Plant geometry and nutrient levels effect on productivity of Bt cotton

P.L. GHULE, D.K. PALVE, J.D. JADHAV*1 AND V.V. DAHIPHALE
Marathwada Krishi Vidyapeeth, PARBHANI (M.S.) INDIA

Abstract: A field investigation was conducted during Kharif season. The experiment was laid out in split plot design with three replications. There were twelve treatment combinations comprising three plant geometries viz., 90 cm x 60 cm, 120 cm x 45 cm and 180 cm x 30 cm and four nutrient levels viz., 80:40:40, 100:50:50, 120:60:60 kg NPK/ha and 75 % RDF + 5 t FYM/ha. The plant geometries were allotted to main plot and nutrient levels were accommodated in sub plots. The plant geometry of 90 cm x 60 cm has recorded significantly higher number of sympodias per plant, the number of picked bolls per plant and seed cotton yield per plant over 120 cm x 45 cm and 180 cm x 30 cm. The seed cotton yield per hectare was also higher in plant geometry of 90 cm x 60 cm than 120 cm x 45 cm and 180 cm x 30 cm. The application of nutrient level i.e. 120:60:60 kg NPK/ha was found superior for enhancing growth parameters viz., plant height, number of leaves, leaf area and dry matter. The application of 75% RDF + 5 t FYM/ha recorded significantly higher seed cotton yield per hectare. Based on the results it can be concluded that the yield attributes of Bt cotton were improved in plant geometry of 90 cm x 60 cm. The seed cotton yield of Bt cotton was significantly higher in plant geometry of 90 cm x 60 cm than 120 cm x 45 cm and 180 cm x 30 cm which recorded 23 % and 21 % higher over 120 cm x 45 cm and 180 cm x 30 cm, respectively. Application of 75% RDF + 5 t FYM/ha to Bt cotton was significantly superior than rest of all other treatments which recorded 14, 9 and 5.5 per cent higher yield over 80:40:40 kg NPK/ha, 100:50:50 kg NPK/ha and 120:60:60 kg NPK/ha, respectively.

Key Words: Plant geometry, Nutrient levels, Bt Cotton

INTRODUCTION

Plant geometry having greater importance in cotton cultivation. Bt cotton crop may be producing excessive vegetative growth at wider plant geometry and excessive reproductive growth at close plant geometry. However, numerically lower monopodial with closer plant geometry and lower sympodial with wider plant geometry were observed indicating more period under vegetative growth with wider spacing (Raghu Rami Reddy and Gopinath, 2008). Closer plant geometry also recorded higher seed cotton yields (Sankaranarayanan et al., 2004; Buttar and Singh, 2006 and Singh et al., 2007).

Nutrients are second most important limiting factor of crop production after water. Most often soil in the rainfed regions are not only thirsty but also hungry. It is now well established that for achieving high yields, the nutrient demand of crop should be met cotton crop growth follows a typical sigmoidal pattern. Dry matter accumulation is maximum during the active growth phase (40-100 days). Application of nutrients should be done well before the grand growth period between 45-60 days. Nutrient management in cotton is complex due to simultaneous production of vegetative and reproductive structures during the active growth phase.

With this preamble, a field experiment was designed and conducted during Kharif season of 2009-2010 with the objectives to study the suitable plant geometry for Bt cotton and to study nutrient requirement for Bt cotton.

MATERIAL AND METHODS

The experiment was laid out in Split Plot Design with
There were twelve treatment combinations comprising three plant geometries viz., 90 cm x 60 cm, 120 cm x 45 cm and 180 cm x 30 cm and four nutrient levels viz., 80:40:40, 100:50:50, 120:60:60 kg NPK/ha and 75% RDF + 5 t FYM/ha. The plant geometries were allotted to main plot and nutrient levels were accommodated in sub plots.

The soil of experimental plot was Vertisol, i.e. clayey in texture, low in available nitrogen and available phosphorus and very high in available potash and slightly alkaline in reaction. The climatic conditions were favourable during 2009-10 for the growth and development of cotton which ultimately resulted in better yield.

