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Site specific nutrient management stragies in Bt cotton

K. S. SHIVARAJA, G. S. YADAHALLI1, G. Y. VIDYAVATHI, B. K. DESAI AND H. S. LATHA

Department of Soil Science and Agricultural Chemistry
University of Agricultural Sciences, Raichur - 584 104, Karnataka, Inida
E-mail: guruyadahalli@gmail.com, shivaraj.agron@gmail.com

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Abstract: The field experiment was conducted during 2014-15 at College of Agriculture, Bheemarayanagudi, under UKP Command, which lies in North Eastern Dry Zone of Karnataka. The field trial was laid out in Factorial RCBD with four SSNM approaches for varied targeted yield, two leaf reddening management practices and one single control as RDF with three replications. Among the nutrient levels, SSNM yield target of 6 t ha^{-1} was recorded significantly higher seed cotton yield (4274 kg ha^{-1}) was superior over SSNM yield target @ 3 t ha^{-1} (3507 kgha^{-1}). However, it was on par with SSNM yield targets of 5 and 4 t ha^{-1}. The increase in seed cotton yield with SSNM yield target of 6 t ha^{-1} over RDF and SSNM yield targets of 3, 4 and 5 t ha^{-1} was 64.19, 21.87, 2.12 and 0.85 per cent, respectively. Significantly highest net returns and B: C ratio was obtained with SSNM yield target of 4 t ha^{-1} (₹ 130260 ha^{-1} and 4.12 respectively) and was superior over other SSNM yield target treatments. However, the superior treatment was alone found on par with SSNM yield target of 5 t ha^{-1} with respect to net returns (₹ 129057 ha^{-1}).

Key words*:* Bt. Cotton, Leaf reddening, Management, Nutrient

Introduction

Cotton (*Gossypium* spp.) is an important commercial fibre crop grown under diverse agro-climatic conditions and is called as a "white gold" and also as "king of fibre" crops contributing 85 per cent of raw materials to textile industry. It plays a vital role in the country's economic growth by providing substantial employment and making significant contributions to export earnings. India ranks first in area (11.95 m. ha) of cotton on a global scale and is the second largest producer of cotton in the world after China accounting for about 18 per cent of the world cotton production (36.5 m bales). The productivity of cotton lint is 540 kg per ha which is much lower than the world average of 766 kg per ha. Karnataka ranks fifth in area of 5.94 lakh ha and fourth in production with 20.90 lakh bales of lint and fifth with an average lint productivity of 629.63 kg per ha (Anon., 2014). Bt cotton is intensively cultivating in the North Eastern Dry Zone and Northern Dry Zone of the state (Zone 2 and 3) covering partly the Tungabhadra and Upper Krishna Commands (TBP and UKP) on black soil. The area under this crop in these commands has been increasing distinctly over the past half decade.

Site-Specific Nutrient Management (SSNM) is a tool which intends for balanced precision nutrition of N, P and K along with secondary and micronutrients based on the nutrient supplying capacity of the soil, the nutrient requirement of a particular crop to produce a unit quantity of yield or set yield target. Further SSNM provides an approach for need based 'feeding' of crops with nutrients by paying close attention to the "Four Rights" (4R's) of fertilizer application: Applying the right nutrient source at the right rate, at the right time in the growing season, and in the right place. This approach aims at increasing farmers' profit by achieving the goal of maximum economic yield of crops. Among physiological disorders, leaf reddening in cotton is also known as red leaf disease. This disorder is an outcome of interaction of location, variety, environmental condition and nitrogen supply. Hence, the present experiment was conducted with an objective of knowing the response of Bt cotton to SSNM yield targets and leaf reddening management practices on growth and yield components of Bt cotton.

