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Soil test based targeted yield approach for balance fertilization of *Bt* cotton in inceptisol

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ABSTRACT : Field experiment on soil test crop response studies of *Bt* cotton was conducted during 2008-2009 and its validation experiments were conducted during 2009-2010 to 2013-2014 at MPKV, Rahuri. Nutrients requirement of *Bt* cotton were 3.91, 1.01 and 3.29 kg N, P and K/q of cotton produce. Soil contribution in total NPK uptake of *Bt* cotton was 45.87, 83.60 and 21.84 per cent, respectively, while FYM contributes 11.7, 14.8 and 24.8 per cent, respectively. The per cent contribution of fertilizer nitrogen, phosphorous and potassium fertilizer in absence of FYM were 33.77, 21.84 and 38.35, respectively, which were increased to 40.8, 27.9 and 39.5, per cent, respectively in conjoint use fertilizer with FYM. The targeted yield fertilizer equations without FYM shows 6.4 per cent deviation in actual yield while 11.2 per cent deviation due to conjoint use of fertilizers and organic manure. Application of fertilizer nutrient per 40 q/ha yield target of *Bt* cotton along with 10 t FYM/ha shows highest yield of 42.62 q/ha with highest B: C ratio of 2.69. The total uptake of N, P and K by *Bt* cotton were 167.95, 66.08 and 89.22 kg/ha, respectively. Fertilizer treatment as per STCR yield target 40 q/ha + 10 t/ha FYM significantly improves residual soil fertility status with 192.1, 20.9, 570 kg/ha available N, P, K, respectively.

Key words : *Bt* cotton, nutrient requirement, targeted yield fertilizer equations

Maharashtra is the largest cotton growing state contributing 34 per cent of area and 24 per cent of the production. With the advent of *Bt* cotton the productivity of cotton is improved considerably hence more than 80 per cent of cotton farmers from cotton growing areas of India adapted *Bt* cotton. Kefyalew *et al.,* (2007) reported that the replacement of old cultures of cotton with transgenics removed the pressure of boll weevils and thereby changed the yield potential. Bhalerao *et al.,* (2012) reported that the introduction of *Bt* gene in cotton has changed the vegetative and reproductive growth pattern. These manipulations alter the nutrient requirement of *Bt* cotton than non *Bt* cotton.

Balanced fertilization is a must for realizing higher efficiency and economy of fertilizer use. Soil test based fertilizer recommendation plays a vital role in ensuring balanced nutrition to crops and fertilizer schedules should therefore be based on the magnitude of crop response to applied nutrients at different soil fertility levels. Keeping this in view, the research work was undertaken to develop fertilizer prescription equation based on soil test value and yield target for precise recommendation of fertilizers in a *Bt* cotton.

MATERIALS AND METHODS

Soil test crop response studies on *Bt* cotton was conducted during 2008-2009 on *Typic Haplusept* at STCR Farm, Mahatma Phule Krishi Viyapeeth, Rahuri. The farm is geographically located at 22°11´ N latitude and 80°09´ E longitude at an altitude of 310 m above MSL. The experimental soil was slighty alkaline in reaction (pH - 8.1 to 8.3), non calcareous, low in soluble salts, (EC 0.18 to 0.24/dSm), low in $KMNO_4$-N (170 to 224 kg/ha), low to medium in 0.5 M $NaHCO_3$ (11.7 to 24.5 kg/ha) and high in N NMH_4OAc-K (384 to 583 kg/ha). The inductive