Besides the yield data, various ancillary observations were recorded periodically to evaluate treatment effects.

**RESULTS AND DISCUSSION**

The various growth aspects and yield of Bt cotton hybrid NCS-145 (Bunny Bt) as influenced by various plant geometries and nutrient levels under dryland conditions have been studied and the results of these findings have been presented in this chapter.

**Growth attributes:**

*Plant height (cm):*

Data on plant height (cm) recorded at various growth stages of crop are presented in Table 1.

Data presented in Table 1 revealed that the mean plant height was increased in successive growth stages and attained its maximum *i.e.* 65.90 cm at harvest. The rate of increase in plant height was slow during seedling stage upto 30 DAS, very fast between 30 DAS to 60 DAS followed by 90, 120, 150 DAS at harvest.

*Plant geometry:*

Data presented in Table 1 revealed that the differences in plant height were significantly recorded in plant geometry of 180 cm x 30 cm at 60, 120 and 150 DAS and at harvest and it was at par with 120 cm x 45 cm at 60, 120 and 150 DAS. Plant height at 30 DAS was not influenced significantly due to different plant geometry.

*Nutrient levels:*

Data presented in Table 1 revealed that the application of higher dose of fertilizer *i.e.* 120:60:60 kg NPK/ha produced significantly more plant height than 75% RDF + 5 t FYM/ha significantly and 80:40:40 kg NPK/ha and it was at par with 100:50:50 kg NPK/ha, at 60, 120 and 150 DAS. The various nutrient levels did not show any marked influence on plant height at 90 DAS.

*Interaction:*

The interaction effects due to different factors under study were not significant in respect of mean plant height at all stages of crop growth.

*Mean number of functional leaves per plant:*

Data in respect of number of functional leaves per plant as influenced by different treatments at various growth stages

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<table>
<thead>
<tr>
<th>Treatments</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant geometry (G)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G.mean</td>
<td>19.62</td>
<td>36.00</td>
<td>43.07</td>
<td>50.99</td>
<td>59.96</td>
<td>65.90</td>
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<tr>
<td>NS=Non-significant</td>
<td></td>
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</tr>
</tbody>
</table>

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Table 1: Mean plant height as influenced by different treatments at various growth stages

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Data presented in Table 2 revealed that the number of leaves were increased gradually in initial stages upto 60 DAS and then at very fast rate between 60 to 90 and 120 DAS, attained to its maximum at 150 DAS and then decreased gradually upto harvest.

**Plant geometry:**
Data presented in Table 2 revealed that the various plant geometries, 180 cm x 30 cm recorded significantly higher number of functional leaves per plant and it was at par with 120 cm x 45 cm and also 90 cm x 60 cm at harvest.

**Nutrient levels:**
Application of 120:60:60 kg NPK/ha recorded higher number of functional leaves over 80:40:40 kg NPK/ha and 75% RDF + 5 t FYM/ha and it was at par with 100:50:50 kg NPK/ha at 60, 90 DAS and at harvest.

**Interaction:**
The interaction effects due to different factors under study were not significant in respect of number of functional leaves at all the days of observation.

Data presenting to leaf are indices as influenced by various treatments at different crop growth stages are given in Table 3. It is evident from the data that LAI was increased upto 121-150 days and decreased thereafter due to leaf senescence.