Material and methods

The experiment was conducted at College of Agriculture Bheemarayanagudi, under Upper Krishna Command; during *kharif* season of 2014-15. The soil was medium to deep black clay having pH 7.80 and electrical conductivity (EC) of 0.19 dS m^{-1}. The soil had medium organic carbon (5.1 g kg^{-1}), low available nitrogen (168 kg ha^{-1}), medium available phosphorus (24.2 kg ha^{-1}) and high available potassium (382.3 kg ha^{-1}). The experiment was laid out in Factorial RCBD with three replications. The first factor consisted four nutrient levels applied based on target yield for varied yield targets *viz.*, N_1: 3 t ha^{-1} (240:84:85.5 N:P:K kg ha^{-1}), N_2: 4 t ha^{-1} (320:112:114 N:P:K kg ha^{-1}), N_3: 5 t ha^{-1} (400:140:142.5 N:P:K kg ha^{-1}), N_4: 6 t ha^{-1} (480:168:171 N:P:K kg ha^{-1}), Second factor consisted two leaf reddening management practices *viz.,* L_1 (no LRM practices) and L_2 (with LRM practices) and one single control practices with RDF application (150:75:75 N:P:K kg ha^{-1} + FYM @ 10 t ha^{-1}). The different level of fertilizer application for different target yields was given by the International Plant Nutrition Institute (IPNI). The exact quantity of fertilizer levels required for different yield targets were worked out based on soil test ratings (adjusted values with low, medium and high fertility status of soil). These values were used for calculating the exact quantity of fertilizers was applied to achieve the target yields based on principles. If available nutrient status of the soil is in medium range, then apply exactly as required quantity. If available nutrient status is low then apply 25 per cent more than required quantity. If available nutrient status is high then apply 25 per cent less than required quantity. Fifty per cent of nitrogen and potassium

fertilizers and full dose of phosphorus were applied at the time of sowing and the remaining 50 per cent of nitrogen and potassium were given as top dress two times with 30 days interval. The crop was sown during third week of July, sowing was done by hand dibbling the seeds with 90 × 60 cm spacing. Observations on yield and growth parameters were recorded in different growth stages of crop.

Results and discussion

Site specific nutrient management approach is one option which focuses on balanced and crop need based nutrient application for a predetermined yield target. Among the different nutrient levels for varied yield targets, SSNM yield target of 6 t ha^{-1} recorded significantly higher seed cotton yield (4274 kg ha^{-1}) as compared to SSNM yield targets of 3 and 4 t ha^{-1} (3507 and 4185 kg ha^{-1}, respectively). However, it was on par with SSNM yield target of 5 t ha^{-1} (4238 kg ha^{-1}). The increase in yield with SSNM yield target of 6 t ha^{-1} over SSNM yield targets of 3, 4 and 5 t ha^{-1} was in the order of 21.87, 2.12 and 0.85 per cent respectively. It is interesting to note that yield with SSNM was spectacularly improved in comparison with recommended dose of fertilizer (2603 kg ha^{-1}). Higher yield in treatment with SSNM yield target of 6 t ha^{-1} was due to higher number of good opened bolls per plant (63.44), mean boll weight (7.99 g) and seed cotton yield per plant (253.12 g) as compared to other nutrient levels for varied yield targets (Table 2). However, these parameters were on par with SSNM yield target of 5 t ha^{-1} (62.01, 7.48 and 246.26 g, respectively). This highlights the importance of location specific nutrient management over the current practice of blanket recommendation for a region/ agro climatic zone. Certainly with newly evolved fertilization technique higher yield targets are possible. Higher the yields, higher will be the demand for all the essential nutrients as well as availability of all other growth factors optimally (Biradar *et al.,* 2011). This has been revealed by several workers (Manjunatha *et al.,* 2014; Police Patil *et al.,* 2012; Vidyavathi *et al.,* 2014; Katharine *et al.,* 2014).

Significantly highest plant height (157.12 cm), higher number of monopodia (4.92), sympodia (24.77), leaf area (301.45 dm^2 plant^{-1}) and highest dry matter production (499.33 g) per plant was recorded in treatment with SSNM yield target of 6 t ha^{-1} and was superior over SSNM yield target of 3 t ha^{-1}. However, it was on par with SSNM yield targets of 5 and 4 t ha^{-1} for all those growth attributes. The final yield of seed cotton depends on these growth and yield attributing parameters and as indicated by the data it was observed significantly increased growth parameters with increased nutrient levels and it was highest in treatment with SSNM yield target of 6 t ha^{-1}. The main reason for higher growth and yield components in this treatment was due to higher doses of nitrogen be attributed to the vital role of it in cell division and cell elongation. Potassium had significant effect on improving the resistance capacity of the crop to drought and alleviates the negative effects of water functioning as the main osmotic solute in plants. Further, the

