYM) seed cotton yield targets. The doses of fertilizer N, P_2O_5 and K_2O for different yield targets were calculated by using soil test crop response based fertilizer prescription equations under integrated nutrient supply (STCR-IPNS) for targeted yield of *Bt* cotton (MRC 6304) developed during 2011-2013 by the Hisar centre of AICRP on "Soil Test Crop Response Correlations" which are given below :

FN = 13.76 T-– 1.95 SN – 0.13 FYM (N)

$F(P_2O_5)$ = 4.47 T – 4.78 SP – 0.12 FYM (P_2O_5)

$F(K_2O)$ = 7.64 T – 0.77SK – 0.10 FYM (K_2O)

where FN, F(P_2O_5)and F(K_2O) are fertilizer N, P_2O_5 and K_2O (kg/ha), respectively. T is seed cotton yield target (q/ha). SN, SP and SK are the soil available N, P and K (kg/ha), respectively. FYM (N), FYM (P_2O_5) and FYM (K_2O) are the N, P_2O_5 and K_2O in FYM (kg/ ha), respectively.

The doses of fertilizer N, P_2O_5 and K_2O were reduced in TY 28 FYM and TY 32 FYM in comparison to TY 28 and TY 32 treatments depending upon the contents of nutrients and their efficiencies in FYM. The crop was sown using standard agronomic practices with 67.5 cm x 60.0 cm spacing in the month of May. The crop was raised up to maturity and seed cotton yield was recorded treatment wise.

RESULTS AND DISCUSSION

The soils of the experimental fields (Table 1) was normal and alkaline in reaction, non-saline with electrical conductivity ranging from 0.26 to 0.84 dS/m and the soil texture varied from sandyloam to loam. The soils were low to medium in organic carbon (3.2 to 6.0 g/kg), low in available N (112 to 140 kg/ha), medium in available P (12 to 20 kg/ha) and high in available K (220 to 305 kg/ha). The soil test values of different fields indicated considerable variations in organic carbon and available N, P & K. The doses of fertilizer nutrients and FYM applied in different treatments in the fields are presented in Table 2.

Seed cotton yield : The seed cotton yield obtained in various treatments at different locations in both the years ranged widely (Tables 3, 4 and 5). The yield of control varied from 1110 kg/ha to 1650 kg/ha (mean 1353 kg/ha) during *kharif* 2013 and from 1140 to 1800 kg/ha (mean 1375 kg/ha) in different locations during *kharif* 2015. The yield in F.P. treatment ranged from 2140 kg/ha to 2570 kg/ha (mean 2363 kg/ ha) during *kharif* 2013 and 2288 to 2778 kg/ha (mean 2487 kg/ha) during *kharif,* 2015 indicating an improvement of yield by about 78 per cent in FP over control on pooled mean basis of two years. The increase in yield in FP over control was due to the application of 125 to 150 kg N and 50 to 60 kg P_2O_5/ha by the farmers (Table 2). The response to fertilizer application over control ranged from 920 to 1148 kg/ ha (mean 1061 kg/ha) in FP for *kharif,* 2013 and

Table 1. Physicochemical properties of the soils of the experimental fields

Sr. No.	Village	pH (1:2)	EC (dS/m) (1:2)	Texture	Organic carbon (g/kg)	Available nutrients(kg/ha) N	P	K
***Kharif*, 2013**								
1	Mehalsra	8.3	0.64	SL	4.6	140	20	228
2.	Shahpur	8.0	0.72	SL	3.4	126	17	220
3.	Adampur	8.2	0.70	LS	3.8	133	15	268
4.	Sadalpur	8.0	0.78	LS	3.2	119	12	224
***Kharif*, 2015**								
1	Kharakheri	8.5	0.32	LS	3.9	119	15	250
2.	Dhangar	7.8	0.19	LS	3.6	112	12	225
3.	Darbi	8.2	0.84	L	5.1	133	17	270
4.	Panihari	8.0	0.26	SL	6.0	140	15	305

Table 2. Fertilizer nutrient doses in different treatments in *Bt* cotton during *kharif* 2013 and 2015

