

Precision Nutrient Management in Bt Cotton Through Site Specific Nutrient Management (SSNM) and Target Yield Approach

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Abstract The field experiment was conducted to study the “Response of Bt cotton to precision nutrient management through Site specific nutrient management (SSNM) based on target yield approach” during *kharif* of 2014-15 under rainfed condition. The experiment was laid out in a randomized complete block design with four replications. The treatments comprised of nutrients applied to achieve target cotton yields of 20, 25, 30, 35, 40, 45 q ha⁻¹, RDF, modified RDF (as per soil test) and absolute control. The study area was low in available nitrogen, high in phosphorus and medium in potash. The results revealed that among the different target yields, nutrients supplied to achieve 45 q ha⁻¹ target yield recorded significantly higher seed cotton yield (39.13 q ha⁻¹), plant height (146.8 cm), monopodial branches plant⁻¹ (3.2), sympodial branches plant⁻¹ (26.5), leaf area (151.5 dm² plant⁻¹), leaf area index (2.81) and leaf area duration (107.4 days). The gross and net returns and B:C ratio were also higher with nutrient applied to achieve target yield of 45 q ha⁻¹ over 20, 25, 30 q ha⁻¹ target yield, RDF, modified RDF and control plot. However, the nutrient supplied to achieve target yield of 35 (36.07 q ha⁻¹) and 40 q ha⁻¹ (38.63 q ha⁻¹) target

yield levels were on par with target yield levels of 45 q ha⁻¹.

Keywords Bt cotton, Economics, Growth, Precision, Target yield.

Introduction

Cotton is one of the major fiber crops of global significance. It is cultivated in diverse agro-climatic conditions and is called as a white gold and also as king of fiber crops. It provides the main raw material for textile industry and employment to several million people involved in cultivation, trade, processing, manufacturing and marketing. Cotton plays a major role in India's economy, both in terms of providing employment directly or indirectly to about 60 million people and earning foreign exchange for the country to the tune of 60,000 crores [1]. India ranks first in global cotton cultivation with an area of 11.70 m ha accounting 33% of the world cotton area and stands second in production (375 lakh bales) next to China. However, the average productivity (552 kg lint ha⁻¹) is low compared to the world average of 766 kg lint ha⁻¹ [2].

There are many reasons for the reduction in the Bt cotton productivity. The major cause being area under rainfed conditions which predominate over irrigated area particularly in the state and country as a whole. More than 50% of rainfed cotton is grown under erratic and low rainfall, without proper fertiliza-

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tion and plant protection measures. Thus, low yield levels prevailing in the country could be attributed to the genetic, physiological and agronomic factors. The main agronomic factors are improper tillage, non incorporation of residue, decline in soil fertility and nutrient imbalance in the soil.

Precision agriculture is a management strategy that employs detailed site specific information to precisely manage production inputs. Precision farming can contribute in many ways to long-term sustainability of agriculture. The idea is to know the soil and crop characteristics unique to each part of the field and to optimize the production inputs within small portions of the field. Of all the production inputs, nutrients occupy the top position and nutrient management is crucial to the success of any farming system. The usual practice is to apply nutrients at one rate throughout the farming area.

Among the several technologies of precision agriculture, the Site-specific nutrient management (SSNM) is seen as one of the options for precision nutrient management. Farming has to be treated as any other business these days and we must try to maximize the resource available to us in the most efficient manner possible. Due to importance of plant nutrition, and their influence on crop yield and quality, it is expected that site specific nutrient management would improve the economic and environmental outcome of crop production. SSNM provides an approach for “feeding” the crops with the nutrients as and when they are needed. The SSNM approach does not specifically aim to either reduce or increase fertilizer use. Instead, it aims to apply nutrients at optimal rates and times to achieve high profit for farmers, with high efficiency of nutrient use by crops across spatial and temporal scales, thereby preventing leakage of excess nutrient to the environment. SSNM based “target yield” concept is unique in the sense that this method not only indicates soil test based fertilizer dose but also the level of yield. The farmer can hope to achieve this if good agronomic practices are followed in raising the crop. For soil plant system, this approach is also unique because it provides a scientific basis for balanced fertilization not only among the fertilizer nutrient themselves but also soil available nutrients. Keeping the above fac-

tors under consideration a field experiment was conducted to evaluate the precision nutrient management in Bt cotton through site specific nutrient management and target yield approach.

