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Quality and Economics of *Bt* Cotton as Influenced by Compost, Organic and Inorganic Fertilisers

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Authors' contributions

This work was carried out in collaboration among all authors. Author KPV designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript and managed nutrient analyses. Author KBR managed the literature searches and corrections in first draft of the manuscript. Author NN managed the biometric observations during the crop growth period. All authors read and approved the final manuscript.

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ABSTRACT

Agricultural application of urban waste as nutrient source for plants and as soil conditioner, is the most cost effective option of waste management because of its advantages over traditional means such as land filling or incineration. Composting is an attractive alternative of urban waste recycling. Intensive cropping and indiscriminate fertilizer application depleted available NPK in almost all soils in India. Hence, replenishment of shoveled out nutrients is very essential, especially when exhaustive crops like cotton is cultivated. With this backdrop an experiment was conducted during *kharif,* 2014 carried out at College Farm, College of Agriculture, PJTSAU, Hyderabad, India to find the effect of combined application of municipal city compost with inorganic fertilisers on the yield, quality and economics of *Bt* cotton. The experiment was laid out in randomised complete block design with three replicates and eleven treatments *viz*; 100 % NPK alone (RDF: 150: 60: 60 kg NPK ha^{-1})100% NPK + FYM (farmers practice) and 100 %, 75%, 50% NPK integrated with 3 levels of Godavari Gold (GG) @ 1.25, 1.875 and 2.5 tonnes ha^{-1} respectively. The results indicated that *Bt* cotton registered significantly higher yield attributes and yield with the integrated application of 100 % NPK + 2.5 t ha^{-1} of Godavari Gold compost as compared to 100% NPK alone, 100% NPK + FYM

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(farmers practice) and 75 % RDF (112.5-45-45 kg NPK ha^{-1}) and 50 % RDF (75-30-30 kg NPK ha^{-1}) integrated with Godavari gold compost @ 1.25, 1.875 and 2.5 tonnes ha^{-1}.There were no significant differences in quality parameters. Highest gross, net returns and B: C ratio was accrued with the application of 100 % NPK + 2.5 t ha^{-1} of Godavari Gold compost.

Keywords: Bt cotton; compost; FYM; inorganic fertilisers; yield; quality and economics.

1. INTRODUCTION

Due to the rapid increase in urbanization, industrialization and population, the generation rate of municipal solid waste in Indian cities and towns is also increased. Application of urban waste compost in agricultural soils can directly alter soil physico-chemical properties as well as promote plant growth [1]. Cotton (*Gossypium spp*.) popularly known as "white gold", is an important commercial fibre crop which plays an important role in livelihood of around 250 million people globally and it accounts for 75 percent of the fibre used in the textile industry in India [2].

Cotton is known for the fibre and oil from seed, which plays a prominent role in the national and international economy. India is the largest cotton growing country in the world with an area of 119.27 lakh ha.India ranks first in area with 11.88 m ha^{-1} accounting to 30 per cent of world coverage and 22 per cent (351 lakh bales of lint) of the world cotton production with a productivity of 568 kg ha^{-1}. Cotton is grown in 7.8 m ha in 296 districts of which 5.1 m ha is rainfed in sixteen states of the country and about 85 percent of the rainfed cotton is grown in 30 districts (4.1 m ha) [3].

Average productivity of cotton in India is 504 kg lint kg ha^{-1}, which is lower as compared to the world average of 725 kg lint ha^{-1}. Nearly 60 per cent of cotton in India and in Telangana is grown in dry lands. More than 65% of the cotton in Southern Telangana Zone and Central Telangana Zone is cultivated in red soils although cotton is recommended for black soils.The area of cotton in Telangana is 18.13 lakh ha with productivity of 423 kg lint ha^{-1} which is lower as compared to national average productivity of 487 kg lint/ha [4]. Poor soil fertility is a major cause of the low crop productivity. High risk associated with rainfed agriculture is the major cause for the non-investment in fertilizer and/or manure [5].

Cotton is an exhaustive crop and indiscriminate use of fertilizers results in micronutrient deficiencies and unproductive soil. Intensive cropping with high yielding varieties and high analysis fertilizers may result in the deficiency of secondary and micronutrients. Under such conditions, the integrated use of nutrient sources can aid in improving the cotton productivity. Integrated use of chemical fertilizers and organic manures is not only essential for achieving higher yields but also plays crucial role in improving soil health. Organic manures alone or in integration with inorganic fertilizers can also improve the productivity of the soils [6,7].