**Plant geometry:**
In plant geometry 180 cm x 30 cm recorded maximum LAI than other plant geometry.

### Table 2 : Mean number of functional leaves per plant as influenced by different treatments at various growth stages

<table>
<thead>
<tr>
<th>Treatments</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant geometry (G)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1 90 cm x 60 cm</td>
<td>9.38</td>
<td>30.21</td>
<td>38.87</td>
<td>52.35</td>
<td>68.26</td>
<td>54.13</td>
</tr>
<tr>
<td>S2 120 cm x 45 cm</td>
<td>11.67</td>
<td>33.54</td>
<td>41.49</td>
<td>54.47</td>
<td>68.41</td>
<td>57.54</td>
</tr>
<tr>
<td>S3 180 cm x 30 cm</td>
<td>13.22</td>
<td>35.24</td>
<td>44.05</td>
<td>59.76</td>
<td>73.80</td>
<td>59.14</td>
</tr>
<tr>
<td>S.E. +</td>
<td>0.46</td>
<td>0.71</td>
<td>0.98</td>
<td>0.62</td>
<td>0.71</td>
<td>0.70</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>1.38</td>
<td>2.11</td>
<td>2.91</td>
<td>1.85</td>
<td>2.10</td>
<td>2.07</td>
</tr>
<tr>
<td><strong>Nutrient levels (NPK kg/ha)</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>F1 80:40:40</td>
<td>10.42</td>
<td>31.65</td>
<td>39.00</td>
<td>52.98</td>
<td>69.05</td>
<td>55.53</td>
</tr>
<tr>
<td>F2 100:50:50</td>
<td>11.60</td>
<td>33.57</td>
<td>42.38</td>
<td>55.20</td>
<td>69.51</td>
<td>57.52</td>
</tr>
<tr>
<td>F3 120:60:60</td>
<td>12.83</td>
<td>34.83</td>
<td>43.78</td>
<td>58.97</td>
<td>72.63</td>
<td>58.76</td>
</tr>
<tr>
<td>F4 75% RDF + 5 t FYM/ha/ha</td>
<td>10.84</td>
<td>31.93</td>
<td>40.72</td>
<td>54.94</td>
<td>69.45</td>
<td>55.93</td>
</tr>
<tr>
<td>S.E. +</td>
<td>0.60</td>
<td>0.77</td>
<td>0.63</td>
<td>0.63</td>
<td>0.73</td>
<td>0.76</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>NS</td>
<td>2.30</td>
<td>1.89</td>
<td>1.88</td>
<td>2.18</td>
<td>2.26</td>
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<td><strong>Interaction (GxF)</strong></td>
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<tr>
<td>S.E. +</td>
<td>1.04</td>
<td>1.34</td>
<td>1.10</td>
<td>1.10</td>
<td>1.27</td>
<td>1.32</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
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<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>G.mean</td>
<td>11.43</td>
<td>33.00</td>
<td>41.47</td>
<td>55.52</td>
<td>70.16</td>
<td>56.94</td>
</tr>
</tbody>
</table>

NS=Non-significant

### Table 3 : Leaf area index (LAI) as influenced by different treatments at various growth stages

<table>
<thead>
<tr>
<th>Treatments</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant geometry (G)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1 90 cm x 60 cm</td>
<td>0.08</td>
<td>0.231</td>
<td>0.452</td>
<td>0.748</td>
<td>1.025</td>
<td>0.765</td>
</tr>
<tr>
<td>S2 120 cm x 45 cm</td>
<td>0.09</td>
<td>0.236</td>
<td>0.456</td>
<td>0.774</td>
<td>1.028</td>
<td>0.790</td>
</tr>
<tr>
<td>S3 180 cm x 30 cm</td>
<td>0.10</td>
<td>0.267</td>
<td>0.499</td>
<td>0.795</td>
<td>1.072</td>
<td>0.812</td>
</tr>
<tr>
<td><strong>Nutrient levels (NPK kg/ha)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1 80:40:40</td>
<td>0.08</td>
<td>0.232</td>
<td>0.443</td>
<td>0.737</td>
<td>1.014</td>
<td>0.753</td>
</tr>
<tr>
<td>F2 100:50:50</td>
<td>0.09</td>
<td>0.239</td>
<td>0.465</td>
<td>0.783</td>
<td>1.04</td>
<td>0.798</td>
</tr>
<tr>
<td>F3 120:60:60</td>
<td>0.10</td>
<td>0.275</td>
<td>0.504</td>
<td>0.794</td>
<td>1.08</td>
<td>0.812</td>
</tr>
<tr>
<td>F4 75% RDF + 5 t FYM/ha/ha</td>
<td>0.09</td>
<td>0.233</td>
<td>0.465</td>
<td>0.776</td>
<td>1.035</td>
<td>0.794</td>
</tr>
<tr>
<td>G.mean</td>
<td>0.09</td>
<td>0.244</td>
<td>0.469</td>
<td>0.772</td>
<td>1.042</td>
<td>0.789</td>
</tr>
</tbody>
</table>

PLANT GEOMETRY & NUTRIENT LEVELS EFFECT ON PRODUCTIVITY OF Bt COTTON
Nutrient levels:  
In nutrient levels, 120:60:60 kg NPK/ha recorded maximum LAI at all growth stages at 150 days. Nutrient level 75% RDF + 5 t FYM/ha recorded maximum LAI at 150 days.