Materials and Methods

The experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* season of 2014-15 under assured rainfall conditions of Northern dry zone of Karnataka (Zone 8). The soil was medium deep black clay having pH 7.2 and electrical conductivity (EC) of 0.25 dSm⁻¹, medium in organic carbon (0.52%), low in available nitrogen (168.5 kg ha⁻¹), high in available phosphorus (48 kg ha⁻¹) and medium in available potassium (320 kg ha⁻¹). The experiment was laid out in randomized complete block design with four replications. The plot consisted of six nutrient levels applied based on target yield i.e., T₁ : 20 q ha⁻¹ (107.4 : 28.0 : 115.04 N : P₂O₅ : K₂O kg ha⁻¹), T₂ : 25 q ha⁻¹ (134.3:35.3:144.20 kg N:P₂O₅:K₂O ha⁻¹), T₃ : 30 q ha⁻¹ (161.0 : 42.3 : 173.00 kg N : P₂O₅ : K₂O ha⁻¹), T₄ : 35q ha⁻¹ (188.4:49.3:201.90 kg N:P₂O₅:K₂O ha⁻¹), T₅ : 40 q ha⁻¹ (214.8 : 56.4 : 230.70 kg N : P₂O₅ : K₂O ha⁻¹), T₆ : 45 q ha⁻¹ (241.7 : 63.4 : 259.50 kg N : P₂O₅ : K₂O ha⁻¹), T₇ : RDF (100 : 50 : 50 kg N : P₂O₅ : K₂O ha⁻¹), T₈ : Modified RDF as per soil test (125.0 : 37.5 : 50.0 kg N : P₂O₅ : K₂O ha⁻¹) and T₉ : Control. Nutrient levels were worked out for target yield based on average Bt cotton nutrient uptake value of N : 4.47 kg, P₂O₅ : 1.72 kg and K₂O : 5.76 kg per 100 kg of seed cotton [3—5]. Fifty per cent of nitrogen and full dose of phosphorus and fifty per cent of potassium were applied at the time of sowing as basal in the form of 10 : 26 : 26 complex fertilizers and the remaining 50% of N and K was top dressed at 60 days after sowing in the form of urea and muriate of potash, respectively. The experiment was sown during second week of July. Sowing of seed was done by hand dibbling with 90 cm × 60 cm spacing at 4 to 5 cm depth. Necessary plant protection measures were taken to control sucking pests, midges and mirid bugs. The annual total rainfall for the year 2014-15 was 962.4 mm. However, during the cropping period 679.4 mm rainfall was received in 54 rainy days. Growth and yield parameters were recorded periodically till harvest during the year. The data col-

Table 1. Growth parameters at different stages and yield of Bt cotton as influenced by different nutrient management for achieving target yields. T₁ : 107.4 : 28.0 : 115.04 N : P₂O₅ : K₂O kg ha⁻¹, T₂ : 134.3 : 35.3 : 144.20 N : P₂O₅ : K₂O kg ha⁻¹, T₃ : 161.0 : 42.3 : 173.00 N : P₂O₅ : K₂O kg ha⁻¹, T₄ : 156.7 : 49.3 : 201.90 N : P₂O₅ : K₂O kg ha⁻¹, T₅ : 214.8 : 56.4 : 230.70 N : P₂O₅ : K₂O kg ha⁻¹, T₆ : 241.7 : 63.4 : 259.50 N : P₂O₅ : K₂O kg ha⁻¹, T₇ : 100.0 : 50.0 : 50.0 N : P₂O₅ : K₂O kg ha⁻¹, T₈ : 125.0 : 37.5 : 50.0 N : P₂O₅ : K₂O kg ha⁻¹, T₉ : No nutrients.

