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***RESEARCH PAPER***

# Response of Bt cotton hybrids on planting density and fertility levels on growth and yield

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**Abstract :** The field experiments were conducted at Zonal Agricultural Research Station, Babbur farm, Hiriyur, University of Agricultural Sciences, Bangalore during *Kharif* 2008 and 2009 under irrigated conditions. The site is located in the central dry zone (zone-4) of Karnataka, India. Treatments of the present investigation included three levels of fertility (150, 100 and 75 per cent of Rec.$NP_2O_5K_2O$ kg/ha) and four levels of spacing (120x120cm, 120x90cm, 90x60cm and 60x45cm) with two Bt cotton hybrid *viz*., Rasi-530Bt (HxH) and MRC-6918 Bt (H x B). Yield loss of cotton was estimated based on linear and quadratic equations. The equation was fitted using leaf area with number of boll dropped at different stages of crop growth. Adoption of cotton Rasi-530 Bt hybrid (H x H) was found significantly superior in respect of higher seed cotton yield (2731.3kg/ha) as compared to MRC-6918 Bt (H x H) (2641.2 kg/ha). Similarly, predicated seed yield based on linear and quadratic equation, lower the seed yield of MRC-6918 Bt by 302.5 kg /ha. Adoption of optimum spacing of 90x60 cm (18158.5 plants /ha) recorded significantly higher seed cotton yield (2803.3 kg/ha) followed by other spacing and higher dense population (24691.3 plants /ha) has obtained lower seed cotton yield (2602.7kg/ha ) and predicated yield loss was marginally lesser in recommended optimum spacing 90x90cm (224.7 kg/ha) *i.e*. 90x60cm. Predicated seed cotton yield in 100 per cent recommended dose of fertilizer was found less yield loss (842.7 kg/ha) over 75 per cent recommended dose of fertilizer (1262.0 kg/ha) as compared to 150 recommended dose of fertilizer.

**Key Words :** Bt cotton, Planting density, Fertility levels

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## INTRODUCTION

Cotton (*Gossypium* spp.) is an important fibre crop of India contributing to 85 per cent of total raw material of textile industries. India has unique distinction of cultivating cotton in 8.74 m.ha, accounting for about 25 per cent of the total cotton growing areas of the world with a share of 8.2 per cent of global production. India ranks first in area and third in production in the world albeit low productivity. India has the world's largest acreage of cotton with an area of 8.9 m.ha (Anonymous, 2004). The average productivity of India is 440 kg/ha which is far below the world average productivity of 677 kg/ha. In Karnataka, DCH-32 is being popular since 1982, as an inter-specific hybrid and it had made break through in cotton production of the state. This hybrid is more susceptible to pest and diseases as a result the productivity per ha and quality of production has declined over the years and lost its gentic purity.

The cotton plant has associated with more than 162 species of insects pests known to devour cotton at various stages of growth and out of which 15 are considered to be key insects pests causing severe damage. Among the insect pests of cotton, the bollworm complexes are the most serious pests in India causing an annual loss of at least 300 million US dollars. Bollworm alone takes a heavy toll costing the farmers an annual loss of Rs.11 billion equal to more than one third of current insecticides use in India. In order to overcome this yield loss, the efforts of incorporation of insect resistance has prime objective of cotton improvement in India .In this view, during in 2002, the Government of India

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has permitted commercial cultivation of genetically modified(GM) Bt cotton. Available potential high yielding inter-specific (HirsutumxBarbadance) private Bt cotton hybrid MRC-6918 which was developed by Mhyco company. The intra-specific (Hirsutum x Hirsutum) Bt cotton hybrid popularly cultivated by the farmers of Chitradurga district of Karnataka is Rasi-530, developed by Rasi company.These two private hybrids contain genes of *Bacillus thuringensis* and produces toxins in the plant to avoid bollworm damage. Bt cotton hybrid carries a gene incorporated into it from another species, which gives resistance against bollworms. Bt cotton hybrid and a normal hybrid with same parents differ only for a single gene *i.e.* Bt gene.

The currently available Bt cotton hybrids do not rejuvenate quickly (re-activate of the plant for yield) after completing its first phase of production due to their early and semi- determinate types, slow rate of the growth and rejuvenate capacity after first flush of flowering. Hence, Bt cotton hybrids need more nutritional requirement after first bearing.

Exploration of potential yield of the Bt cotton with addition of nutrition over and above the normal recommended fertilizers. Similarly, establishment of acceptable population of cotton seedling is paramount to obtain higher yields in cotton (Siebert and Stewart, 2006) and positive relationship was obtained with alteration plant population in Bt cotton (Pettigrew and Meredith., 1997). Current planting geometry recommended for conventional cotton is 18158.5 plants per ha and the Bt cotton crop demand more nutrition after first flush and it is necessary to study varied plant geometry with varied levels of nutrients in Bt cotton. Hence, the present investigation was under taken to study the response of Bt cotton hybrids to varied levels of plant geometry and fertility levels in Bt cotton.