Table 1. Growth parameters of Bt cotton as influenced by SSNM yield targets

Treatment	Plant height (cm)	Monopodia plant^{-1}	Sympodia plant^{-1}	Leaf area (dm^2 plant^{-1})	Leaf area index	DMP (g plant^{-1})
Nutrients for target yield (N)						
N_1: 3 t ha^{-1}	145.69^c	3.43^b	19.88^b	252.14^b	4.68^b	409.14^b
N_2: 4 t ha^{-1}	152.25^b	4.71^a	24.12^a	288.19^a	5.33^a	484.30^a
N_3: 5 t ha^{-1}	154.05^b	4.78^a	24.56^a	293.79^a	5.43^a	493.56^a
N_4: 6 t ha^{-1}	157.12^a	4.92^a	24.77^a	301.45^a	5.57^a	499.33^a
S.Em.±	0.86	0.11	0.41	4.51	0.08	7. 00
C.D. at 5 %	2.55	0.32	1.21	13.39	0.24	20.78
Leaf reddening management (L)						
L_1: Control	151.24	4.04	22.66	278.60	5.15	458.71
L_2: LRM	153.31	4.52	24.01	289.18	5.35	484.45
S.Em.±	0.60	0.08	0.29	3.19	0.06	4.95
C.D. at 5 %	1.78	0.23	0.86	9.47	0.18	14.70
Interaction (N × L)						
N_1L_1	144.50^d	3.31^{bc}	18.92^b	245.82^c	4.54^c	394.80^c
N_1L_2	146.88^d	3.54^b	20.85^b	258.46^c	4.81^{bc}	423.50^c
N_2L_1	151.42^c	4.66^a	23.66^a	282.53^b	5.23^{ab}	472.95^b
N_2L_2	153.08^{bc}	4.77^a	24.59^a	293.86^{ab}	5.43^a	495.66^{ab}
N_3L_1	153.00^{bc}	4.75^a	23.98^a	290.74^{ab}	5.38^a	482.20^{ab}
N_3L_2	155.11^{abc}	4.81^a	25.15^a	296.85^{ab}	5.49^a	504.93^{ab}
N_4L_1	156.05^{ab}	4.87^a	24.08^a	295.33^{ab}	5.46^a	484.92^{ab}
N_4L_2	158.20^a	4.96^a	25.46^a	307.58^a	5.69^a	513.75^a
RDF	107.64^e	2.86^d	15.02^c	194.60^d	3.60^d	311.60^d
S.Em.±	1.25	0.17	0.76	7.25	0.14	10.17
C.D. at 5 %	3.75	0.50	2.26	21.63	0.40	30.34

Note: Means with same alphabet do not differ significantly

LRM: Leaf reddening management with soil application of $MgSO_4$ @ 25 kg ha^{-1} + foliar application of both $MgSO_4$ & 19:19:19 @ 1 %

RDF: Recommended dose of fertilizer (150:75:75 NPK kg ha^{-1} + FYM @ 10 t ha^{-1})

results are also in line with the findings of Katharine *et al.* (2014) and Police Patil *et al.* (2009) reported higher values for growth and yield components for higher yield targets. Similarly, Hosamani *et al.* (2013) and Sangh Ravikiran *et al.* (2012) also recorded higher values for these components with 125 per cent RDF as compared to 75 per cent RDF.

Yield is the interactive product of resources provided and prevailing weather conditions. One of the highly limiting effects due to weather in cotton is leaf reddening which has substantial, deleterious/limiting effect on crop performance. Studies indicated a yield reduction ranged from 30 to 60 per cent due to leaf reddening, further it depends on variety and reddening intensity (Pagare, 2011). In the present investigation also yield reduction in control treatment over leaf reddening management (LRM) practices was to the extent of 8.11 per cent (Table 2). Probably because, during the year of investigation low leaf reddening incidence was noticed (Grade 2.0 as against a maximum of 5.0). In other words yield with introduction of LRM practices was 4209 kg ha^{-1} against control (3893 kg ha^{-1}). The reduction in yield with no LRM practices was observed very less in the present investigation over LRM practices. It was mainly due to combined effect of primary nutrients like NPK in treatments where LRM practices were not taken *i.e.,* with increased nutrition of nitrogen not only increase chlorophyll content but also decreased the reddening of cotton leaves. Further, the enhanced uptake of nitrogen and magnesium by the plant because of relation might have supported the plant to stand with leaf reddening to a greater extent. Further, foliar nutrition apart from soil application of $MgSO_4$ was designed to supply critically needed nutrients at the most responsive time during the growth cycle and to stimulate and optimize the assimilation and production process in leaves. These results confirm the findings of Hosmath *et al.* (2014) reported that, the increased seed cotton yield with soil and foliar application of $MgSO_4$ @ 25 kg ha^{-1} and 1 per cent respectively. Katharine *et al.* (2014) concluded that the increased seed cotton yield due to soil test crop response based application of nutrients for higher yield targets.