Nutrient management for achieving target yield	Plant height (cm)			Leaf area				Leaf area to 60 DAS	Number of mon-odial branches to plant ⁻¹	Number of sympodial branches plant ⁻¹		At harvest	Seed cotton yield (kg/ha ⁻¹)
	60 DAS	120 DAS	At harvest	60 DAS	120 DAS	60 DAS	120 DAS			60 DAS	120 DAS		
T ₁ : 20 q ha ⁻¹	35.2	108.9	122.5	29.7	118.9	0.55	2.20	82.5	2.2	8.5	12.6	21.1	2478.3
T ₂ : 25 q ha ⁻¹	39.5	114.0	130.0	32.9	127.8	0.61	2.37	89.2	2.5	9.3	14.3	22.6	2811.0
T ₃ : 30 q ha ⁻¹	47.2	120.3	136.3	36.2	139.5	0.67	2.58	97.6	2.8	10.1	16.5	24.1	3206.8
T ₄ : 35 q ha ⁻¹	52.8	126.4	142.3	39.8	148.7	0.74	2.75	104.7	3.1	11.3	18.0	25.6	3607.3
T ₅ : 40 q ha ⁻¹	53.1	129.8	143.5	41.2	150.4	0.76	2.79	106.4	3.2	11.4	17.6	25.9	3863.0
T ₆ : 45 q ha ⁻¹	55.1	130.5	146.8	41.7	151.5	0.77	2.81	107.4	3.2	11.9	17.8	26.5	3913.5
T ₇ : RDF	33.2	109.7	127.4	29.0	113.6	0.54	2.10	79.2	2.3	10.6	13.6	21.6	2445.3
T ₈ : Modified RDF	41.7	117.5	134.5	33.2	129.0	0.62	2.39	90.1	2.6	9.3	15.1	23.1	2868.0
T ₉ : Absolute control	32.4	88.5	100.0	18.0	91.0	0.35	1.69	60.6	1.8	7.1	9.5	17.1	1605.0
SEm±	1.37	1.75	1.86	0.84	2.52	0.01	0.05	1.54	0.09	0.26	0.56	0.46	105.78
LSD (0.05)	3.99	5.11	5.42	2.46	7.34	0.04	0.14	4.51	0.27	0.76	1.65	1.34	315.30

lected from the experiment were subjected to statistical analysis as described by Gomez and Gomez [6].

Results and Discussion

Response of Bt cotton for different levels of nutrients based on target yield approach

The seed cotton yield (SCY) in cotton depends on yield plant⁻¹, number of bolls plant⁻¹, number of sympodia and monopodia plant⁻¹, Leaf area and leaf area index. In the present investigation, seed cotton yield (SCY) differed significantly due to application of different nutrients as per target yield. Application of nutrients for the target yield of 45 q ha⁻¹ (241.7 : 63.4 : 259.50 kg N : P₂O₅ : K₂O ha⁻¹) recorded significantly higher seed cotton yield of 39.13 q ha⁻¹, as compared to other nutrient levels applied for different target yields (Table 1). However, nutrient supplied to achieve 35 (36.07 q ha⁻¹) and 40 q ha⁻¹ (38.63

q ha⁻¹) target yield level was on par with target yield level 45 q ha⁻¹ and increase in yield was to the tune of 36.6, 28.17, 18, 7.8, 1.3, 37.5, 26.71 and 58.9% over target yield of 20, 25, 30, 35, 40 q ha⁻¹, RDF, modified RDF and control plot, respectively. Significantly lower seed cotton yield was recorded with control plots due to application of only FYM and native soil nutrient supply and was ascribed to inadequate nutrient supply from the soil that was rated low in available nitrogen. However, the target yield was achieved with the nutrient management for achieving target yield of 35 q ha⁻¹ (36.07 q ha⁻¹). Further the cotton yields were increased to 38.63 and 39.13 q ha⁻¹ with the increase in nutrient levels to achieve the yield of 40 and 45 q ha⁻¹. But the targeted yield could not be achieved with the treatments of 40 and 45 q ha⁻¹. This could be attributed to the genetic potentiality of the genotype coupled with interaction of environmental factors. Moreover, the experiment was conducted under rainfed conditions of northern transition zone of Karnataka and it suffered from moisture stress at boll

Table 2. Economics of Bt cotton as influenced by different nutrient management for achieving target yields. T₁: 107.4 : 28.0 : 115.04 N : P₂O₅ : K₂O kg ha⁻¹, T₂: 134.3 : 35.3 : 144.20 N : P₂O₅ : K₂O kg ha⁻¹, T₃: 161.0 : 42.3 : 173.00 N : P₂O₅ : K₂O kg ha⁻¹, T₄: 156.7 : 49.3 : 201.90 N : P₂O₅ : K₂O kg ha⁻¹, T₅: 214.8 : 56.4 : 230.70 N : P₂O₅ : K₂O kg ha⁻¹, T₆: 241.7 : 63.4 : 259.50 N : P₂O₅ : K₂O kg ha⁻¹, T₇: 100.0 : 50.0 : 50.0 N : P₂O₅ : K₂O kg ha⁻¹, T₈: 125.0 : 37.5 : 50.0 N : P₂O₅ : K₂O kg ha⁻¹, T₉: No nutrients.