cum fertility gradient approach was followed for conducting the field experiment. Experimental plot was divided into low, medium and high fertility gradients by the applying graded doses of fertilizer (00:00:00, 200: 100:100 and 400:200:200 kg/ha N: P_2O_5: K_2O, respectively) and stabilized with growing fodder maize crop. After harvest of fodder maize FYM blocks (0, 10 and 20 t/ha) were imposed across the fertility gradient. Twenty one different treatment combinations ($N_{00}P_{50}K_{50}$, $N_{50}P_{25}K_{25}$, $N_{50}P_{50}K_{25}$, $N_{50}P_{25}K_{50}$, $N_{50}P_{50}K_{50}$, $N_{100}P_{50}K_{00}$, $N_{100}P_{0}K_{50}$, $N_{100}P_{25}K_{25}$, $N_{100}P_{50}K_{25}$, $N_{100}P_{25}K_{50}$, $N_{100}P_{50}K_{75}$, $N_{100}P_{75}K_{50}$, $N_{100}P_{75}K_{75}$, $N_{100}P_{75}K_{75}$, $N_{150}P_{25}K_{25}$, $N_{150}P_{50}K_{25}$, $N_{150}P_{75}K_{25}$, $N_{150}P_{50}K_{50}$, $N_{150}P_{75}K_{50}$, $N_{150}P_{50}K_{75}$, $N_{150}P_{75}K_{75}$) of graded level of N (00, 50, 100, 150 kg/ha) , P_2O_5 (00, 25, 50,75 kg/ha) and K_2O (00, 25, 50, 75 kg/ha) were distributed along with 3 control plots ($N_{00}P_{00}K_{00}$). These 24 treatments were randomly distributed in such a way that each fertility gradient block and FYM block includes all the 24 treatment set. The *Bt* cotton hybrid Mallika were used as a test crop. All the recommended package of practices were followed while raising the plants. Full dose of phosphorous and potassium were applied as basal dose through single superphosphate while nitrogen fertilizers are applied in 3 equal splits (at sowing , 30 days after sowing and 60 days after sowing) as per treatment.

The initial soil samples were collected from each plot before application of FYM and fertilizer and analyzed for their $KMnO_4$-N Olsen-P and neutral normal NH_4OAc –K. The FYM used in the experiment was analyzed for total nitrogen by H_2SO_4 digestion mixture using macro Kjeldhals method while phosphorous and potassium were estimated by tri acid mixture (9:3:1 HNO_3: $HClO_4$: H_2SO_4) at 180-200 ^{0}C (AOAC, 2005). Seed cotton yield and stover yield were recorded and these samples were analyzed for N, P and K content and uptake values are computed. Using the data of nutrient uptake, seed cotton yield, initial soil available nutrients and fertilizer doses applied, basic parameters, *viz.,* nutrient requirement (NR), contribution of particular nutrient from soil (CS), contribution of FYM (CFYM) and contribution of fertilizer without FYM *(Cfa)* and with FYM *(Cfb)* were calculated. These basic parameter were used for formulating the fertilizer prescription equations.

The validation of targeted yield equations developed for *Bt* cotton were tested by conducting five different follow up trials during five consecutive years from 2009-2010 to 2013-2014 on *Inceptisol* at STCR farm, MPKV, Rahuri. The experiments were laid out in randomized block design with 3 replications and 8 treatments *viz.,* Control (no fertilizer), GRDF (100: 60: 60 kg/ha N: P_2O_5: K_2O + FYM @ 10 t/ha) , Fertilizer as per soil test values (150:90:30 kg/ha N: P_2O_5: K_2O), Fertilizers as per STCR target of 30 q/ha and 40 q/ha without FYM and with 10 t/ha FYM, respectively and only FYM @ 20 t/ha. Based on the initial soil tests and the yield targets aimed, fertilizer N, P_20_5 and K_20 doses were applied for STCR treatments. Fertilizers sources and method of application were same as in main trial. Seed cotton yield and straw yield was recorded for each plot and analyzed for NPK uptake, economics was worked out for each treatment.

RESULTS AND DISCUSSION

Yield and nutrient uptake : The range and mean value of cotton yield and total nutrient uptake of treated and control plot were given in Table 1. The cotton yield in treated plots ranged from 35.0 to 47.6 q/ha with a mean of 41.3 q/ha. Whereas, in control plot, seed cotton yield ranged from 15.7 to 27.0 q/ha with a mean of 22.3 q/ha . The total nutrient uptake of nitrogen, phosphorous and potassium in treated plot were ranged from 71.1 to 265.6, 13.6 to 87.4, and 91.6 to 175.0 kg/ha with a mean of 168.3, 50.5 and 133.3 kg/ha , respectively. Whereas, the total nutrient uptake of nitrogen, phosphorous and

Table 1. Range and average value of seed cotton yield and nutrient uptake in treated and control plot