Although FYM is conventionally recommended, its availability is becoming scarce on account of low or negligible maintenance of cattle population in the farm. In this context, alternate organic sources like urban waste compost is one of the sound option on account of its rich nutrient content apart from better utilisation of huge wastes generated in urban areas.

The commercial cultivation of Bt. Hybrids is more profitable and relatively safe for the environment due to 50-75% reduction in pesticide application. But Bt cotton is known to draw huge quantities of nutrients especially nitrogen than the hybrids and varieties, which will have serious repercussions on already depleted soil fertility status. Trends of high nitrogen requirement by fast expanding *Bt* hybrids in India on one hand and rapid depletion of nutrients in the soils warrants integrated nutrient management to restore the soil fertility and sustain crop productivity levels. Keeping the above points in view the present experiment on *Bt* cotton was designed to find the Quality and economics of *Bt* cotton as influenced by compost, organic and inorganic fertilisers.

2. MATERIALS AND METHODS

The present experiment was carried out during *kharif* season 2014 at the College Farm, Professor Jaya Shankar Telangana State Agricultural University (PJTSAU), College of Agriculture, Rajendranagar, Hyderabad. The farm is located at 17°18'49" North *latitude* and 78°24'42" East Longitude. The experimental site soil (Table 1) was sandy clay loam with soil pH (7.4), EC (0.32 dS m^{-1}) and OC (0.41%). The soil

was low in available nitrogen (226.0 kg ha^{-1}), high in available phosphorus (36.0 kg ha^{-1}) and medium in available potassium (224.0 kg ha^{-1}). This experiment was laid out in a randomized complete block design consisted of eleven treatments and replicated thrice. Field study consisted of Godavari gold (GG), a product of Coramandel fertilizers limited, is fortified city compost with major nutrients as detailed in Table 1. The treatments comprised of T_1: 100% NPK - Recommended dose of fertilizers (150: 60: 60 Kg NPK ha^{-1}), T_2: 100% NPK + FYM @ 10 tons/ ha (Farmers Practice), T_3: 100% NPK + Godavari Gold @ 1.25 tons/ ha, T_4: 100% NPK + Godavari Gold @ 1.875 tons/ ha, T_5: 100% NPK+ Godavari Gold @ 2.5 tons/ ha, T_6: 75% NPK + Godavari Gold @ 1.25 tons/ ha, T_7: 75% NPK + Godavari Gold @ 1.875 tons/ ha, T_8: 75% NPK + Godavari Gold @ 2. 5 tons/ ha, T_9: 50% NPK + Godavari Gold @ 1.25 tons/ ha, T_{10}: 50% NPK + Godavari Gold @ 1.875 tons/ ha and T_{11}: 50% NPK + Godavari Gold @ 2.5 tons/ ha. The size of gross and net plots was 7.2 m X 6.0 m (43.2 m^2). Well rotten farmyard manures (FYM) and composted waste (Godavari gold) were applied 15-20 days before sowing. The data on the observations made were analyzed statistically by applying the technique of analysis of variance for randomized block design and significance was tested by F-test [8]. Critical difference for examining treatment means for their significance was calculated at 5 per cent level of probability.

Table 1. Physico-chemical properties and nutrient analysis of Godavari gold

Parameters	Value
Moisture content (%)	15.0 - 25.0
Color	Dark brown to Black
C/N ratio	<20
Nitrogen (%)	0.8
Phosphorus (%)	0.4
Potassium (%)	0.4
p*H*	6.5-7.5
Conductivity (As dsm^{-1})	4.0
Arsenic (mg kg^{-1})	10.0
Cadmium (mg kg^{-1})	5.0
Chromium (mg kg^{-1})	50.0
Copper (mg kg^{-1})	300.0
Lead (mg kg^{-1})	100.0
Mercury (mg kg^{-1})	0.15
Nickel (mg kg^{-1})	50.0
Cadmium (mg kg^{-1})	5.0
Zinc (mg kg^{-1})	1000.0

Two seeds $hill^{-1}$ of cotton hybrid Jadoo were dibbled at a spacing of 90 cm x 60 cm in second fortnight of August and fertilizers were applied as per treatments for cotton.

