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# Productivity potential and monetary evaluation of *Bt* cotton hybrids under varied agronomic manipulations in semi-arid conditions

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**Abstract**

Field experiments comprising three *Bt* cotton hybrids in main, two plant geometries in sub and three nutrient levels in sub sub plots of Split Plot design replicated thrice were conducted at PAU, Regional Research Station, Faridkot during *Kharif* 2010 and 2011. MRC7361 recorded significantly the highest SCY (3121.6 kg $ha^{-1}$) followed by Bioseed 6488 (2649.5 kg $ha^{-1}$) and RCH134 (2107.4 kg $ha^{-1}$). Statistically improved bolls per plant and boll weight primarily helped MRC7361 in achieving the highest yield. Owing to better fertilizer use efficiency (5.47) and water productivity (649.3 $gm^{-3}$), highest net returns of ₹101047 $ha^{-1}$ were observed with MRC7361 as compared to Bioseed 6488 (₹ 83343 $ha^{-1}$) and RCH134 (₹ 63014 $ha^{-1}$). Bolls per plant and benefit cost ratio was significantly enhanced under wider geometry of 67.5 x 90 cm. Application of 225 kg N, 45kg P $ha^{-1}$ produced significantly higher SCY (2825.9 kg $ha^{-1}$) owing to improved sympods and bolls per plant than 150kg N, 30kg P $ha^{-1}$ (2374.9 kg $ha^{-1}$) and 187.5kg N, 37.5kg P $ha^{-1}$ (2677.6 kg $ha^{-1}$). As a result of this, statistically highest net returns of ₹ 89552 $ha^{-1}$ were obtained with application of 225 kg N, 45 kg P $ha^{-1}$. Water productivity improved significantly with each successive increase in the level of nutrients. Contrarily, fertilizer use efficiency exhibited reverse trend with statistically highest value (5.08) for the lowest level of nutrients.

**Key words**

Benefit cost ratio, Fertilizer use efficiency, Seed cotton yield, Water productivity

## Introduction

The area under *Bt* cotton has increased to 121.9 lakh ha in 2011 with an adoption rate of 92.0% of the total cotton area in India. In Punjab, *Bt* cotton is presently covering 94 % of total cotton acreage. Besides improvement in yield, *Bt* cotton has lowered the pest incidence and reduced environmental pollution by limited use of insecticides by about 50 % ( Karihaloo and Kumar, 2009). Gandhi and Namboodri (2006) reported *Bt* cotton cultivation to be highly remunerative as it increased the yield significantly with least expenditure on insecticides. However, now few interesting issues are emerging up with cotton cultivation. Now, public sector cotton varieties and hybrids, which are intensively tested for agro ecological suitability for specific regions, prior to approval, are no longer being used by farmers, because they do not have *Bt* gene. It is surprising to note that only 40 intra-*hirsutum* hybrids were released by the public sector over 40 years from 1970 to 2010, after rigorous field testing (Kranthi, 2012). However, as of now 1128 *Bt* cotton hybrids, from more than 40 seed companies, have been approved for sale and cultivation by Genetic Engineering Appraisal Committee in merely 7 years, from 2005 to 2012, for commercial cultivation. Private companies are flooding the market with innumerable *Bt* hybrids, without testing their site-specific agro-ecological suitability. Moreover, there is severe lack of information on nutrition and agronomic requirements (spacing and plant geometry etc) of these *Bt* hybrids, which is creating confusion among farmers. Cotton growers are in a dilemma and it is difficult for them to select a suitable *Bt* hybrid for their site specific agro climatic needs. Under such situations, farmers either continue to grow *Bt* hybrids which were high yielding or popular during initial years of their release (but later become susceptible to certain insect-pests and diseases) or they are persuaded to try new hybrids every year which is very risky and mostly turns out to be unprofitable, sometimes leading to suicides. At present, no