Parameter	Treated plot		Control plot	
	Range	**Mean**	Range	**Mean**
Seed cotton yield (q/ha)	35.0-47.6	**41.3**	15.7-29.0	**22.3**
Total nutrient uptake (kg/ha)				
Nitrogen	71.1-265.6	**168.3**	70.4-118.3	**94.3**
Phosphorus	13.6 -87.4	**50.5**	14.0-27.2	**20.6**
Potassium	91.6- 175.0	**133.3**	79.6-116.2	**97.9**

potassium in control plot were ranged from 70.4 to 118.3, 14.0 to 27.2, and 79.6 to 116.2 with a mean of 94.3, 20.6 and 97.9 kg/ha , respectively. The data clearly indicates wide variability existed in yield and total nutrient uptake in treated and control plots, which is prerequisite for calculating basic parameters and fertilizer equations for calibrating fertilizer dose for specific yield target.

Basic parameter : The amount of nutrients required to produce one quintal cotton yield were observed to be 3.91, 1.01 and 3.29 kg N, P and K , respectively. The soil contribution (*Cs*) in total uptake of nitrogen, phosphorous and potassium in *Bt* cotton were 45.87, 83.60 and 21.84 per cent , respectively. The FYM contributes 11.7, 14.8 and 24.8 per cent of total uptake nitrogen, phosphorous and potassium in *Bt* cotton. The per cent contribution of fertilizer nitrogen, phosphorous and potassium in absence of FYM (*Cfa*) were 33.77, 21.84 and 38.35 , respectively which were increased to 40.8, 27.9 and 39.5 per cent , respectively due to conjoint use chemical fertilizers with FYM (*Cfb*).

The nutrient contribution from fertilizer source along with FYM was greater than that of in absence of FYM. The application of FYM might have played important role in improving physico chemical properties and enhance the microbial population and enzyme activity in soil which plays important role in nutrient transformation and availability of nutrient. These finding are in close conformity with those reported by Kadam and Sonar (2006).

Fertilizer prescription equations : The basic data generated were used to derive the fertilizer prescription equations. The equations derived for calibration of fertilizer nutrient dose for specific yield target of *Bt* cotton based upon soil test values in *Inceptislos* are as below

Fertilizer equations without FYM

Fertilizer equations with FYM : FN = 10.36 x T – 1.21 x SN FP_2O_5 = 4.62 x T – 3.83 x SPFK_2O = 8.57 x T - 0.46 x SK FN = 9.58 x T- 1.15 x SN -1.42 x FYMFP_2O_5=3.62 x T- 2.99 x SP-1.59 x FYMFK_2O=8.32 x T– 0.45 x SK –3.77 x FYM

Where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg/ha , respectively. T is yield target in q/ha from 30-45 q for *Bt* cotton and SN, SP and SK are soil available N, P and K in kg/ha , FYM is farm yard manure in t/ha

Table 2. Nutrient requirement, contribution from soil, fertilizer and FYM for *Bt* cotton

Parameter	N	P	K
Nutrient requirement (kg/q)	3.91	1.01	3.29
Contribution from soil available nutrients (%)	45.87	83.60	21.84
Contribution of fertilizer in absence of FYM (*Cfa*) (%)	37.77	21.84	38.35
Contribution of fertilizer with FYM (*Cfb*) (%)	40.8	27.9	39.5
Contribution of FYM (%)	11.7	14.8	24.8

Table 3. Fertilizer dose (kg/ha) based upon soil test value and yield target of *Bt.* cotton

Soil test value (kg/ha)	Yield Target (35 q/ha)		Yield Target (40 q/ha)	
	Fertilizer without FYM	Fertilizer with (10 t/ha) FYM	Fertilizer without FYM	Fertilizer with (10 t/ha) FYM
Nitrogen				
125	211	181	263	229
150	181	153	233	201
175	151	125	203	173
200	121	97	172	145
225	90	69	142	117
Phosphorous				
14	108	69	131	87
17	97	60	120	78
20	85	51	108	69
23	74	42	97	60
26	62	33	85	51
Potassium				
300	162	119	205	160
350	139	96	182	138
400	116	74	159	115
450	93	51	136	93
500	70	29	113	70

Multiple regression equation for fertilizer treated plot : Y = -329.65 + 0.06875* FN + 0.0477 FP – 0. 04 FK + 1.89058* SN - 1.2281* SP + 0.081254*SK + 0.000065 FN^2 + 0.00007 FP^2 - 1.0655 SK^2 - 0.0004 FN X SN - 0.0019 FP X SP - 0.00011FK X SK (**R^2 = 0.725****)

A significant value of coefficient of determination of R^2 value (0.725**) indicates the goof fit of the equation with 0.72 per cent variation in *Bt* cotton yield due to variation in soil test values, fertilizer dose and FYM

On the basis of these equations, ready recknor were prepared for making precise fertilizer recommendation for specific yield target with varied soil test value. The fertilizer dose is in kg/ha for 35 and 40 q/ha yield target as per varying soil test values are presented in Table 3.