Sr. No.	Treatment	Fertilizer nutrients (kg/ha)		
		N	P_2O_5	K_2O
***kharif*, 2013**				
1	Control	0	0	0
2	F.P.	125-150	50-60	0
3	P.R.	175	60	60
4	TY 28	112-153	29-60	8-45
5	TY 32	208-176	47-86	38-72
6	TY 28 FYM	92-133	17-56	0-25
7	TY 32 FYM	157-188	35-74	18-55
***kharif*, 2015**				
1	Control	0	0	0
2	F.P.	150	50	0
3	P.R.	175	60	60
4	TY 28	112-167	44-68	21-60
5	TY 32	167-222	62-86	10-71
6	TY 28FYM	92-147	32-56	0-21
7	TY 32FYM	147-202	50-74	0-51

2015. The seed cotton yield varied in PR treatment varied from 2700 to 2960 kg/ha (mean 2820 kg/ha) during *kharif,* 2013 and from 2740 to 3066 kg/ha (mean 2904 kg/ha) during *kharif* 2015. The mean response in PR over control was 1467 and 1529 kg/ha during 2013 and 2015, respectively with overall mean value of 1498 kg/ha. The improvement in yield and response in PR over FP was due to higher application of fertilizers in PR, thereby making strong case of balanced fertilizer application in PR treatment. The NPK consumption ratio is highly skewed towards N resulting in imbalanced and inadequate use of fertilizers particularly that of K resulting in mining of soils posing question mark to yield sustainability in cotton. Antil *et al.,* (2015) reported that the area under low to medium category in available K in soils of Haryana was widespread to about 73 per cent which require K application through fertilizers for better crop yields and sustaining productivity and fertility of soils. The increase in yield of *Bt* cotton due to application of higher levels of nutrients in balanced proposition was also reported by Devraj *et al.,* (2011) and Hoshamani *et al.,* (2013) The highest seed cotton yield was recorded at all the eight sites under 32 q/ha STCR-IPNS (TY 32 FYM) ranging from 2990 to 3260 kg/ha (mean 3120 kg/ha) during 2013 and from 2980 to 3063 kg/ ha (mean 3022 kg/ha) during 2015. The mean response was 1768 and 1647 kg/ha (mean 1707 kg/ ha) in this treatment during two years. The yield and response to fertilizer application in treatments where fertilizer alone were applied for 32 q/ha yield target, was slightly lower as compared to TY 32 FYM treatment. The mean yield in TY 32 treatment was 3038 and 3026 kg/ha during *kharif,* 2013 and 2015, respectively. The mean response in TY 32 was 1685 and 1651 kg/ha during the year 2013 and 2015, respectively. The yield and response to fertilizer/and FYM application under targeted yield of 28 q/ha was moderate which were higher than FP treatment but lower than PR and TY 32/TY 32FYM treatments. The mean yield in TY 28 and TY 28 FYM treatments on the basis of pooled data of two years was 2695 and 2766 kg/ha, with mean response of 1332 and 1402 kg/ha, respectively. These results can well be interpreted by comparing the yield data (Table 3) and fertilizer nutrient doses at different experimental sites. The application of N and P_2O_5 in TY 28 / TY 28 FYM treatments in different locations were lower than that in FP treatments but K_2O was also applied based on soil tests for targeted yield of 28 q/ha. Thus, balanced application of all the

Table 3. Seed cotton yield, response, per cent deviations and economics of fertilizer application in *Bt* cotton during *kharif* 2013

S. No.	Treatment	Seed cotton yield (kg/ha)	Response (kg/ha)	Response yard stick (kg/kg)	Per cent deviation	Benefit from additional produce (Rs/ha)	Price of fertilizers and FYM (Rs)	Profit	B/C ratio (Rs/Re)
Village – Mehalsara									
1	Control	1650							
2	F.P.	2570	920	4.60		45080	4144	40937	10.88
3	P.R.	2960	1310	4.44		64190	6713	57477	9.56
4	TY 28	2715	1065	5.95	-3.0	52185	3837	48348	13.60
5	TY 32	3020	1370	4.71	-5.6	67130	6347	60783	10.58
6	TY 28 FYM	2845	1195	6.68	1.6	58555	3931	54624	14.89
7	TY 32 FYM	3150	1500	5.15	-1.6	73500	6452	67048	11.39
Village – Shahpur									
1	Control	1240							
2	F.P.	2270	1030	5.15		50470	4144	46327	12.18
3	P.R.	2700	1460	4.95		71540	6713	64827	10.66
4	TY 28	2690	1450	6.33	-3.9	71050	5090	65960	13.96
5	TY 32	3150	1910	5.75	-1.6	93590	7494	86096	12.49
6	TY 28 FYM	2720	1480	6.46	-2.9	72520	5184	67336	13.99
7	TY 32 FYM	3260	2020	6.08	1.9	98980	7588	91392	13.04
Village –Adampur									
1	Control	1410							
2	F.P.	2470	1060	5.30		51940	4144	47797	12.54
3	P.R.	2880	1470	4.98		72030	6713	65317	10.73
4	TY 28	2580	1170	6.26	-7.9	57330	4244	53086	13.51
5	TY 32	3040	1630	5.62	-5.0	79870	6647	73223	12.02
6	TY 28 FYM	2650	1240	6.63	-5.4	60760	4698	56062	12.93
7	TY 32 FYM	3080	1670	5.76	-3.8	81830	6741	75089	12.14
Village - Sadalpur									
1	Control	1110							
2	F.P.	2140	1030	5.15		50470	4144	46327	12.18
3	P.R.	2740	1630	5.53		79870	6713	73157	11.90
4	TY 28	2630	1520	5.78	-6.1	74480	6295	68185	11.83
5	TY 32	2970	1860	5.08	-7.2	91140	8698	82442	10.48
6	TY 28 FYM	2710	1600	6.08	-3.2	78400	6389	72011	12.27
7	TY 32 FYM	2990	1880	5.14	-6.6	92120	8792	83328	10.48