## MATERIAL AND METHODS

The field experiments were conducted at Zonal Agricultural Research Station, Babbur farm, Hiriyur, University of Agricultural sciences, Bangalore during *Kharif* 2008 and 2009 under irrigated conditions. The site is located in the central dry zone (zone-4) of Karnataka, India, between 13°57'32N Latitude and 70°37'38E longitude at an altitude of 606.1m above mean sea level with medium to deep black soil. The soils of experimental plot had pH 8.75, available nitrogen, phosphorus and potassium content were 201.1, 4.37 and 104 .46 kg/ha, respectively (Table A). Treatments of the present investigation included three levels of fertility (150, 100 and 75 % of rec. N $P_2O_5K_2O$ kg/ha) and four levels of spacing (120x120cm,120x90cm,90x60cm and 60x45cm) with two Bt cotton hybrid *viz*., Rasi-530Bt (HxH) and MRC-6918 Bt (H x B). The seeds were sown by dibbling method during second week of July 2008 and 2009. The recommended dose of phosphorus, potassium and half of the recommended dose of nitrogen was applied at the time of sowing and remaining 50 per cent of nitrogen was applied at the time of flower initiation as per treatment. The net plot size harvested each year was 3.6 x 2.4 m (8.64 $m^{-2}$). Other cultural practices and plant protection measures were given as per the recommendation of the university schedules (Anonymous, 2011). At time maturity five plants per plot were randomly selected for recording the observation on bolls per plant, yield per plant and other ancillary characters. Yield estimation was worked out by using parameters of number of dry matter production per plant as against leaf area of plant at different stages the linear and quadratic type of equation Y=a + bX and Y=a + $bX^2$ were fitted using least square technique as given in Snedecor and Cochran (1967). The yield of plant was derived by differentiating the above function with respect to X and equation to zero. *i.e.*

$Y=a + bX+cX^2$

$dy/dx=b+2cX$

$X=-b/2c$

**Table A : Mechanical and chemical properties of experimental site**

| | |
|---|---|
| **Physical properties** | |
| Mechanical analysis | |
| Sand | 26 % |
| Silt | 20 % |
| Clay | 54 % |
| Bulk density | $1.43Mg/m^3$ |
| Per cent porosity | 46.24 |
| Infiltration rate | 1.30 cm/hr |
| Water holding capacity | 52 % |
| **Chemical properties** | |
| pH | 8.75 |
| EC | 0.314 d S/m |
| CEC | 34.71 c.mol(p+) $kg^{-1}$ |
| Organic carbon | 5.90 g/kg |
| Nitrogen | 201.16 kg/ha |
| Phosphorous | 4.37 kg/ha |
| Potassium | 104.46 kg/ha |
| Boron | 0.98 ppm |

## RESULTS AND DISCUSSION

Results of the present investigation (Table 1 and 2) revealed that adoption of cotton Rasi-530 Bt hybrid (H x H) recorded significantly superior higher seed cotton yield (2731.3kg/ha) as compared to MRC-6918 Bt(hxh) (2641.2 kg/ha). Similarly, predicated seed yield based on linear and quadratic equation, lower the seed yield of MRC-6918 Bt by 302.5 kg /ha. The lower in seed cotton yield was attributed to yield parameters such as seed cotton yield per boll, seed cotton yield per plant, and number of bolls per plant. Which was mainly due to accumulation of crop lesser biomass, due to reduction in partitioning of assimilate to the formation of leaf area and a decrease in the efficient use of intercepted radiation for the production of above ground biomass and more shedding of squares and lesser fiber fines and length (Colomb *et al*., 1995). Pettigrew (1999) stated that part of the overall effect was reducing the amount of photosynthate available for reproductive sink, which produced change in lint yield and fibre quality.

