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Research Paper

Response of Bt. cotton hybrid (*Gossypium hirsutum*) to integrated nitrogen management and potassium

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ABSTRACT

A field experiment was conducted to evaluate the influence of integrated nutrient supply on the Bt. cotton (*Gossypium hirsutum* L.) hybrid 'Mallika' during *kharif* season of 2009 and 2010 at the Agricultural Research Station Adilabad in Andhra Pradesh. The results showed that the leaf area, dry matter, bolls/plant and seeds/boll increased significantly through the substitution of 25% N with vermicompost both in 2009 and 2010. This treatment also found to remove significantly more N, P and K. Recommended dose of 120 kg N and 60 kg P_2O_5/ha P yielded 2.09 t/ha seed cotton in 2009. This was on par with the yield of 2.0 t/ha due to substitution of 25% N with vermicompost. In 2010 seed cotton yield of 3.36 t/ha was recorded with substitution of 25% N with vermicompost, which was significantly higher than seed cotton yield of 3.13 t/ha recorded with recommended dose of N and P through inorganic. Maximum net profit of ₹39,564/ha and ₹96,421/ha were obtained with the application of recommended dose of 120 kg N and 60 kg P/ha with 60 kg K/ha in 2009 and 2010 respectively. Maximum benefit:cost ratio of ₹0.95 and ₹2.32/ were also realized from this treatment in the corresponding years. The integrated nutrient management reduced the profits per rupee investment. Seed cotton yield recorded significant response to K application up to 60 kg/ha in 2009 and 90 kg k/ha in 2010. Variation in response across the two season attributed to rainfall variation and its distribution

***Key words**:* Bt. cotton, Economics, Integrated nitrogen management, Potassium, Vermicompost

The introgression of *Bacillus thuringiensis* bacteria in cotton has changed the crop morphology, phenology, physiology (Chen *et al*. 2002) and translocation efficiency of photosynthates into the bolls. The nutrient and water requirements also increased. 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. This has driven increased nutrient uptake especially of nitrogen. Therefore, new management practices are to be developed for the Bt. cotton. The application of K is the key to withstand moisture stress. It provides osmotic pull to draw water into the plant roots (Nagdeve *et al*. 2008). Cotton is considered inefficient in K absorption due to its poor root activity (Cassman *et al*. 1989). The early maturing genotypes are more susceptible to K deficiency. Since Bt. cotton showed early maturity compared to non Bt, the K requirement should be assessed (Pettigrew *et al*. 1996). Cope (1981) reported that cotton is more sensitive to K deficiencies than many other row crops, because cotton has less dense root system than the cereal crops (Gerrik *et al*. 1987). Bhalerao *et al*. (2012) reported that the introduction of Bt. gene in cotton has changed the vegetative and reproductive growth pattern. The vegetative growth is restricted due to maximum setting of bolls. These manipulations need high levels of nutrient application for better yield. Therefore, there is a need to re–examine the new challenges. Paradoxically, the shortage of fertilizers in the recent years, continuous depletion of soil available nutrients and acute shortage of organic manures have further added to the lacuna of undernourished husbandry of the long duration cotton crop. Potassium has become the most frequently forgotten nutrient. Its deficit situation under rainfed conditions become critical. Of late vermicompost is widely recognized as an improved organic manure with high concentration of nutrients and low C:N ratio than other bulky organic manures. Hence, the present investigation was under taken to study the effect of integrated nutrient management on crop growth, yield attributes, nutrient uptake, yield and profits of seed cotton.