Price of N = Rs. 11.77/kg, P_2O_5 = Rs. 47.56/kg, K_2O=Rs. 30.00/kg, Seed cotton=Rs. 49.00/kg and FYM Rs 100/t

three major nutrients resulted in higher yields in this treatment in comparison to FP treatment. In PR treatment, blanket application of 175, 60 and 60 kg N, P_2O_5 and K_2O were applied in all the fields irrespective of the soil test values, whereas the application of these nutrients varied considerably for targeted yield treatments in different fields depending upon the

soil test values of a specific field. These results are in line with those reported by Gudadhe *et al.,* (2013), Manjunatha *et al.,* (2014) Katherine *et al.,* (2014) and Gudadhe *et al.,* (2015) in *Bt* cotton who reported the superiority of STCR based fertilizer recommendations over farmer's practices and blanket recommendations.

In general, the yields under STCR-IPNS were higher than STCR fertilizer alone which might be due to favourable environment in

Table 4. Seed cotton yield, response, per cent deviations and economics of fertilizer application in *Bt* cotton during *kharif* 2015

S. No.	Treatment	Seed cotton yield (kg/ha)	Response (kg/ha)	Response yard stick (kg/kg)	Per cent deviation	Benefit from additional produce (Rs/ha)	Price of fertilizers and FYM (Rs)	Profit	B/C ratio (Rs/Re)
Village – Kharakheri									
1	Control	1260							
2	F.P.	2340	1080	5.40		41040	4138	36903	9.92
3	P.R.	2945	1685	5.71		64030	6503	57527	9.85
4	TY 28	2820	1560	6.87	0.7	59280	4871	54409	12.17
5	TY 32	3052	1792	5.41	-4.6	68096	7200	60896	9.46
6	TY 28 FYM	2909	1649	7.26	3.9	62662	5043	57619	12.42
7	TY 32 FYM	3063	1803	5.45	-4.3	68514	7372	61142	9.29
Village – Dhangar									
1	Control	1140							
2	F.P.	2288	1148	5.74		43624	4138	39487	10.54
3	P.R.	2863	1723	5.84		65474	6503	58971	10.07
4	TY 28	2700	1560	5.65	-3.6	59280	6262	53018	9.47
5	TY 32	3043	1903	5.02	-4.9	72314	8563	63751	8.44
6	TY 28 FYM	2746	1606	5.82	-1.9	61028	6434	54594	9.49
7	TY 32 FYM	3046	1906	5.03	-4.8	72428	8599	63829	8.42
Village – Darbi									
1	Control	1300							
2	F.P.	2540	1240	6.20		47120	4138	42983	11.39
3	P.R.	2740	1440	4.88		54720	6503	48217	8.42
4	TY 28	2550	1250	7.10	-8.9	47500	3727	43773	12.75
5	TY 32	2950	1650	5.89	-7.8	62700	6055	56645	10.36
6	TY 28 FYM	2590	1290	7.33	-7.5	49020	4272	44748	11.47
7	TY 32 FYM	2980	1680	6.00	-6.9	63840	6227	57613	10.25
Village - Panihari									
1	Control	1800							
2	F.P.	2778	978	4.89		37164	4138	33027	8.98
3	P.R.	3066	1266	4.29		48108	6503	41605	7.40
4	TY 28	2878	1078	6.53	2.8	40964	3803	37161	10.77
5	TY 32	3057	1257	5.07	-4.5	47766	5572	42194	8.57
6	TY 28 FYM	2954	1154	6.99	5.5	43852	4509	39343	9.73
7	TY 32 FYM	3000	1200	4.84	-6.3	45600	6011	39589	7.59