Adoption of optimum spacing of 90x60 cm (18158.5 plants /ha) recorded significantly higher seed cotton yield (2803.3 kg/ha) followed by other spacing and higher dense population (24691.3 plants /ha) has obtained lower seed cotton yield (2602.7kg/ha) and predicated yield loss was marginally lesser in recommended optimum spacing 90x90cm (224.7 kg/ha) *i.e*. 90x60cm. Optimum plant populations (2.0-5.1 plants $m^{-2}$) typically demonstrate greater fruit retention and produce more apical main-stem nodes $plant^{-1}$, bolls on monopodial branches $plant^{-1}$ and bolls on distal sympodial branch fruiting positions $plant^{-1}$ (Bednarz *et al.*, 2000; Jones and Wells, 1998; Siebert and Stewart, 2006). Bolls produced on monopodial branches and sympodial branch fruiting positions past the second position are reported to be of higher quality than those on sympodial branches (Bednarz *et al.*, 2005; Bednarz *et al.*, 2006; Jones and Wells, 1997). Similarly lower plant population 120 x 120 cm (6944.4 plants/ha) and high density population has obtained lower seed cotton yield (2584.8kg/ha) and predicated seed yield loss was (299.6 kg/ha) which was mainly due to lower plant populations shading caused by excessive vegetative growth may result in a greater potential for boll rot (York, 1983), fruit abscission (Bednarz *et al.*, 2000), increased plant height (Siebert and Stewart, 2006) and delayed maturity (Cathey and Meredith, 1988; York, 1983), leading to reduced yield (Cathey and Meredith, 1988; Gwathmey and Craig Jr., 2003; Siebert and Stewart, 2006; York, 1983). Bednarz *et al.* (2006) reported an increase in fibre length at lower plant populations (3.6-9.0 plants $m^{-2}$), but an increase in the percentage of immature fibres at higher plant populations and lower plant population (9.0-21.5 plants $m^{-2}$) when measured across fruiting positions.

Application more than 150 per cent of recommended fertilizer showed significantly higher seed cotton yield (2942.7 kg/ha) over 100 and 75 per cent of recommended fertilizers levels and predicated yield of recommended fertilizer was lesser (842.7 kg/ha) and 75 per cent

**Table 1 : Effect of Bt cotton hybrids, plant geometry and fertility levels on yield and yield parameter of cotton**

| Treatments | No. of bolls /plant | Seed cotton yield /boll (g) | Seed cotton yield /plant (g) | Seed cotton yield (kg/ha) |
|---|---|---|---|---|
| **Bt hybrids (A)** | | | | |
| 1. Rasi-530 Bt (HXH) | 59.1 | 3.37 | 237.4 | 2731.3 |
| 2. MRC-6918 Bt (HXB) | 64.7 | 3.33 | 230.0 | 2641.2 |
| S.E.± | 0.27 | 0.03 | 1.54 | 9.51 |
| C.D. (P=0.05) | 1.64 | NS | NS | 57.87 |
| **Spacing (B)** | | | | |
| 1.120x120cm (6944.4 Plants/ha) | 83.7 | 4.56 | 380.2 | 2584.8 |
| 2.120x90cm (9259.2 plants /ha) | 76.0 | 3.93 | 298.0 | 2754.2 |
| 3.90x60cm (18158.5 plants /ha) | 49.2 | 3.06 | 151.5 | 2803.3 |
| 4.90x45cm (24691.3 plants /ha) | 38.6 | 2.67 | 105.1 | 2602.7 |
| S.E.± | 1.01 | 0.03 | 7.34 | 29.08 |
| C.D. (P=0.05) | 3.11 | 0.09 | 22.61 | 63.36 |
| **Fertility levels (C)** | | | | |
| 1. 150 % Rec.NPK and FYM | 65.7 | 3.74 | 257.9 | 2942.7 |
| 2. 100 % Rec.NPK and FYM | 62.2 | 3.57 | 234.2 | 2696.4 |
| 3. 75 % Rec.NPK and FYM | 58.2 | 3.36 | 209.0 | 2419.7 |
| S.E.± | 1.47 | 0.04 | 5.93 | 32.92 |
| C.D. (P=0.05) | 4.24 | 0.11 | 17.13 | 95.06 |
| **Interaction** | | | | |
| AXB S.E.± | 1.47 | 0.04 | 10.38 | 41.12 |
| C.D (P=0.05) | 4.24 | 0.11 | NS | 118.7 |
| AXC SE.± | 2.08 | 0.06 | 8.38 | 46.55 |
| C.D (P=0.05) | NS | NS | NS | NS |
| BXC S.E.± | 2.95 | 0.08 | 11.86 | 46.55 |
| C.D (P=0.05) | NS | NS | NS | NS |
| AXBXC S.E.± | 4.17 | 0.12 | 16.77 | 93.11 |
| C.D (P=0.05) | NS | NS | NS | NS |