MATERIALS AND METHODS

A field experiment was conducted at the Agricultural Research Station, Adilabad district in Andhra Pradesh in the rainy season during 2009 and 2010. The soil was clay in texture with 150 mm/m water holding capacity, slightly

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alkaline in reaction with 8.03 pH, normal electrical conductivity (0.384 dS/m), medium in organic carbon (0.62%) and available nitrogen (320 kg N/ha), rich in phosphorus (36 kg P/ha) and medium in potassium (240 kg K/ha). The seed of Bt. cotton hybrid 'Mallika' was sown at 90 × 60 cm spacing on 27 June in 2009 and 6 June in 2010. The mean annual rainfall is 1,145 mm. The rainfall received during the crop growth period was 627.5 mm in 2009 and 1,015.0 mm in 2010. There was a dry spell of 18 days from 23 July to 10 August, for 41 days from 7 September to 16 November and again for 30 days from 17 November to 20 December in 2009. Conversely, weather was wet with well distributed rainfall throughout the crop growth period in 2010. The stored soil moisture of the previous week and rainfall in the current week exceeded the PET and thereby maintained moist soil (Fig.1).

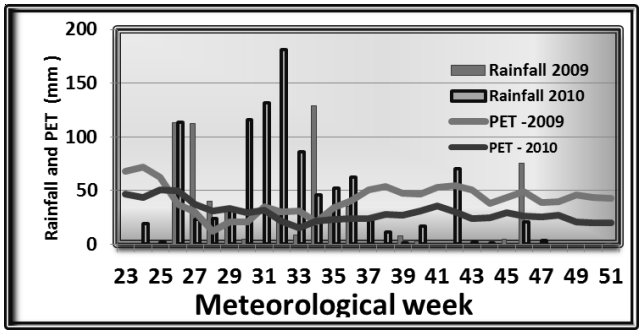

Fig. 1. Rainfall and Potential evapotranspiration in 2009 and 2010 at Adilabad

The experiment was conducted in a three times replicated split plot design with 4 main-plot and 4 sub-plot treatments. The main-plot treatments were F1 – Recommended dose of fertilizer @ 120:60 kg/ha NP, F2 – 75% N through inorganic and 25 % N through vermicompost, F3 – 50% N through inorganic and 50% N through vermicompost and F4 – 25% N through inorganic and 75% N through vermicompost. The sub-plot treatments consisted potassium levels of 0, 30, 60 and 90 kg/ha. The vermicompost had 1.5% N, 0.9% P and 1.5% K. It had 40% moisture at the time of incorporation in the soil. The quantity of vermicompost was calculated from the relationship Q = R/C x 100 and FQ = Q (100 – Moisture content) × 100, where Q = Quantity of vermicompost on dry weight basis, R = Recommended rate of nutrient concentration to be substituted and C = Nutrient concentration in the sampled lot and FQ = Quantity of vermicompost to be applied on fresh weight basis. In the present investigation, the nutrient concentration and moisture percent were almost similar in the vermicompost in 2009 and 2010 prepared with the same material at the research station. The quantity of vermicompost incorporated in the soil to substitute 25, 50 and 75% recommended level of 120 kg/ha N was estimated at 3.33, 6.66 and 10 t/ha respectively. Additional 18, 36 and 54 kg P/ha and 30, 60 and 90 kg K/ha was supplemented through these levels of vermicompost. The nitrogenous fertilizer was applied in split i.e half at sowing along with entire quantity of P and remaining 30 days after sowing. Potassium was applied in equal quantity at sowing, one month and two months after sowing. The crop had a duration of 174 days in the first year and 168 days in the second year. The nutrient content in the crop was estimated by following the standard laboratory procedures. The pooled analyses of variance for seed cotton yield was done by adopting the procedure of same site and same randomization (McIntosh, 1981).

RESULTS AND DISCUSSION

Growth and yield attributes

The plant height, leaf area and dry matter accumulation/plant were severely affected due to the dry spells in 2009. Consequently, the number of bolls/plant, seeds/boll and the seed index were substantially low in 2009 than in 2010. The substitution of 25% N with vermicompost significantly increased the leaf area and dry matter/plant, number of bolls/plant and seeds/boll over other treatments in 2009 and 2010. The plant height increased significantly in 2010 and seed index only in 2009. The application of 60 kg K/ha significantly increased the plant height, dry matter accumulation/plant, number of bolls/plant and seeds/boll in 2009, while in 2010 response was upto 90 kg K/ha. The significant interactions showed that the application of 60 kg K/ha and the substitution of 25% N with vermicompost was the best combination to improve the plant height and number of bolls/plant.