Weeds were controlled by using power weeder as a common practice in all the treatments. The data on bolls per plant and quality parameters were recorded from randomly selected five representative plants from each plot and seed cotton yield was recorded on per plot basis and converted to $kgha^{-1}$. Adequate plant protection measures were taken as per recommendations.

For analysing Quality parameters of cotton *viz;* fibre fineness, fibre strength, staple length and uniformity ratio samples were sent and analyzed at Central Institute for Research on Cotton Technology (CIRCOT), Guntur, Lam.

The ginning per cent and lint index were calculated by the following formula:

$$\text{Ginning Percentage (\%)} = \frac{\text{Weight of lint (g)}}{\text{Weight seed cotton (g)}} \text{ X } 100$$

Lint Index: It is the weight of lint from 100 seeds

$$\text{Lint index} = \frac{\text{Weight of 100 seeds}}{100 - \text{GP}} \text{ X GP}$$

The nutrient analysis of compost was carried out following standard procedures. B: C ratio was calculated taking gross returns into consideration and gross returns was computed based on the existing market price.

3. RESULTS AND DISCUSSION

3.1 Yield Attributes

A close perusal of data on yield attributes indicated that the sympodial branches and number of bolls varied significantly (CD @ 5%) among nutrient management treatments (Table 2). There was a significant increase in sympodia and number of bolls with each increment in fertiliser application from 50 % to 100% RDF along with conjunctive use of Godavari Gold compost from 1.25 to 2.5 t ha^{-1}. Among the treatments conjunctive use of 100% NPK + 2.5 t GG / ha recorded significantly more number of sympodial branches (28.43) and number of bolls (38.2) and it was followed by the treatments 100% NPK + 1.875 t GG/ha (26.03 and 36.6), 100% NPK + FYM @ 10 t/ha - Farmers practice (25.50 and 35.7) and 100% NPK alone (21.50 and 32.5). Application of 75%

NPK + 2.5 t GG/ha followed these treatments and registered significantly higher sympodia and number of bolls over 75% RDF+ lower levels of Godavari gold compost (1.875 and 1.5 tha^{-1}) and 50 % RDF+ Godavari gold compost at all the three levels. While, the lowest sympodial branches (10.40) and bolls per plant (17.8) were recorded in the crop applied with 50% NPK + 1.25 t GG / ha.

Improved sympodial branches and bolls per plant registered with the application of 100% NPK + 2.5 t GG / ha could be attributed to the consistent and adequate supply of nutrients besides improved physico-chemical properties of the soil owing to the application of higher dose of organics. These results find support with the findings of Mahavishnan et al. [9].

3.2 Yield

An overview of the seed cotton yield clearly showed a marked and significant variation among different nutrient management treatments. Similar to the yield attributes there was a significant increase in seed cotton yield with incremental dose of inorganic fertilisers from 50 to 100% in conjunction with Godavari Gold fertiliser from 1.25 to 2.5 t ha^{-1}. Significantly higher seed cotton yield was registered in plots fertilised with 100% NPK + 2.5 t GG/ha (2398.87 kg ha^{-1}) followed 100% NPK + FYM @ 10 t/ha - Farmers practice (1938.90 kg ha^{-1}) and 100% NPK alone (1708.47kg ha^{-1}). These treatments were followed by 75% NPK + GG @ 2.5 t ha^{-1}, 75% NPK + GG @1.8755 t ha^{-1} and 75% NPK + GG @ 2.5 t ha^{-1}.

Improved yield in this treatment was probably due to the greater and consistent nutrient availability throughout crop growth period with conjunctive use of organics with recommended dose of inorganics. Organic manures, presumably, play a key role in enhancing the efficiency of utilization of native as well as applied nutrients, also augment the availability of micro-nutrients and provide certain growth promoting substances, which promote better growth, boll retention, boll weight and yield in cotton. These findings are in line with those reported by Pragathi et al. [10].

The per cent increase in seed cotton yield with the application of 100% NPK with 2.5 t, 1.875 t and 1.25 t GG/ha was to the tune of 40.41, 31.06, 21.62 as compared to 100% RDF alone and 23.70, 15.48 and 7.17% respectively over 100 % NPK + FYM @ 10 t/ha - farmers practice.