The leaf reddening management practices significantly increased growth and yield parameters of *Bt* cotton as compared to control with no leaf reddening management practices. In the present investigation, the increase in yield with LRM practices is attributed to the higher number of good opened bolls per plant (61.61), mean boll weight (6.32), seed cotton yield per plant (243.36 g plant^{-1}) and per hectare (4209 kg ha^{-1}) (Table 2). Similarly, significantly higher plant height (153.31 cm), leaf area

Table 2. Number of good opened bolls, mean boll weight, seed cotton yield of Bt cotton as influenced by SSNM yield targets

Treatment	Good bolls (no. Plant^{-1})	Mean boll weight (g)	Seed cotton yield (g plant^{-1})	Seed cotton yield (kg ha^{-1})
Nutrients for target yield (N)				
N_1: 3 t ha^{-1}	53.53^{c}	6.31^{c}	210.04^{b}	3507^{c}
N_2: 4 t ha^{-1}	61.24^{b}	6.94^{bc}	237.85^{ab}	4185^{b}
N_3: 5 t ha^{-1}	62.01^{ab}	7.48^{ab}	246.26^{a}	4238^{ab}
N_4: 6 t ha^{-1}	63.44^{a}	7.99^{a}	253.12^{a}	4274^{a}
S.Em.±	0.63	0.24	3.96	22.68
C.D. at 5 %	1.87	0.71	11.76	67.35
Leaf reddening management (L)				
L_1: Control	58.50	6.04	230.77	3893
L_2: LRM	61.61	6.32	243.36	4209
S.Em.±	0.45	0.17	2.80	16.04
C.D. at 5 %	1.33	NS	8.31	47.63
Interaction (N × L)				
N_1L_1	51.83^{e}	6.15^{e}	202.48^{d}	3334^{e}
N_1L_2	55.23^{d}	6.48d^{e}	217.60^{cd}	3681^{d}
N_2L_1	59.61^{c}	6.80cd^{e}	231.97^{bc}	4010^{c}
N_2L_2	62.87^{ab}	7.08^{bcd}	245.73^{ab}	4360^{a}
N_3L_1	60.94^{bc}	7.36^{abc}	240.26^{ab}	4096^{bc}
N_3L_2	63.08^{ab}	7.60^{abc}	252.26^{a}	4380^{a}
N_4L_1	61.60^{bc}	7.86^{ab}	248.37^{ab}	4133^{b}
N_4L_2	65.27^{a}	8.13^{a}	257.86^{a}	4416^{a}
RDF	42.52^{f}	5.38^{f}	158.91^{e}	2603^{f}
S.Em.±	0.96	0.26	6.04	32.74
C.D. at 5 %	2.86	0.77	18.02	97.69

Note: Means with same alphabet do not differ significantly

LRM: Leaf reddening management with soil application of $MgSO_4$ @ 25 kg ha^{-1} + foliar application of both $MgSO_4$ & 19:19:19 @ 1 %

RDF: Recommended dose of fertilizer (150:75:75 NPK kg ha^{-1} + FYM @ 10 t ha^{-1})