Nutrients removed

The crop removed about half of the nutrients in 2009 than in 2010 owing to the variation in rainfall pattern (Table 2). The substitution of 25% N with vermicompost significantly increased the quantity of N, P and K/ha over the inorganic source of nutrients both in 2009 and 2010. The crop removed significantly more nitrogen with increasing level of potassium up to 90 kg and phosphorus up to 60 kg/ha in 2009. The response increased up to 60 kg K/ha to remove significantly more N and up to 30 kg K/ha for the removal of P in 2010. The response to remove more K increased up to 60 kg K/ha in 2009 and 2010.

Seed cotton yield

The seed cotton yield was 1.5 to 2 times less due to severe water deficits in 2009 than in 2010. The crop fertilized with the recommended dose of nutrients yielded 2.09 t/ha in 2009. This was on par with the yield of 2.0 t/

ha due to the substitution of 25% N through vermicompost. But, the yield increased significantly from 3.13 t/ha due to the inorganic nutrients to 3.36 t/ha by this integrated nutrient management treatment in 2010. This positive effect could possibly be due to the cumulative effect of high and well distributed rainfall throughout the crop growth period leading to early decomposition of vermicompost, release of nutrients in the current season and the residual effect of the manure in the previous season. The yield reduced significantly by increasing the substitution of N to 50 or 75% both during 2009 and 2010. The pooled analysis of variance showed that significant increase in seed cotton yield was obtained by the substitution of 25% N through vermicompost. Thus significant increase in seed cotton yield was obtained due to the cumulative improvement in crop growth, yield attributes and nutrient uptake only in the presence of sufficient moisture throughout the crop growth period by the substitution of

Table 1. Crop growth and yield attributes of Bt. cotton hybrid as influenced by the integrated nutrient management and levels of K application.

Treatment	Crop growth						Yield attributes					
	Plant height (cm)		Leaf area/ plant (cm^2)		Dry matter/ plant (g)		Bolls/plant		Seeds/boll		Seed index (g)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Integrated nutrient management												
F1 – 120:60 kg/ha NP	99.0	168.2	354	394	275	564	63.4	98.9	15.3	16.4	7.3	12.0
F2 – 75% N – F + 25% N – VC	103.7	173.3	413	441	283	583	73.3	103.5	20.2	21.8	12.5	12.3
F3 – 50% N – F + 50% N – VC	98.3	160.1	335	375	237	540	57.1	93.4	16.1	16.3	11.2	11.4
F4 – 25% N – F + 75% N – VC	91.0	164.3	343	423	234	546	55.1	91.6	13.4	13.3	10.6	10.4
SEm±	2.6	1.4	13	11	2	4	0.9	1.0	0.2	1.1	0.1	0.07
CD (P=0.05)	9.0	5.0	44	38	6	15	3.2	3.4	0.7	3.9	0.5	0.20
K level (*kg/ha*)												
K1–0	91.9	166.6	366	402	233	536	56.1	90.6	15.0	15.5	10.8	11.1
K2–30	95.4	162.4	378	428	257	591	56.3	95.0	16.1	16.4	11.0	11.5
K3–60	102.7	167.0	344	411	285	558	64.6	99.2	16.5	17.2	11.3	11.5
K4–90	104.5	170.4	358	391	255	548	69.8	102.2	17.3	18.7	12.4	11.9
SEm ±	2.0	1.06	14	17	2	4	1.5	1.1	0.4	0.8	0.2	0.07
CD (P= 0.05)	6.0	3.1	NS	NS	5	13	4.6	3.1	1.2	2.4	0.6	0.20
Interaction												
SEm±	4.1	2.1	29	35	4	9	3.1	2.1	0.8	1.7	0.4	0.21
CD (P=0.05)	12.0	6.2	NS	NS	NS	NS	9.2	6.4	NS	NS	NS	NS

Table 2. Nutrients removed, seed cotton yield and net profit per hectare by Bt. cotton hybrid as influenced by the integrated nutrient management and levels of K application.