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documented studies are available that show the quantitative effects of plant geometry and nutrient application on yield dynamics of tested *Bt* cotton hybrids in this region and their monetary evaluation. Generation of such information through field experimentation is therefore of utmost importance, for guiding the farmers besides creating increased availability of better hybrids and healthy competition among seed companies. Among different agronomic manipulations, selection of potential *Bt* cotton hybrids having high yield, their optimum plant population and suitable fertilization plays crucial role in increasing the productivity (Singh *et al*., 2007). Fulfilment of nutritional requirements of the cotton is not only essential for achieving the higher yields but also for fibre quality parameters (Kalaichelvi, 2009). Higher SCY due to improved yield contributing parameters per plant under elevated levels of nutrients, has also been observed by Bhalerao *et al* (2010), Sunitha *et al.* (2010). Significant improvement in seed cotton yield and consequently, better monetary parameters with application of optimum nutrient levels, has also been reported in *Bt* cotton (Singh *et al.,* 2013). Farmers lack any kind of information on cultivar differences in response to location specific needs. Obviously, the best way to achieve these aims is through scientific evaluation of new *Bt* hybrids. Hence, the studies were undertaken to evaluate productivity potential of *Bt* cotton hybrids, their agronomic requirements and also their economic viability under the site specific agro-climatic conditions.

## Materials and Methods

The experiment was conducted during *Kharif* 2010 and 2011 at PAU, Regional Research Station, Faridkot which lies in Trans-Gangetic agro-climatic zone, representing the Indo-Gangetic alluvial plains (30º 40'N and 74º 44 'E) Punjab { a typical representative of semi-arid South-Western cotton belt (Zone IV)} situated at 200m above MSL. The soil of the experimental field was loamy in texture, slightly alkaline (pH8.7), normal EC (0.40 mmhos $cm^{-1}$), medium in OC (0.48%),low in available P (7.5 Kg $ha^{-1}$) but high in available K (750 $ha^{-1}$). The experiment comprising of three *Bt* cotton hybrids (MRC 7361, Bioseed 6488 and RCH134) in main, two plant geometries (i.e. 67.5 x 75 cm and 67.5 x 90 cm) in sub and three nutrient levels {i.e. 100% of recommended (150 kg N, 30kg P $ha^{-1}$), 125% of recommended (187.5kg N, 37.5kg P $ha^{-1}$) and 150% of recommended (225 Kg N, 45kg P $ha^{-1}$)} in sub-sub plots was conducted in Split Plot design replicated thrice. Being Zonal Check, RCH134 was used as Standard for evaluation of potential productivity of hybrids. The crop was sown in first fortnight of May, by dibbling 2-3 seeds per hill which were later thinned to one seedling per hill. A uniform inter row spacing of 67.5 cm was maintained. Full dose of P was applied before sowing while N dose was given in two splits i.e first half at the time of thinning and the remaining half at the flowering stage. rain received during the crop season was 432.8 mm and 606.4 mm for 2010 and 2011, respectively. No. of rainy days (41) were also higher during 2011 as compared to only 34 days in 2010. All other agronomic practices were followed as per the recommended package of practices recommended by the Punjab Agricultural University. Data on yield attributes were recorded from five randomly selected plants in each treatment plot. Seed cotton yield was recorded from whole plot. The data were analyzed statistically as per the standard procedure proposed by