Price of N = Rs. 12.39/kg, P_2O_5 = Rs. 45.58/kg, K_2O = Rs. 26.66/kg, Seed cotton = Rs. 38.00/kg and FYM Rs 100/t

rhizosphere of the crop due to improvement in soil conditions. The pooled data of the two years revealed that the highest mean cotton seed yield was recorded in TY 32 FYM treatment which decreased in the following order: TY 32 FYM > TY 32 > PR > TY28 FYM > TY28 > FP > control.

Response yardstick : The response yardstick varied widely from 4.29 in PR in village Panihari to 7.3 kg/kg in TY 28 FYM treatment in village Darbi during *kharif,* 2015. The mean response yardstick on the basis of two years pooled data was 5.30, 5.08, 6.31, 5.32, 6.66 and 5.43 kg of seed cotton/kg of applied nutrients. These high response yardstick values in different treatments revealed the high responsiveness of *Bt* cotton to nutrient application. The response yardstick was the highest in targeted yield treatment of TY 28 and TY 28 FYM (mean 6.49) followed by TY 32 and TY 32 FYM (mean 5.38). The higher response yardstick under STCR approach over PR and FP might be due to balanced supply of nutrients from soils as well as fertilizers and manures. Rao and Srivastava (2000) reported that the balanced supply of nutrients under STCR-IPNS, efficient utilization of applied fertilizer nutrients in the presence of organic sources and synergistic effect of the conjoint use of various sources of nutrients resulted in higher responsivness of crops to nutrient application

Per cent achievement of yield targets : The perusual of data presented in Table 3 and 4 indicated that the yield targets of cotton were fully to marginally achieve at different locations in both the years. The yield targets of 28 and 32 q/ha with fertilizers alone (TY 28 and TY 32) was achieved within deviations of -8.9 to +2.8 and -7.8 to -4.5 per cent, respectively. Similarly, 28 and 32 q/ha yield targets under IPNS (TY 28 FYM and TY 32 FYM) were achieved within devaitions of -7.5 to + 5.5 and -6.9 to + 1.9 per cent, respectively. These results clearly revealed the validity of soil test based fertilizer prescriptions for targeted yields of cotton under STCR/STCR-IPNS as all the targets were achieved within acceptable limit of ± 10 per cent (Saranya *et al* 2012).

Economics : The mean benefit pooled for different locations for two years was Rs 74602/-

Table 5. Pooled seed cotton yield, response, per cent deviations and economics of fertilizer application in *Bt* cotton during *kharif* 2013 and 2015

S. No.	Treatment	Seed cotton yield (kg/ha)	Response (kg/ha)	Response yard stick (kg/kg)	Per cent deviation	Benefit from additional produce (Rs/ha)	Price of fertilizers and FYM (Rs)	Profit	B/C ratio (Rs/Re)
1	Control	1364	-	-	-	-	-	-	-
2	F.P.	2425	1061	5.30	-	45864	4141	41723	11.08
3	P.R.	2862	1498	5.08	-	64995	6608	58387	09.82
4	TY 28	2695	1332	6.31	-8.9 to +2.8	57759	4766	52992	12.26
5	TY 32	3035	1672	5.32	-7.8 to - 4.5	72826	7072	65754	10.30
6	TY 28FYM	2766	1402	6.66	-7.5 to + 5.5	60850	5057	55792	12.15
7	TY 32FYM	3071	1707	5.43	-6.9 to +1.9	74602	7223	67379	10.33