Treatment	Nutrients removed (kg/ha)						Seed cotton yield (t/ha)		Pooled mean
	Nitrogen		Phosphorus		Potassium				
	2009	2010	2009	2010	2009	2010	2009	2010	
Integrated nutrient management									
F1 – 120:60kg/ha NP	88.4	190.5	18.5	49.7	94.0	203.4	2.09	3.13	2.61
F2 – 75% N – F + 25% N – VC	93.0	205.3	29.5	53.4	115.5	210.8	2.00	3.36	2.72
F3 – 50% N – F + 50% N – VC	85.3	194.1	29.5	46.1	143.6	192.1	1.64	2.88	2.26
F4 – 25% N – F + 75% N – VC	80.0	193.8	24.6	45.4	119.3	192.0	1.35	2.60	1.97
SEm±	0.9	0.7	0.9	0.9	2.7	2.1	0.046	0.027	0.50
CD (P=0.05)	3.4	2.7	3.4	3.4	9.5	7.0	0.16	0.10	0.11
K level of (kg/ha)									
K1– 0	22.6	191.2	21.7	20.4	119.5	190.2	1.59	2.60	2.14
K2–30	87.2	192.6	24.4	48.2	134.5	193.8	1.82	2.97	2.40
K3–60	89.4	199.8	27.6	50.0	142.9	204.5	1.92	3.19	2.55
K4–90	93.4	201.2	28.2	51.1	111.6	208.6	1.74	3.21	2.47
SEm±	0.7	0.9	0.7	1.0	2.52	2.0	0.07	0.052	0.061
CD (P=0.05)	2.5	2.8	2.5	3.4	7.4	5.9	0.20	0.15	0.20
Interaction									
SEm±	2.7	1.9	8.1	2.3	6.5	4.1	137	0.10	0.12
CD (P=0.05)	8.1	5.9	NS	NS	NS	NS	NS	NS	NS

25% N with vermicompost. Hosmath *et al*. (2011) also reported significant increase in yield of Bt. cotton hybrid by the application of 3 tonne vermicompost/ha with the recommended dose of fertilizers. The present study indicated that the substitution of 25% N with vermicompost did not increase the yield due to severe moisture deficit in 2009.

The response to K was significant in both the years. But, significant increase in yield was recorded from 1.59 t/ha in control to 1.8 t/ha by the application of 30 kg K/ha in 2009. The response was more to increasing level of K up to 60 kg/ha in the subsequent year. This response was mainly due to the wet soil moisture regime than the moisture depletion at different intervals in the previous year. The pooled analysis showed that the seed cotton yield of the hybrid increased to 2.55 t/ha at this level of fertilizer application from a mean of 2.14 t/ha in control.

Economics

The cost of cultivation increased substantially with increase in the proportion of N substituted through the vermicompost and each increment of K (Table 3). The gross value of the produce was almost equivocal by the substitution of 25% N fertilizer with vermicompost at different levels of K. But, the recommended dose of N and P fertilizers at each level of K fetched more net returns/ha owing to the low cost of cultivation. Maximum benefit: cost ratio of ₹39,564/ha was realized by the application of recommended dose of 120 kg N and 60 kg P along with 60 kg K/ha in 2009 and ₹96,421/ha in 2010. The profit reduced to ₹17,381 and 83,239/ha due to the substitution of 25% N with vermicompost in the corresponding years. Increase in the substitution of N through vermocompost to 50 or 75% further reduced the profit in 2010. But, the profit turned negative in 2009 due to the significantly low yield under moisture stress condition.