Lower yield under 50% RDF+ 1.25 t GG ha^{-1} was probably due to the inadequate nutrient availability that resulted in poor growth parameters (lesser dry matter accumulation) coupled with lower yield attributes (sympodial branches and number of bolls) as evident from the respective data (Table 2).

The data on ginning percent and lint index indicated that there were no significant differences (CD @ 5%) among different nutrient management treatments.

Table 2. Yield attributes and yield of *Bt* cotton as influenced by organic and inorganic fertilisers

Treatments	No. of sympodia	No. of bolls	Seed cotton yield (kg ha^{-1})	Ginning (%)	Lint index
T_1 (100% NPK)	21.50	32.5	1708.47	35.0	5.5
T_2 (100% NPK + FYM @ 10 t/ha-(Farmers Practice)	25.50	35.7	1938.90	35.7	5.8
T_3 (100% NPK + 1.25 t GG/ha)	24.03	33.0	2078.00	35.2	5.6
T_4 (100% NPK + 1.875 t GG/ha)	26.03	36.6	2239.17	36.0	6.1
T_5 (100% NPK + 2.5 t GG/ha)	28.43	38.2	2398.87	36.3	6.4
T_6 (75 % NPK + 1.25 t GG/ha)	15.37	22.7	1361.80	32.8	4.7
T_7 (75 % NPK + 1.875 t GG/ha)	18.87	24.5	1501.90	33.0	4.8
T_8 (75 % NPK + 2.5 t GG/ha)	20.30	28.6	1683.93	33.3	5.0
T_9 (50% NPK + 1.25 t GG/ha)	10.40	17.8	949.37	30.9	3.7
T_{10} (50% NPK + 1.875 t GG/ha)	12.17	18.8	1089.83	31.9	4.0
T_{11} (50% NPK + 2.5 t GG/ha)	14.57	20.7	1262.60	32.2	4.2
SE m ±	0.74	0.87	46.45	0.06	0.01
CD @ 5%	2.10	2.58	137.04	NS	NS

3.3 Quality Parameters

An overview of the data indicated that none of the quality parameters (staple length (2.5 per cent span length mm), Uniformity Ratio (%) micronaire value and bundle strength 3.2 (g tex^{-1}) were significantly influenced by the various nutrient management treatments. (Table 3). However, numerically higher values of all quality parameters were recorded due to the application of 100% RDF + 2.5 t GG ha^{-1}. All the quality parameters were genetic character of a variety which were not influenced by fertilizer levels [11,12].

3.4 Economics

From the data (Table 4) on economic analysis it could be inferred that the cost of cultivation increased with graded levels of Godavari gold compost form 1.25 to 2.5 t ha^{-1}over 100 % NPK alone. The cost of cultivation was highest with 100% RDF + 2.5 t GG ha^{-1} (56842 Rs,ha^{-1}) owing to the additional cost incurred on the purchase of composted waste.

The gross returns increased with increasing level of inorganic fertilisers from 50 to 100% in conjunction with increase in Godavari Gold compost from 1.25 to 2.3 t ha-1. Highest gross returns (108908.55 Rs.ha^{-1}) were accrued from the plots supplied with 100% NPK + 2.5 t GG ha^{-1} on account of higher yield in comparison to rest of the treatments. It was followed by100 % NPK +1.875t GG ha^{-1} (101658.17 Rs.ha^{-1}) and 100% NPK +1.25t GG ha^{-1} (94341.20 □ha^{-1}) and 100 %NPK+ FYM @ 10 t/ha-Farmers Practice (88026.06 Rs.ha^{-1}). While the lowest gross returns (43101.25 Rs ha^{-1}) were accrued with application 50 % NPK + 1.25t GG $ha^{-1.}$