NS=Non-significant

recommended was lower by 1262.0 kg/ha compared to 150 per cent of recommended fertilizer due to lint yield increased linearly with N fertility levels, attaining a maximum yield of 1842 kg $ha^{-1}$ at 224 kg $ha^{-1}$ N (Fritschi *et al.*, 2003). Yield advantages because of optimal N application have been attributed to larger bolls at a greater number of fruiting sites (Boquet and Breitenbeck, 2000). Boquet (2005) reported that increasing N from 90 to157 kg $ha^{-1}$ did not result in increased lint yield in irrigated or rain-fed cotton. Bauer and Roof (2004) observed lower lint quality, including fiber length, length uniformity, and fibre strength, in plots that did not receive N fertilization. This could be attributed to the fact that N is an important nutrient for new growth (Borowski, 2001) and preventing abscission of squares and bolls. Nitrogen deficiency has been observed to decrease the auxin content and markedly increased the content of inhibitors in the leaves and stems (Anisimov and Bulatova, 1982). Several factors, including soil type, affect cotton response to P. The critical level of P is a function of actual concentration of the labile pool that in turn determines the available P at a given time during the growth of cotton (Crozier *et al.*, 2004). Several variables, including early P accumulation, biomass, and lint yields, positively responded to P fertilization (Bronson *et al.*, 2003). Reiter and Kreig (2000) reported some positive and notable P effects on lint fiber quality factors, although both lint yield and lint quality were driven more by moisture availability than by P. The role of K in plants suggests that it affects abscission and yield. Guinn (1985) indicated that nutritional stress increases boll shedding (an important aspect of cut- out) through an increase in ethylene production; however, K fertilizer had been reported to reduce boll shedding (Zeng, 1996). Results for boll numbers to K application in this study were similar to those obtained by Gormus (2002)

## Conclusion:

According to these studies, adoption of Bt cotton hybrid (HXH) Rasi-530 recorded more yield and while

**Table 2 : Predicated and yield loss of Bt cotton hybrids, different spacing and fertility levels**

| Sr. No. | Function | $r^2$ | S.E | Percentage yield reduction(kg/ha) | Predicated seed cotton yield (kg/ha) |
|---|---|---|---|---|---|
| **Bt cotton hybrids** | | | | | |
| 1.Rasi-530Bt (HxH) | | | | | |
| | Linear Y=5.937+0.16132 | 0.96 | 9.97 | 302.5 | 2872.5 |
| | Quadratic Y=-26.9956+ 0.4596-0.00016 | 0.99 | 7.10 | | |
| 2.MRC-6918 Bt (HXB) | | | | | |
| | Linear Y=9.494+0.1312 | 0.99 | 2.61 | 0 | 2570.0 |
| | Quadratic Y=1.003+0.2071-0.3084 | 0.99 | 6.77 | | |
| **Spacing** | | | | | |
| 1.120X120 cm(6944.4 Plants/ha) | | | | | |
| | Linear Y=6.60381+0.1652 | 0.98 | 7.75 | 299.6 | 2567.1 |
| | Quadratic Y=-18.3418+0.3594-0.00014 | 0.99 | 5.50 | | |
| 2.120X90cm (9259.2 plants /ha) | | | | | |
| | Linear Y=4.1557+0.16175 | 0.99 | 5.33 | 177.7 | 2689.0 |
| | Quadratic Y=-9.07011+0.27583-0.00011 | 0.99 | 5.05 | | |
| 3.90X60cm(18158.5 plants /ha) | | | | | |
| | Linear Y=5.7453+0.14511 | 0.98 | 6.53 | 224.7 | 2542.0 |
| | Quadratic Y=-16.7089+0.35589-0.00014 | 0.99 | 1.04 | | |
| 4.90X45cm(24691.3 plants /ha) | | | | | |
| | Linear Y=121491+0.112391 | 0.98 | 4.16 | 0 | 2866.7 |
| | Quadratic Y=-4.17893+0.28735+0.00021 | 0.99 | 0.28 | | |
| **Fertility levels** | | | | | |
| 1.150% Rec. NPK+FYM | | | | | |
| | Linear Y=7.086794+0.149898 | 0.98 | 7.19 | 0 | 3256.6 |
| | Quadratic Y=-18.0932472+0.358233-0.00011 | 0.99 | 3.21 | | |
| 2.100% Rec. NPK+FYM | | | | | |
| | Linear Y=7.086794+0.149898 | 0.98 | 5.06 | 842.7 | 2409.4 |
| | Quadratic Y=-5.36912+0.2891311-0.00012 | 0.99 | 1.74 | | |
| 3.75% Rec. NPK+FYM | | | | | |
| | Linear Y=3.8234+0.15481 | 0.98 | 5.72 | 1262.0 | 1994.6 |
| | Quadratic Y=-12.720247+0.319140-0.00016 | 0.99 | 4.33 | | |

adoption of MRC-9818 (HXB) found marginally lesser yield. With this view the application of recommended dose of $N,P_2O_5$, $K_2O$ 842.7 kg/ha was found with lesser yield over control, 150 per cent recommended nitrogen or 75 per cent (2501.8 kg/ha) in this study and similarly by adoption of optimum spacing 90x60 cm recorded higher seed cotton yield over lesser and higher density populations and predictability was 98 to 99 and yield variation with respective nutrient ,Bt hybrids and spacing or planting density application was found best solution for the farming community. These results of the present investigation would assist the researchers in establishing suitable strategies for Bt hybrids nutrients requirement and population density management in cotton and further individual nutrients, varied Bt hybrids and planting density needs additional research in cotton.

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