The application of recommended dose of 120 kg N and 60 kg P through fertilizers also fetched more profit on the basis of per rupee investment than the integrated nutrient management treatments both in 2009 and 2010. Maximum net profit of ₹0.95 in 2009 and ₹2.32/₹ in 2010 was obtained by the application of recommended dose of N and P fertilizers with 60 kg K/ha. The substitution of 25% N with vermicompost drastically reduced the profit per rupee invested at any level of K. The returns diminished with increase in the rate of N substitution to 50 and 75% and turned negative in 2009. Hence, if vermicompost is to be purchased there could be a severe loss both under low and ill distributed as well as high and well distributed rainfall pattern.

The present investigation showed that the integrated nutrient management by the substitution of 25% of the recommended 120 kg N/ha through vermicompost and application of 60 kg/ each of P and K improve the crop growth, yield attributes, nutrient uptake and yield of Bt. hybrid cotton Mallika in the moisture retentive *vertisols* under well distributed rainfall pattern. This is a useful strategy if vermicompost is prepared in the field. However, the integrated nutrient management is not more profitable than the application of recommended dose of fertilizers, if

Table 3. Economics of Bt. cotton as influenced by the integrated nutrient management and level of K application

Treatment	Cost of Cultivation ($\times 10^3$/ha)	2009–10			2010–11		
		Gross returns ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	(B: C ratio (₹/₹)	Gross returns ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$₹/ha)	(B: C ratio (₹/₹)
T1 – 120:60 kg/ha N:P – K0	41.0	71.4	30.4	0.74	111.4	70.3	1.71
T2 – 120:60 kg/ha N:P – K30	41.2	73.7	32.5	0.79	127.4	86.1	2.09
T3 – 120:60 kg/ha N:P – K60	41.4	81.0	39.6	0.95	137.9	96.4	2.32
T4 – 120:60 kg/ha N:P – K90	41.6	72.5	30.8	0.74	136.4	94.7	2.27
T5 – 75% N F 25% N VC – K0	54.0	71.4	17.4	0.32	120.3	66.2	1.22
T6 – 75% N F 25% N VC – K30	54.2	76.4	22.2	0.41	126.3	72.0	1.33
T7 – 75% N F 25% N VC – K60	54.4	71.8	17.4	0.32	137.8	83.3	1.53
T8 – 75% N F 25% N VC – K90	54.6	72.0	17.3	0.31	146.9	92.2	1.69
T9 – 50%N F 50% N VC – K0	67.0	53.2	-13.9	-0.21	101.0	34.0	0.51
T10 – 50%N F 50% N VC – K30	67.2	60.2	-7.02	-0.10	114.8	47.6	0.71
T11 – 50%N F 50% N VC – K60	67.4	64.4	-3.03	-0.04	116.3	48.8	0.72
T12 – 50%N F 50% N VC – K90	67.5	57.5	-10.2	-1.28	126.8	59.1	0.87
T13 – 25% N F 75% N VC – K0	80.0	43.5	-36.5	-0.46	94.1	14.1	0.17
T14 – 25% N F 75% N VC – K30	80.3	49.9	-3.4	-0.38	102.6	22.3	0.28
T15 – 25% N F 75% N VC – K60	80.5	52.1	-28.4	-0.35	113.7	35.2	0.41
T16 – 25% N F 75% N VC – K90	80.7	48.5	-32.3	-0.40	116.2	35.4	0.44

Cost/kg – Vermicompost: ₹4.0; N: ₹10.50; P: ₹16.60; and K: ₹7.40 and Seed cotton: ₹36.0 in 2009 and ₹ 41.0 in 2010

it is purchased at the prevailing market price. This is not viable for the small farmers because of the high cost and less profit per rupee investment. In years of dry spells, the substitution of vermicompost do have a positive role to increase the yield or profitability.

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