Verification of fertilizer prescription equations : The validity of the STCR equations for *Bt* cotton were tested in five follow up trials conducted at STCR farm during 2009-2010 to 2013-2014 for 30 q/ha and 40 q/ha yield target with and without FYM. The data presented in Table 4 showed that the deviation in actual cotton yield obtained from that of desired targeted yield was 6.4 cent in treatments receiving only chemical fertilizers on STCR basis and 11.2 per cent due to conjoint use of chemical fertilizers and organic manure (FYM). The lower deviation in actual yield confirms validity of both with and without FYM fertilizer prescription equations for *Bt* cotton.

The results also showed that the highest cotton yield (42.62 q/ha) was found in treatment STCR target of 40 q/ha + 10 t/ha FYM due to the highest nutrient uptake (167.95, 66.08 and 89.22 kg/ha N, P and K , respectively). The higher nutrient uptake by the *Bt* cotton might be associated with FYM addition in conjunction with chemical fertilizer increased the nutrient availability in soil by the increased microbial population. These available nutrients released upon microbial activity was absorbed by the *Bt* Cotton. The same treatment exhibit the highest Benefit: Cost ratio (2.69). This is due to the fact that fertilizer recommendation of yield target approach was based upon actual soil test values and it avoids sub or super optimal use of fertilizer.

Residual soil fertility in respect to soil available nitrogen, phosphorus and potassium was found to improved in fertilizer treatment as per STCR yield target 40 and 30 q/ha + 10 t/ha FYM. (192.1, 20.9, 570 kg/ha and 190.4, 20.7, 580 kg/ha available N, P, K , respectively) Thus, the IPNS based yield target approach provides scientific basis for balance fertilization and maintaining residual soil fertility status.

CONCLUSION

Nutrient requirement of *Bt* cotton were 3.91, 1.01 and 3.29 kg N, P and K/q of cotton produce. The targeted yield fertilizer equations developed for *Bt* cotton shows 6.4 - 11.2 per cent

Table 4. Effect of fertilizer application based on targeted yield approach on yield, economics, nutrient uptake and residual fertility status (pooled data of 5 years)

Treatment	Cotton yield (q/ha)	Nutrient uptake (kg/ha)			Residual fertility status				B:C ratio
		N	P	K	Org. C(%)	Av. nutrients (kg/ha)			
						N	P_2O_5	K_2O	
Absolute control	20.86	77.06	30.66	45.01	0.58	166.4	15.0	485	1.86
GRDF	32.19	128.55	48.94	72.79	0.61	187.2	18.0	530	2.20
As per soil test	31.45	121.82	45.45	70.59	0.59	188.1	17.7	521	2.62
STCRC target for 30 q/ha	32.71	135.60	52.13	73.33	0.58	182.4	18.6	522	2.57
STCRC target for 40 q/ha	38.49	153.72	56.79	83.34	0.59	186.3	19.0	562	2.68
STCRC target 30 q/ha+10 t/ha FYM	34.74	144.57	57.13	73.87	0.61	190.4	20.7	580	2.27
STCRC target 40 q/ha+10 t/ha FYM	42.62	167.95	66.08	89.22	0.62	192.1	20.9	570	2.69
Only 20 t/ha FYM	26.42	97.62	39.30	53.99	0.68	181.5	16.8	554	1.53
SE +	0.75	5.85	2.16	2.97	0.012	3.03	0.46	18.80	
CD (p=0.05)	2.17	17.02	6.28	8.64	0.035	8.88	1.36	54.74	

variation than the actual yield. Application of fertilizer nutrient as per 40 q/ha yield target of *Bt* cotton along with 10 t FYM /ha recorded the highest yield, B: C ratio and maintain the soil fertility in Inceptisols.

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