**Table 1 :** Yield and yield contributing characters of *Bt* cotton hybrids under different plant geometry and nutritional levels

| Treatments | Sympods / plant | | | Bolls / plant | | | Boll weight (g) | | | Seed cotton yield (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | Pooled | 2010 | 2011 | Pooled | 2010 | 2011 | Pooled | 2010 | 2011 | Pooled |
| ***Bt* Cotton hybrids** | | | | | | | | | | | | |
| MRC 7361 | 29.5 | 30.4 | 29.9 | 57.8 | 64.2 | 61.0 | 5.41 | 5.19 | 5.30 | 2795.4 | 3447.8 | 3121.6 |
| Bioseed 6488 | 21.8 | 24.0 | 22.9 | 54.6 | 60.8 | 57.7 | 3.91 | 4.20 | 4.05 | 2217.5 | 3081.4 | 2649.5 |
| RCH134 | 22.2 | 20.9 | 21.6 | 47.8 | 47.3 | 47.5 | 4.50 | 4.35 | 4.43 | 1897.1 | 2317.6 | 2107.4 |
| **CD (0.05)** | **0.9** | **1.1** | **0.6** | **4.3** | **4.9** | **2.7** | **0.23** | **0.50** | **0.23** | **257.1** | **289.8** | **160.9** |
| **Plant geometry** | | | | | | | | | | | | |
| 67.5 x 75 cm | 23.1 | 24.7 | 23.9 | 51.3 | 55.5 | 53.4 | 4.50 | 4.59 | 4.54 | 2218.7 | 2916.9 | 2567.8 |
| 67.5 x 90 cm | 25.8 | 25.5 | 25.7 | 55.5 | 59.3 | 57.4 | 4.71 | 4.58 | 4.65 | 2387.9 | 2981.0 | 2684.5 |
| **CD (0.05)** | **2.3** | **NS** | **1.1** | **3.2** | **NS** | **2.3** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| **Nutrient levels** | | | | | | | | | | | | |
| (150kg N, 30kg P $ha^{-1}$) **100 %Rd** | 22.3 | 23.3 | 22.8 | 51.7 | 53.8 | 52.7 | 4.46 | 4.43 | 4.44 | 1914.7 | 2835.1 | 2374.9 |
| (187.5kg N, 37.5 kg $ha^{-1}$) **125 % Rd** | 24.8 | 25.2 | 25.0 | 53.6 | 58.0 | 55.8 | 4.62 | 4.62 | 4.62 | 2404.0 | 2951.2 | 2677.6 |
| (225 Kg N, 45kg P $ha^{-1}$) **150 % Rd** | 26.4 | 26.8 | 26.6 | 55.0 | 60.4 | 57.7 | 4.75 | 4.69 | 4.72 | 2591.3 | 3060.5 | 2825.9 |
| **CD (0.05)** | **2.4** | **1.8** | **1.4** | **NS** | **3.9** | **2.6** | **NS** | **0.17** | **0.14** | **184.9** | **137.7** | **112.2** |



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Cheema and Singh (1991). The interaction effects among the various kinds of treatments were found to be non-significant. Hence, only pooled means of the main effects have been used to discus the results.

## Results and Discussion

**Effect of *Bt* cotton hybrids :** The tested *Bt* cotton hybrids differed significantly for yield attributing characters as well as for seed cotton yield (Table 1). Pooled data revealed significantly higher SCY (3121.6 kg ha$^{-1}$) for MRC7361 due to improved yield contributing characters such as sympods and bolls per plant as compared to Bioseed6488 (2649.5 kg ha$^{-1}$) and RCH134 (2107.4 kg ha$^{-1}$). Bioseed 6488 also resulted statistically higher SCY by 25.7 % over RCH134 due to improved bolls per plant. Singh *et al* (2007) found significant differences for SCY among *Bt* cotton hybrids due to the difference in number of bolls and sympods per plant. Boll weight of MRC7361 (5.30 g) was found to be significantly higher by 19.6 and 30.8 % over that of RCH134 and Bioseed6488, respectively. This might have contributed in big way for recording the highest seed cotton yield under MRC7361. Statistically, the least boll weight (4.05 g) was observed for Bioseed 6488. MRC7361 and Bioseed6488 recorded significantly higher boll number by 28.4 and 21.4 %, respectively over RCH134.The boll weight in case of RCH134 (4.43g) was significantly superior as compared to Bioseed6488 (4.05g). However, RCH134 produced significantly least (47.5) number of bolls per plant. In present investigations, MRC7361 recorded statistically better yield by 17.8 and 48.1 % over Bioseed 6488 and RCH134, respectively owing to improved yield contributing characters. Manjunatha *et al.* (2010) reported significant differences for SCY among different *Bt* cotton hybrids, particularly due to improved number of bolls per plant. All of the above discussed parameters further culminated to give statistically higher fertilizer use efficiency (FUE) and water productivity (WP) indices for MRC7361. RCH134 exhibited significantly least FUE (3.65) as well as WP (438.2 gm$^{-3}$ ) indices. Significantly highest net returns of ₹ 101047 ha$^{-1}$ were recorded with MRC7361 as compared to Bioseed6488 (₹ 83343 ha$^{-1}$) and RCH134 (₹ 63014 ha$^{-1}$). Bioseed 6488 also recorded significantly better net returns than RCH134. Highest B:C (4.22) ratio owing to significantly improved net returns also indicated superiority of MRC7361 over rest of the hybrids (Table 2). Statistically the least value for B:C ratio (2.93) in case of RCH134 was clearly indicative of its being less remunerative as compared to the other Bt hybrids in the study.