Seed cotton yield per hectare:  
Data on seed cotton yield per hectare are presented in Table 4. The average seed cotton yield was 1304 kg per hectare.

Plant geometry:  
Plant geometry 90 cm x 60 cm recorded significantly higher seed cotton yield than 180 cm x 30 cm and 120 cm x 45 cm geometries.

Nutrients levels:  
Application of 75% RDF + 5 t FYM/ha i.e. 75:37.5:37.5 kg NPK/ha + 5 t FYM/ha recorded significantly higher seed cotton yield than nutrient levels 80:40:40, 100:50:50 and 120:60:60 kg NPK/ha. Lower level of 80:40:40 kg NPK/ha recorded significantly lower seed cotton yield than other nutrient levels.

Interaction:  
Interaction effect was not found significant.

Straw yield (kg/ha):  
Straw yield obtained from different plant geometry and nutrient levels presented in Table 4. The average straw yield recorded was 2059.1 kg/ha.

Plant geometry:  
Plant geometry 180 cm x 30 cm recorded higher straw yield (2089.3 kg/ha) than plant geometry 120 cm x 45 cm and 90 cm x 60 cm.

Nutrients levels:  
Nutrient level 120:60:60 kg NPK/ha recorded higher straw yield (2083.5 kg/ha) over 75% RDF + 5 t FYM kg NPK/ha and it was at par with 100:50:50 and 80:40:40 kg NPK/ha.

Interaction:  
Interaction effect was not found significant.

Biological yield (kg/ha):  
Biological yield obtained from different plant geometry and nutrient levels is presented in Table 4. The average biological yield recorded was 3363 kg/ha.

Plant geometry:  
Plant geometry 90 cm x 60 cm recorded higher biological yield (3569 kg/ha) than plant geometry 180 cm x 30 cm and 120 cm x 45 cm.

Nutrients levels:  
Nutrient level 75 % RDF + 5 t FYM/ha recorded higher biological yield (3427 kg/ha) over 80:40:40, 120:60:60 and 100:50:50 kg NPK/ha.

Interaction:  
Interaction effect was not found significant.

Harvest index (%):  
Harvest index was obtained from different plant geometry
and nutrient levels is presented in Table 4. The average harvest index recorded was 38.59%.

**Plant geometry:**
Harvest index not influenced significantly by plant geometry 90 cm x 60 cm plant geometry recorded maximum harvest index (42.75%) from other plant geometry.

**Nutrients levels:**
Harvest index was not influenced significantly by different nutrient levels. Nutrient level 75% RDF + 5 t FYM/ha recorded higher harvest index (40.77%) than other.

**Interaction:**
Interaction effect was not found significant.

**Effect of plant geometry and nutrient levels on quality parameters of Bt cotton:**

**Ginning percentage:**
The ginning percentage is shown in Table 5. The average ginning percentage was 35.35.

**Plant geometry:**
There was no significant influence of plant geometry on ginning per cent. 120 cm x 45 cm plant geometry recorded maximum ginning per cent (35.74%) than 90 cm x 60 cm and 180 cm x 30 cm.

**Nutrient level:**
There was no significant influence of nutrient levels on ginning per cent. 100:50:50 kg NPK kg/ha recorded higher ginning per cent (35.98%) than other nutrient levels.

**Lint index:**
The data in respect of lint index at various plant geometry and nutrient levels are presented in Table 5.

**Plant geometry:**
Lint index was not influenced significantly by different treatments of plant geometry. 120 cm x 45 cm plant geometry recorded maximum lint index (4.66 g) than other plant geometry.