Table 3. Economics of Bt cotton cultivation as influenced by SSNM yield targets

Treatments	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit cost ratio
Nutrients for target yield (N)			
N_1: 3 t ha^{-1}	144017^{c}	105819^{c}	3.77^{c}
N_2: 4 t ha^{-1}	171836^{b}	130260^{a}	4.12^{a}
N_3: 5 t ha^{-1}	174012^{ab}	129057^{a}	3.87^{b}
N_4: 6 t ha^{-1}	175511^{a}	125418^{b}	3.50^{d}
S.Em.±	-	931	0.02
C.D. at 5 %	-	2765	0.05
Leaf reddening management (L)			
L_1: Control	159856	117358	3.77
L_2: LRM	172831	127919	3.86
S.Em.±	-	659	0.01
C.D. at 5 %	-	1957	0.02
Interaction (N × L)			
N_1L_1	136894^{e}	99903^{e}	3.70^{d}
N_1L_2	151141^{d}	111736^{d}	3.83^{c}
N_2L_1	164650^{c}	124282^{c}	4.07^{b}
N_2L_2	179021^{a}	136239^{a}	4.18^{a}
N_3L_1	168181^{bc}	124434^{c}	3.84^{c}
N_3L_2	179842^{a}	133681^{ab}	3.89^{c}
N_4L_1	169701^{b}	120815^{c}	3.47^{e}
N_4L_2	181321^{a}	130021^{b}	3.53^{e}
RDF	106879^{f}	68019^{f}	2.75^{f}
S.Em.±	-	1345	0.03
C.D. at 5 %	-	4013	0.08

Note: Means with same alphabet do not differ significantly

LRM: Leaf reddening management with soil application of $MgSO_4$ @ 25 kg ha^{-1} + foliar application of both $MgSO_4$ & 19:19:19 @ 1 %

RDF: Recommended dose of fertilizers (150:75:75 NPK kg ha^{-1} + FYM @ 10 t ha^{-1})

(289.18 dm^2 $plant^{-1}$), dry matter production per plant (484.45 g), monopodia (4.52) and sympodia per plant (24.01) were noticed as compared to control treatment (Table 1). SSNM yield target of 6 t ha^{-1} along with leaf reddening management practices recorded significantly higher seed cotton yield (4416 kg ha^{-1}) and it was superior over SSNM yield target of 3 t ha^{-1} and RDF application (2603 kg ha^{-1}). However, superior one is on par with SSNM yield target of 4 and 5 t ha^{-1} along with leaf reddening management practices. Similarly, the treatment with SSNM yield target of 6 t ha^{-1} along with leaf reddening management practices recorded significantly highest seed cotton yield per plant (257.86 g), mean boll weight (8.13 g) and higher number of bolls per plant. These results are in compliance with the findings of Hosmath *et al.* (2012).

Application of nutrients for SSNM yield target of 6 t ha^{-1} resulted in significantly higher gross returns (₹ 175511 ha^{-1}), net returns (₹ 125418 ha^{-1}) and B:C ratio (3.50) over all other nutrient levels. The leaf reddening management practices resulted in significantly higher gross returns (₹ 172831 ha^{-1}), net returns (₹ 127919 ha^{-1}) and B:C ratio (3.86) over no leaf reddening management practices (control). Among interactions, SSNM yield target of 6 t ha^{-1} along with leaf reddening management practices recorded significantly higher gross returns (₹ 181321 ha^{-1}) and was superior over other nutrient treatment combinations. However, it was on par with SSNM yield targets of 5 and 4 t ha^{-1} along with leaf reddening management practices. Significantly higher net returns and B:C ratio was obtained with SSNM yield target of 4 t ha^{-1} along with leaf reddening management practices (₹ 136239 ha^{-1} and 4.18 respectively) over other nutrient levels but with respect to net returns, SSNM yield target of 5 t ha^{-1} along with leaf reddening management practices was on par with it (₹ 133681 ha^{-1}). Significantly lowest net returns and B:C ratio (₹. 68019 ha^{-1} and 2.75) was obtained in treatment with RDF application (Table 3). Similarly, Manjunatha *et al.* (2014) recorded significantly higher gross returns (₹ 1,77,305 ha^{-1}), net returns (₹ 1,21,022 ha^{-1}) and B : C ratio (3.15) was obtained with SSNM yield target of 4 t ha^{-1} as compared to lower yield targets, the findings of Vidyavathi *et al.* (2014) are also in line with the results obtained. From this study, it can be conclude that among four varied SSNM yield targets (3, 4, 5 and 6 t ha^{-1}) 4 t ha^{-1} yield target along with leaf reddening management practices out yielded (4360 kg ha^{-1} seed cotton yield) over other SSNM yield targets with and without leaf reddening management practices, in terms of net returns (₹ 136239 ha^{-1}) and benefit cost ratio (4.18).

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