**Effect of plant geometries :** Data revealed that plant geometries could not affect SCY significantly (Table 1). Srinivasulu *et al.* (2006) and Brar *et al.* (2008) also reported non-significant differences for SCY with respect to plant geometries. However, in the present investigations, pooled data indicated statistically improved number of sympods and bolls per plant under wider geometry (67.5 x 90 cm). Wider plant geometry (67.5 x 90 cm) recorded 7.53 and 7.49 % significantly higher sympods and bolls per plant, respectively over that of narrow geometry (67.5 x 75 cm). This might be due to better light interception and lesser competition among intra rows which lead to statistical improved mature bolls as well as sympods per plant in case of wider geometry. Narayana *et al.* (2007) reported significantly better number of bolls per plant under wider (120 x 60cm) than the closer plant geometry (90 x60cm) owing to the reasons discussed

**Table 2 :** Effect of different treatments on fertilizer use efficiency , water productivity, net returns and B: C ratio

| Treatments | Fertilizer use efficiency (kg SCY kg$^{-1}$ fert. applied) | | | Water productivity (gm$^{-3}$) | | | Net returns (₹ ha$^{-1}$) | | | B:C ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | Pooled | 2010 | 2011 | Pooled | 2010 | 2011 | Pooled | 2010 | 2011 | Pooled |
| **Bt Cotton hybrids** | | | | | | | | | | | | |
| MRC 7361 | 4.90 | 6.03 | 5.47 | 532.4 | 766.1 | 649.3 | 88971 | 113123 | 101047 | 3.88 | 4.55 | 4.22 |
| Bioseed 6488 | 3.75 | 5.38 | 4.56 | 422.3 | 684.7 | 553.5 | 67301 | 99384 | 83343 | 3.08 | 4.15 | 3.61 |
| RCH134 | 3.24 | 4.06 | 3.65 | 361.3 | 515.0 | 438.2 | 55287 | 70742 | 63014 | 2.65 | 3.21 | 2.93 |
| CD (0.05) | 0.43 | 0.52 | 0.28 | 48.9 | 64.4 | 33.6 | 9640 | 10869 | 6034 | 0.32 | 0.33 | 0.19 |
| **Plant geometry** | | | | | | | | | | | | |
| 67.5 x 75 cm | 3.81 | 5.09 | 4.45 | 422.6 | 648.2 | 535.4 | 67247 | 93100 | 82174 | 3.07 | 3.91 | 3.49 |
| 67.5 x 90 cm | 4.11 | 5.22 | 4.67 | 454.8 | 662.4 | 558.6 | 73792 | 95733 | 84763 | 3.34a | 4.03 | 3.68 |
| CD (0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | 0.25 | NS | 0.15 |
| **Nutrient levels** | | | | | | | | | | | | |
| (150kg N, 30kg P ha$^{-1}$) 100 %Rd | 4.09 | 6.06 | 5.08 | 364.7 | 630.0 | 497.3 | 56351 | 90554 | 73453 | 2.72 | 3.93 | 3.32 |
| (187.5kg N, 37.5kg ha$^{-1}$) 125 % Rd | 4.11 | 5.05 | 4.58 | 457.9 | 655.8 | 556.8 | 74297 | 94502 | 84399 | 3.34 | 3.98 | 3.66 |
| (225 Kg N, 45kg P ha$^{-1}$) 150 % Rd | 3.69 | 4.36 | 4.03 | 493.5 | 680.1 | 586.8 | 80912 | 98193 | 89552 | 3.54 | 4.01 | 3.78 |
| **CD (0.05)** | **0.32** | **0.24** | **0.19** | **35.2** | **30.6** | **22.7** | **6935** | **5165** | **4210** | **0.23** | **NS** | **0.13** |

