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SV Deshmukh
Dr. Balasaheb Sawant Konkan Krishi Vidypeeth Dapoli, (M.S.), India

US Kudtarkar
Dr. Balasaheb Sawant Konkan Krishi Vidypeeth Dapoli, (M.S.), India

AB Jadhav
Dr. Balasaheb Sawant Konkan Krishi Vidypeeth Dapoli, (M.S.), India

AD Kadlag
Dr. Balasaheb Sawant Konkan Krishi Vidypeeth Dapoli, (M.S.), India

Correspondence
SV Deshmukh
Assistant Professor, Regional Research Station Vengurle, Dist. Sindhudurg. M.S, India

Fertilizer nutrients adjustment for BT cotton with conjoint use of farm yard manure based on targeted yield approach on vertisols

SV Deshmukh, US Kudtarkar, AB Jadhav and AD Kadlag

Abstract
Field experiment on Bt cotton by conjoint use of organic and inorganic fertilizers based on targeted yield approach on vertisols was conducted with Bt cotton (NCS-207, Mallica) in Rahuri during 2007-08. Fertilizer adjustment equations were formulated under (STCRC) system for Bt cotton following Ramamurthy's inductive-cum-targeted yield model. The nutrient requirement for production of one quintal of Bt cotton was found to be 5.84, 2.02 and 3.51 kg of N, P_2O_5 and K_2O, respectively. The per cent contribution soil and fertilizer nutrients were found to be 45.87 and 37.77 for N, 83.63 and 31.90 for P_2O_5 and 17.68 and 27.99 for K_2O, respectively. Likewise, the per cent contribution from farmyard manure (FYM) was 11.74, 14.54 and 14.57 kg ha^{-1} of N, P_2O_5 and K_2O, respectively.

Keywords: Bt-cotton, STCRC, fertilizer adjustment equations, vertisols

Introduction
The present levels of fertilizer production in India are not enough to meet the total plant nutrient requirement of the crops in order to feed growing population of the country. The continuous unjudicious use of chemical fertilizers adversely affects the sustainability of agriculture production and causing environmental pollution. Because of imbalanced and inadequate fertilizer use coupled with low efficiency of other inputs response ratio to added nutrients has declined under intensive agriculture.

BT cotton is one of the important commercial cash crops grown in India has the largest acreage (95.30 lakh hectares) under cotton at global level and has the Productivity of 553 kg lint ha^{-1} and ranks second in production (310 lakh bales) after China during 2007-08. The productivity is still below the world average (642 kg ha^{-1}). The Maharashtra state is having the largest cotton growing area of 31.91 lakh ha and production of 60 lakh bales with productivity of 320 kg lint ha^{-1}.

The fertilizer application practices indicated the possibility of enhancing production potentials of Bt cotton. It will be always better that crops should be fertilized based on soil fertility and crop requirement. Such recommendations are possible only through inductive-cum-targeted yield approach (Ramamoorthy *et al.* 1967) [4] which provides a scientific basis for balanced fertilization not only among the fertilizer nutrients but also with soil available nutrients. The Bt cotton is widely cultivated in Maharashtra and so far STCRC studies have not been conducted. Hence, the present study was undertaken to develop a balanced fertilizer recommendations for conjoint use of organic and inorganic fertilizers based on targeted yield approach on vertisols.

Materials and methods
A field experiment based on inductive-methodology was conducted in vertisols of Rahuri during *kharif* 2007-08 with BT cotton (var. Mallica NCS-207). The soil of the experimental field is clayey in texture with pH 8.1 and EC 0.30 dS/m. The initial $KMnO_4$-N, Olsen – P and NH_4OAc – K status was 191.6, 17.69 and 449.8 kg ha^{-1}, respectively. Following the inductive methodology of Ramamoorthy *et al.* (1967) [4], three fertility gradients were created by dividing the experimental field into three equal strips which were fertilized with $N_0P_0K_0$, $N_1P_1K_1$ and $N_2P_2K_2$ levels. The recommended fertilizers ($N_1P_1K_1$) were 200, 150 and 150 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. An exhaust crop of fodder maize was grown so that the fertilizers could interact with soil, plants and microbes and become a part of soil system.