Nutrient management for achieving target yield	Gross returns (Rs ha ⁻¹)	Net returns (Rs ha ⁻¹)	B : C ratio
T ₁ : 20 q ha ⁻¹	113659.33	58293.14	2.05
T ₂ : 25 q ha ⁻¹	128993.47	72109.11	2.27
T ₃ : 30 q ha ⁻¹	147097.99	88702.32	2.52
T ₄ : 35 q ha ⁻¹	165415.86	105504.39	2.76
T ₅ : 40 q ha ⁻¹	177022.38	115621.62	2.88
T ₆ : 45 q ha ⁻¹	179381.37	116464.66	2.85
T ₇ : RDF	112091.83	56151.71	2.00
T ₈ : Modified RDF	131453.49	77231.44	2.42
T ₉ : Absolute control	73711.08	24384.08	1.49
SEm±	4778.13	4778.13	0.09
LSD (0.05)	13946.38	13946.38	0.26

development and boll opening stages. Similar results were reported Police Patil et al. [7], Biradar et al. [8] and Manjunath et al. [9]. The increase in yield with increasing nutrient levels was attributed to the better growth and higher number of sympodial branches coupled with leaf area and genetic potentiality of the genotype and interaction of environmental factors.

Seed cotton yield was governed by several factors which have a direct and indirect impact. Plant height was an important growth factor which is measured periodically had an indirect effect on cotton production. In the present investigation, application of nutrients based on target yield of 45 q ha⁻¹ recorded taller plant at 60, 120 days after sowing, and at harvest stage (55.10, 130.5 and 146.3 cm, respectively) as compared to the other nutrient levels applied as per target yield. However, 35 and 40 q ha⁻¹ target yields were on par with nutrient levels as per target yield of 45 q ha⁻¹. Significantly lower plant height was recorded with control plot (32.35, 88.5 and 100 cm, respectively). This might be due to increased protoplasmic constituent and acceleration in the process of cell division and there by resulting in luxuriant growth. Increased plant height was reflected on the increased dry matter production and finally the cotton yield ha⁻¹. Earlier workers also reported increased plant height with increased fertilizer levels [10—12].

Among the different nutrient levels based on tar-

get yields, 45 q ha⁻¹ target yield recorded significantly higher number of sympodial (11.4, 17.6 and 26.5 at 60, 120 DAS and at harvest, respectively) and monopodial branches plant⁻¹ (3.2 at 120 DAS) as compared to other target yields and target yield of 35 and 40 q ha⁻¹ were on par with 45 q ha⁻¹ target yield level. Significantly lower number of sympodial (7.1, 9.5 and 17 at 60, 120 and at harvest) and monopodial branches plant⁻¹ (1.8 at 120 DAS) was recorded with control plot.

Leaf area duration (LAD) is physiological character that decides the rate of growth. The higher LAD under higher levels of target yields (Table 1) might be due to increased nitrogen supply to increase auxin activity, production of carbohydrates and organic compounds leading to accelerate meristematic activity at the shoot apex which inturn increased leaf area and LAI resulted in higher LAD.

Economics

There was significant increase in gross monetary returns, net monetary returns and B:C ratio with different nutrient levels in Bt cotton. Significantly higher gross return (1,79,381.37 Rs ha⁻¹), net return (1,15,621 Rs ha⁻¹) and B:C (2.85) ratio was realized with application of nutrients required for achieving target yield of 45 q ha⁻¹ as compared to all other nutrient levels based on target yield. However, 35 (2.88) and 40 (2.0)

q ha⁻¹ target yield levels were on par with target yield level of 45 q ha⁻¹ (Table 2). Higher net returns and B:C ratio with higher levels of target yields might be due to higher seed cotton yield. These results are in agreement with those reported earlier [13].

Though the higher yields were obtained with nutrient management for achieving target yield of 45 q ha⁻¹. The targeted yield in cotton can be achieved through precision nutrient management with the application of nutrients required to achieve 35 q ha⁻¹ (188.4 : 49.3 : 173 kg N : P₂O₅ : K₂O ha⁻¹). Further, increase in the level of fertilizers to achieve 40 and 45 q ha⁻¹ does not impact much in producing higher cotton yield up to either 40 or 45 q ha⁻¹ under assured rainfall conditions.

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