above. Reddy and Gopinath (2008) observed statistically improved bolls per plant under wider plant geometry (90 x 90cm) as compared to closer one (90 x 60 and 90 x 30cm) due to lesser competition among the plants for available resources. Except for B:C ratio, which was superior (3.68) under wider geometry, monetary parameters such as net returns, FUE and WP were found to be non-significant among plant geometries (Table 2).

**Effect of nutrient levels :** Among nutrient levels, statistically increased sympods, boll weight and bolls per plant were observed with application of 225 kg N, 45 kg P $ha^{-1}$ (150% ) than 150 kg N, 30 kg P $ha^{-1}$ (100% Rd) level. Bolls per plant improved from 52.7 to 55.8 and then 57.7, with each successive increase in level of nutrient application. Similarly, statistically improved number of sympods (26.6) were recorded with application of 225 Kg N, 45kg P $ha^{-1}$ (150% ) over that of 150 kg N, 30 kg P $ha^{-1}$. As a cumulative effect of improved yield contributing parameters, highest level of nutrients *i.e.* 150% produced 18.9 and 5.53 % higher SCY (2825.9 kg $ha^{-1}$) than 100 % (2374.9 kg $ha^{-1}$) and 125% (2677.6 kg $ha^{-1}$), respectively (Table 1). Singh *et al.* (2007) also reported significant improvement in SCY with increasing nitrogen levels among *Bt* cotton hybrids. Higher SCY due to better number of bolls per plant under elevated levels of nutrients was reported by Bhalerao *et al.* (2010) and Sunitha *et al.* (2010). Water productivity also improved significantly with every increase in nutrient levels *i.e* from 497.3 (100% Rd) to 556.8 (125% Rd) and then to a statistically highest level of 586.8 $gm^{-3}$ with application of 225 kg N, 45kg P $ha^{-1}$ (150% Rd). These results are in accordance with Singh *et al.* (2013) who observed a significant improvement in water productivity up to 710.8 $gm^{-3}$ with improved nutrition in *Bt* cotton over that of control (491.5 $gm^{-3}$). Contrarily, FUE followed the reverse trend as it declined from 5.08 to 4.58 and then to a significantly least value of 4.03 with every successive increase in nutrient levels. Significantly highest net returns (₹ 89552 $ha^{-1}$) and higher B:C ratio (3.78) were recorded with application of 225 Kg N, 45kg P $ha^{-1}$ (150% ). Whereas, statistically the least B:C ratio (3.32) was observed with the application of 150 kg N, 30kg P $ha^{-1}$ (100% Rd). These results are in conformity with the findings of Biradar *et al.* (2010) who reported higher returns with enhanced level of nutrition (150% Rd) than 100% recommended level.