By conducting fertility gradient experiment, the range in soil fertility was created in the fertility strips which was evaluated by analysing the soil after harvest of gradient crop. After the harvest of the exhaust crop, each fertility strip was divided into 24 plots, out of which there were 21 treatments with three levelsof N (100, 200 and 300 kg ha^{-1}), three levels of P_2O_5 (75, 125 and 150 kg ha^{-1}), three levels of K_2O (100, 150 and 200 kg ha^{-1}) and three levels of FYM (0, 10 and 20 t ha^{-1}) and 3 controls were superimposed to different plots in each strip in such a way that these occurred in three consecutive sub-blocks whether taken in north to south or east to west direction thus making a total of 72 plots over the three strips in both the directions. The fertilizer components *viz.*, NPK alone, NPK plus FYM were applied across each strip. Pre-sowing soil samples were collected from each plot before the superimposition of the treatments and were analysed for alkaline $KMnO_4$-N (Subbiah and Asija, 1956) [7], Olsen-P (Olsen *et al.*, 1954) [2] and neutral normal NH_4OAc-K (Hanway and Heidal, 1952) [1]. The test crop BT cotton (var. Mallica, NCS-207) was sowed during July, 2007 and grown to maturity and harvested during December 2007. The seed cotton and stalk yields were recorded plot wise. The plant samples from each plot were analysed for total N, P and K content (Piper, 1966) [3] and total uptake was computed using BT cotton seed cotton and stalk yield data.

Using the data on seed cotton yield, nutrient uptake, pre sowing soil available nutrients and fertilizer dose applied, the basic parameters *viz.*, nutrient requirement (kg q^{-1}) contribution of nutrients from soil (CS) and contribution of fertilizer (CF) were calculated as described by Ramamoorthy *et al*. (1967) [4] and Reddy *et al*. (1994) [5]. The per cent contribution of nutrients from the applied FYM was estimated as described by Santhi *et al*. (2002) [6]. The percent NPK composition of FYM used in the experiment was 068, 0.35 and 0.55 respectively. These parameters were used for the formulation of fertilizer adjustment equations for deriving fertilizer doses and the soil test based fertilizer recommendations were presented in the form of ready reckoner for described yield target of Bt cotton under NPK alone as well as NPK with FYM.

Results and discussion

Soil available nutrients and seed cotton yield

The range and mean values of seed cotton yield uptake and soil available nutrients of treated and control plots are presented in Table 1. The $KMnO_4$ –N ranged from 170 to 224 kg ha^{-1} with a mean of 197 kg ha^{-1}, Olsen -P ranged from 17.6 to 28.2 kg ha^{-1} with a mean of 19.9 kg ha^{-1} and NH_4OAc -K ranged from 388 to 583 kg ha^{-1} with a mean 485.5 kg ha^{-1}. The seed cotton yield in treated plots ranged from 22.00 to 34.93 q ha^{-1} and in control plots ranged from 20.54 to 27.00 q ha^{-1}. The above data clearly indicate that a wide variability existed in the soil test values and seed cotton yield of treated and control plots, which is a pre requisite for calculating the basic parameters and fertilizer adjustment equations for calibrating the fertilizer doses for specific yield targets.

Basic parameters

The basic data *viz.*, the nutrient requirement for producing one quintal of Bt cotton yield (kg q^{-1}), the per cent contribution of nutrients (NPK) from soil (CS), fertilizer (CF) and FYM (CFYM) have been calculated and given in Table 2. These basic parameters were used for formulating the fertilizer adjustment equations under NPK alone and NPK with FYM.

The nutrient requirements of N, P_2O_5 and K_2O were 5.84, 2.02 and 3.51 kg q^{-1} of BT cotton, respectively. The per cent contributions from soil nutrients were found to be 45.87 and 37.77 for nitrogen, 83.63 and 31.90 for phosphorus (P_2O_5) and 17.68 and 27.99 for potassium (K_2O) respectively. The per cent contribution from fertilizer nutrients without FYM was 37.8 for nitrogen, 31.9 for phosphorus and 28.0 for potassium, respectively while the per cent contribution of N, P_2O_5 and K_2O from fertilizer with FYM was 40.17, 37.38 and 31.47, respectively and per cent contribution from FYM was 11.74, 14.54 and 14.57, respectively.

Fertilizer prescription equations for desired yield targets of BT cotton

Soil test based fertilizer models or equations for targeted yield of BT cotton were formulated using the basic parameters and are presented in Table 3. On the basis of these equations a ready reckoner was prepared for varying soil test values and different yield targets with and without FYM (Table 4). It is evident from the data that the fertilizer N, P_2O_5 and K_2O requirements decreased with increase in soil test values.