Similarly the net returns also improved with an increase graded level of inorganic fertilisers from 50 to 100% along with graded levels of Godavari Gold compost from 1.25 to 2.3 t ha-1. Highest net returns (52066.55 Rs. ha^{-1}) were obtained from the plots supplied with 100 % RDF + 2.5 t GG ha^{-1} on account of higher seed cotton yield as compared to rest of the treatments. It was followed by 100% NPK+1.875t GG ha^{-1} (46177.17 Rs .ha^{-1}) and 100% NPK +1.25t GG ha^{-1} (40474.20 Rs.ha^{-1}). While the lowest gross returns (-10351.75 Rs.ha^{-1}) were accrued with application 50% NPK + 1.25t GG $ha^{-1.}$

Highest B: C ratio was realised with the application of 100% RDF + 2.5 t GG $ha^{-1.}$ (1.92) and it was followed by the treatments 100% NPK +1.875t GG ha^{-1} (1.83) and 100% NPK +1.25t GG ha^{-1} (1.75). While the lowest B: C returns were obtained from the plots that consisted application of 50% NPK + 1.25t GG ha^{-1} (0.81).

Higher gross, net returns and B:C ratio realised with the application of 100% RDF + 2.5 t GG ha^{-1} was due to the higher seed cotton yield registered in comparison to the rest of the nutrient management treatments [13]. Lowest gross returns, net returns and B:C ratio were obtained from the treatment 50% RDF +1.25 t GG ha^{-1} on account of lowest seed cotton yield recorded over rest of the treatments.

Table 3. Quality parameters (CIRCOT) of *Bt* cotton as influenced by organic and inorganic fertilizers

Treatments	Staple length (2.5% mm)	Uniformity ratio (%)	Micronaire value	Bundle strength 3.2(g tex^{-1})
100 % RDF	31.8	48.0	4.0	23.8
100%RDF + FYM @10 tons/ ha	32.0	47.0	4.4	24.0
100 % NPK + GG @ 1.25 tons/ ha	32.1	47.0	4.3	24.3
100 % NPK + GG @ 1.875 tons/ ha	32.4	48.3	4.4	24.7
100 % NPK + GG @ 2.5 tons/ ha	32.5	49.0	4.6	24.9
75 % NPK + GG @ 1.25 tons/ ha	31.2	47.0	4.0	23.1
75 % NPK + GG @ 1.875 tons/ ha	31.6	47.0	4.3	23.3
75 % NPK + GG @ 2.5 tons/ ha	31.8	46.0	4.1	23.5
50 % NPK + GG @ 1.25 tons/ ha	30.6	47.0	3.9	22.4
50 % NPK + GG @ 1.875 tons/ ha	30.7	47.0	4.0	22.8
50 % NPK + GG @ 2.5 tons/ ha	30.8	48.0	4.3	23.0
SE m ±	0.03	0.06	0.01	0.04
CD @ 5 %	NS	NS	NS	NS

Table 4. Economics of *Bt* cotton as influenced by organic and inorganic fertilizers

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1 (100% NPK)	51396	77564.39	26168.39	1.51
T_2 (100% NPK + FYM @ 10 t/ha-(Farmers Practice)	62835	88026.06	25191.06	1.40
T_3 (100% NPK + 1.25 t GG/ha)	53867	94341.20	40474.20	1.75
T_4 (100% NPK + 1.875 t GG/ha)	55481	101658.17	46177.17	1.83
T_5 (100% NPK + 2.5 t GG/ha)	56842	108908.55	52066.55	1.92
T_6 (75 % NPK + 1.25 t GG/ha)	53656	61825.72	8169.72	1.15
T_7 (75 % NPK + 1.875 t GG/ha)	55270	68186.26	12916.26	1.23
T_8 (75 % NPK + 2.5 t GG/ha)	56632	76450.57	19818.57	1.35
T_9 (50% NPK + 1.25 t GG/ha)	53453	43101.25	-10351.75	0.81
T_{10} (50% NPK + 1.875 t GG/ha)	55067	49478.43	-5588.57	0.90
T_{11} (50% NPK + 2.5 t GG/ha)	56428	57322.04	894.04	1.02

4. CONCLUSIONS

From the results of the present study it could be concluded that under Southern Telangana region application of 100% RDF+ 2.5 t ha^{-1} Godavari Gold compost to *Bt* cotton registered improved yield attributes, seed cotton yield and higher monetary returns. The per cent yield increase in seed cotton yield was to the tune of 40.41% and 20.73% over application of 100% NPK alone and 100% NPK + FYM @ 10 t/ha^{-1} farmers practice.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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