Pooled results of two year studies indicated that under semiarid conditions of North India, farmers should opt for MRC7361 over other tested *Bt* hybrids and must apply nutrients @225Kg $N^{-1}$, 45kg P $ha^{-1}$ to realize higher seed cotton yield and consequently remunerative returns.

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## References

Bhalerao, P.D., B.R. Patil, P.U. Ghatol and P.P. Gawande: Effect of spacing and fertilizer levels on seed cotton yield under rainfed condition. *Indian J. Agric. Res.*, **44**, 74 – 76 (2010)

Biradar, V., S. Rao and V. Hosamani: Economics of late sown *Bt* cotton (*Gossypium hirsutum*.) as influenced by different plant spacing, fertilizer levels and NAA applications under irrigation. *Inter. J. Agric. Sci.,* **6**, 196-198 (2010)

Brar, J.S., B.S. Sidhu, K.S. Sekhon and G.S. Buttar: Response of *Bt* cotton (*Gossypium hirsutum* L.) to plant geometry and nutrient combinations in sandy loam soil. *J. Cotton Res. Dev.,* **22**, 59-61 (2008)

Cheema, H.S. and B. Singh: Software: *Statistical package CPCS-1 Deptt. of Math, Statistics and Physics*; Punjab Agricultural University, Ludhiana (1991)

Gandhi, V. and N.V. Namboodri: The adoption and economics of *Bt* cotton in India: Preliminary results from a study. IIMA Working paper no.2006-09-04 pp. 1-27 (2006)

Kalaichelvi, K.: *Bt* cotton response to plant geometry and fertilizer levels. *J. Cotton Res. Dev.*, **23**, 96-99 (2009)

Karihaloo, J.L. and P.A. Kumar: *Bt* cotton in India – A status report. 2nd Edn., Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB), New Delhi, India. p. 56 (2009)

Kranthi, K.R.: *Bt* Cotton,Questions and Answers by SecretaryCentral Institute for Cotton Research, Nagpur. Indian Society For Cotton Improvement (ISCI), Mumbai p.1-71(2012)

Manjunatha, M.J., A.S. Halepyati, B.G. Koppalkar and B.T. Pujari: Yield and yield components, uptake of nutrients, quality parameters and economics of *Bt*cotton (*Gossypium hirsutum* L.) genotypes as influenced by different plant densities. *Karnataka J. Agric. Sci.,* **23**, 423-425 (2010)

Narayana, E., K. Hema, K. Srinivasulu, N.V.V.S.D. Prasad and N.H.P. Rao: Agronomic evaluation of *Gossypium hirsutum* hybrids for varied spacings and nitrogen levels in vertisols under rainfed conditions. *J. Cotton Res. Dev*., **21**, 197-200 (2007)

Reddy, P. R. Rami and M. Gopinath: Influence of fertilizers and plant geometry on performance of *Bt* cotton hybrid. *J. Cotton Res. Dev.* **22**, 78-80(2008)

Singh, K., V. Jindal, V. Singh and P. Rathore: Performance of *Bt* cotton hybrids under different geometrical arrangements. *J. Cotton Res. Dev.*, **21**, 41-44 (2007)

Singh, K., H. Singh, R.K. Gumber and K. Singh: Growth, yield and quality characteristics of *Bt* cotton (*Gossypium hirsutum L.*) as influenced by foliar feeding of nutrients. *J. Cot. Res. Dev.*, **27**, 213-216 (2013).

Srinivasulu, K., K. Hema, N.V.V.S.D. Prasad and K.V. Krishna Rao: Performance of cotton hybrids under different spacings and nitrogen levels in black cotton soils of coastal Andhra Pradesh. *J. Cotton Res. Dev.*, **20**, 99-101 (2006)

Sunitha, V., K. Chandrasekhar and R. Veeraraghavaiah: Performance of *Bt* cotton hybrids at different nitrogen levels. *J. Cotton Res. Dev.,* **24**, 52-55(2010)