, 72862/-, 64995/-, 60850/-, 57759/- and 45864/ ha in TY 32 FYM, TY 32, PR, TY 28 FYM, TY 28 and FP treatment, respectively (Table 3, 4 and 5). Similarly, the net profit after substracting the cost of fertilizer and FYM from the total benefit was also highest in TY 32FYM (Rs. 67379/-) which was followed by TY 32 (Rs. 65754/-), PR (Rs. 58387/-), TY 28FYM (Rs. 55792/-), TY 28 (Rs. 52992/-) and lowest profit of Rs. 41723/ha in FP treatment. The higher profit in yield target of 32 q/ha was due to higher yield obtained in the treatment. The marginal B:C ratio varied from 8.42 to 14.89 in different locations and years. The mean marginal B:C ratio of two years for different locations varied from 9.82 in PR treatments to 12.26 Rs/ Re invested on nutrients in TY 28 treatments. In general the B:C ratio for respective treatments were lower in 2015 as compared to 2013 because of increase in prices of fertilizers in 2015. The net profit in TY 28 / TY 28 FYM was Rs. 52992/- and Rs 55792/- as compared to Rs. 41723/ha in FP treatment with higher productivity of about 300 kg/ha in former treatment. The farmers' may opt for STCR approach for lower yield targets of 28 q/ha under resource constraints. These results clearly revealed the superiority of STCR based fertilizer recommendations over farmers' practices and general package recommendations.

CONCLUSION

Soil test crop response based fertilizer prescription equations under IPNS developed at Research Farm were found to hold good at farmers' field conditions. The results of present study clearly demonstrated that balanced nutrients application only through fertilizers (PR) without knowledge of soil fertility is undermined by the actual balance nutrients application to bridge the gap between the total crop rquirement of nutrients and those supplied by the soil. The STCR approach serve this purpose recommending site specific nutrient application considering the crop requirement and replenishment of nutrients from soil. The targeted yield based fertilizer recommendations are dynamic in nature as it can be increased or decreased for each unit decrease or increase in soil available nutrients. The fertilizer nutrients application for 32 q/ha seed cotton yield target based on soil test under irrigated condition was found to be superior over farmers' practice (FP) and generalised package recommendations owing to higher response, response yardstick, productivity, benefit and viable marginal B:C ratio.

REFERENCES

Antil, R.S., Singh, Mohinder, Grewal, K.S., Panwar, B.S., Devraj, Singh, J.P. and Narwal, R.P. 2016. Status and distribution of major nutrients in soils of Haryana. *Ind. Jour. Fert.* **12** : 24-33

Chaudhary, B. and Gaur, K. 2014. Biotech cotton in India. ISAAA Series of Biotech Crop Profiles. ISAAA: Ithaca, NY.

Cotton Corporation of India Ltd. 2016. Government of India undertaking under Ministry of Textile website : *www.cotcorp.gov.in*

Dev Raj, Bhatoo, B.S., Duhan, B.S., Kumari, Promilla and Jain, P.P. 2011. Effect of crop geometry and fertilizer levels on seed cotton

yield and nutrient uptakeof *Bt* cotton under irrigated condition. *J. Cotton Res. Dev.* **25**: 176-80

Gudadhe, N., Dhonde, M.B. and Hirwe, N.A. 2015 Effect of integrated nutrient management on soil properties under cotton chickpea cropping sequence in vertisols of Deccan plateau of India. *Ind. Jour. Agri. Res.* 49 : 207-14.

Gudadhe, N.N., Dake, A.P., Lambade, B.M. and Jibhkate, S.B. 2013. Effect of different INMS treatments on growth, yield, quality, nutrient uptake and economics of hybrid cotton (*Gossypium hirsutum* L.). *Ann.Agri, Res.* **34 :** 342-48

Hoshmani, V., Halepyati, A.S., Koppalkar, B.G., Desai, B.K. and Ravi, M.V. 2013. Yield quality parameters and uptake of nutrients in irrigated *Bt* coton (*Gossypium hirsutum* L.) as influenced by macro nutrients and liquid fertilizers. *Karnataka Jour. Agri. Sci.* **26** : 421-23

Katharine, P.S., Santhi, S., Maragatham, S., Natesan, R. Ravukumar, V. and Dey Pradip 2013. Soil test based fertilizer prescriptions through inductive cum targeted yield model for transgenic cotton on Inceptisol. *IOSR – Jour. Agri. Veter. Sci.* **6** : 36-44.

Manjunatha, S.B., Biradar, D.P. and Aladakatti, Y.R. 2014. Response of *Bt* cotton to nutrients applied based on target yield. *Res. Envir. Life Sci.* **7** : 247-50.

Rao, Subba, A. and Srivastava, Sanjay 2000. Soil test based fertilizer use- A must for sustainable agriculture. *Fertilizer News* **45**: 25-38

Saranya, S., Santhi, R., Appavu, K and Rajamani, K. 2012. Soil test based integrated plant nutrition system for ashwagandha on inceptisols. *Ind. Jour. Agri, Res.* **46 :** 88-90

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