Using these equations the fertilizer doses are calculated for the yield target of 40 q ha^{-1} of seed cotton and soil test values 150 16 and 400 kg ha^{-1} of NPK respectively are 436, 211 and 246 kg ha^{-1} of N, P_2O_5 and K_2O, respectively without FYM and 390, 167 and 196 kg ha^{-1} respectively with 10 t ha^{-1} FYM. This indicates substantial saving in fertilizers by conjoint use of organic manures and fertilizers.

Table 1: Range and mean values of available nutrients in surface soil and seed cotton yield in experimental field.

Parameter	Range	Mean
Soil test value (kg ha^{-1})		
N	170-224	197
P	17.6-28.2	19.9
K	388-583	485.5
Seed cotton yield (q ha^{-1})		
Treated plots	22.00-34.93	28.46
Control plots	20.54-27.00	23.77

Table 2: Nutrient requirement, per cent contribution from soil, fertilizer and FYM

Parameter	N	P_2O_5	K_2O
Nutrient requirement (kg q^{-1} of Bt cotton)	5.84	2.02	3.51
Contribution from soil available nutrients (%)	45.87	83.63	17.68
Without FYM			
Contribution from fertilizer nutrients (%)	37.77	31.90	27.99
With FYM			
Contribution from fertilizer nutrients (%)	40.17	37.38	31.47
Contribution from FYM (%)	11.74	14.54	14.57

Table 3: Soil test based fertilizer equations for with and without FYM

Fertilization programme	Fertilizer adjustment equation
Without FYM	FN = 15.46 T – 1.21 SN FP_2O_5 = 6.33 T – 2.62 SP FK_2O = 12.54 T – 0.63 SK
With FYM	FN = 14.53 T – 1.14 SN – 1.97 FYM FP_2O_5 = 5.40 T – 2.23 SP – 1.33 FYM FK_2O = 11.15 T – 0.56 SK – 2.53 FYM

Note: FN, FP_2O_5 and FK_2O - fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, T - yield target q ha^{-1} and SN, SP and SK - soil available N, P and K kg ha^{-1} and FYM - farm yard manure in t ha^{-1}.

Table 4: Estimation of soil test based fertilizer doses for different yield targets (kg/ha) of Bt cotton

Soil test values	**Without FYM**			**With FYM (10 t ha^{-1})**		
(kg ha^{-1})	**30**	**35**	**40**	**30**	**35**	**40**
$KMnO_4$-N	**N (kg ha^{-1})**					
140	294.4	371.7	449.0	256.6	329.25	401.9
150	282.3	359.6	436.9	245.2	317.85	390.5
160	270.2	347.5	424.8	233.8	306.05	379.1
170	258.1	335.4	412.7	222.4	295.05	367.7
180	246.0	323.3	400.6	211.0	283.65	356.3
190	233.9	311.2	388.5	199.6	272.25	344.7
200	221.8	299.1	376.4	188.2	260.85	333.5
210	209.7	287.0	364.3	176.8	249.45	322.1
Olsen – P	**P_2O_5 (kg ha^{-1})**					
12	158.46	190.11	221.96	121.94	160.91	175.94
13	155.84	187.49	219.14	119.71	146.71	173.71
14	153.22	184.87	216.52	117.48	144.48	171.48
15	150.60	182.25	213.90	115.23	142.25	169.25
16	147.98	179.63	211.28	113.02	140.02	167.02
17	145.36	177.01	208.66	110.79	137.79	164.79
18	142.74	174.39	206.04	108.56	135.56	162.56
19	140.12	171.77	203.42	106.33	133.33	160.33
NH_4OAc – K	**K_2O (kg ha^{-1})**					
200	247.5	309.75	372.0	197.2	252.95	308.7
250	216.0	278.25	340.5	169.2	224.95	280.7
300	184.5	246.75	309.0	141.2	196.95	252.7
350	153.0	215.25	277.5	113.2	168.95	224.7
400	121.5	183.75	246.0	85.2	140.95	196.7
450	90.0	152.25	214.5	57.2	112.95	168.7
500	58.5	120.75	183.0	29.2	84.95	140.7
550	27.0	89.25	151.5	1.2	56.95	112.7

The findings of the above study indicate that in conjoint use of organic and inorganics, the fertilizer doses are tailored to the requirements of specific yield targets of BT cotton taking into account the contribution from soil, fertilizers and organics. Hence, there will be a balanced supply of nutrients coupled with recycling of organic wastes avoiding either under-or over-usage of fertilizer inputs.

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