**Nutrient level:**
Lint index was not influenced significantly by different nutrient levels. 100:50:50 kg NPK/ha recorded higher lint index (4.61 g) than other nutrient levels.

**Interaction:**
Interaction effect was not found significant.

**Test weight:**
The data in respect of test weight at various plant geometry and nutrient levels are presented in Table 5.

**Plant geometry:**
Test weight was not influenced significantly by different plant geometry. 120 cm x 45 cm plant geometry recorded higher test weight (78.33 g) than other plant geometry.

**Nutrient level:**
Nutrient levels 80:40:40 kg NPK/ha recorded maximum test weight (79.66 g) and it was at par with 100:50:50 and

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Ginning (%)</th>
<th>Lint index (g)</th>
<th>Test weight (g)</th>
<th>Earliness index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant Geometry (G)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S&lt;sub&gt;1&lt;/sub&gt; 90 cm x 60 cm</td>
<td>34.67</td>
<td>4.40</td>
<td>78.25</td>
<td>0.41</td>
</tr>
<tr>
<td>S&lt;sub&gt;2&lt;/sub&gt; 120 cm x 45 cm</td>
<td>35.74</td>
<td>4.66</td>
<td>78.33</td>
<td>0.40</td>
</tr>
<tr>
<td>S&lt;sub&gt;3&lt;/sub&gt; 180 cm x 30 cm</td>
<td>35.65</td>
<td>4.37</td>
<td>76.00</td>
<td>0.39</td>
</tr>
<tr>
<td>S.E. ±</td>
<td>0.63</td>
<td>0.10</td>
<td>1.51</td>
<td>0.01</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

| **Nutrient levels (NPK kg/ha)** |
| F<sub>1</sub> 80:40:40 | 35.52 | 4.60 | 79.66 | 0.40 |
| F<sub>2</sub> 100:50:50 | 35.98 | 4.61 | 78.55 | 0.39 |
| F<sub>3</sub> 120:60:60 | 34.56 | 4.51 | 79.00 | 0.39 |
| F<sub>4</sub> 75% RDF + 5 t FYM/ha | 35.35 | 4.18 | 72.88 | 0.41 |
| S.E. ± | 0.72 | 0.15 | 1.30 | 0.01 |
| C.D. (P=0.05) | NS | NS | 3.88 | NS |

| **Interaction (GxF)** |
| S.E. ± | 1.26 | 0.26 | 2.26 | 0.02 |
| C.D. (P=0.05) | NS | NS | NS | NS |
| G.mean | 35.35 | 4.48 | 77.52 | 0.40 |

NS=Non-significant
120:60:60 kg NPK/ha.

**Interaction:**
Interaction effect was not found significant.

**Earliness index:**
The data in respect earliness index at various plant geometry and nutrient levels are presented in Table 5.

**Plant geometry:**
Earliness index was not influenced significantly by different of plant geometry. 90 x 60 cm plant geometry recorded maximum earliness index (0.41) than other plant geometry.

**Nutrient level:**
Earliness index was not influenced significantly by different nutrient level, 75% RDF + 5 t FYM/ha/ha recorded maximum earliness index (0.41) and other nutrient levels.

**Interaction:**
Interaction effect was not found significant.

**Economics of Bt cotton:**

**Gross monitory returns:**
Table 6 indicated that the mean gross monitory returns/ha was affected by different geometry and nutrient levels was 38330 Rs/ha.

**Plant geometry:**
Plant geometry 90 cm x 60 cm recorded significantly higher gross monitory returns than plant geometry 180 cm x 30 cm and 120 cm x 45 cm.

**Nutrient levels:**
Nutrient level 75% RDF + 5 t FYM/ha/ha recorded significantly higher gross monitory returns over 80:40:40 kg NPK/ha and it was at par with 120:60:60 and 100:50:50 kg NPK/ha.

**Interaction:**
Interaction effects due to different treatments under study were not significant in respect of gross monitory returns per hectare.

**Net monitory returns:**
Table 6 indicated that the mean net monitory returns/ha was affected by different geometry and nutrient levels was 22990 Rs/ha.

**Plant geometry:**
Plant geometry 90 cm x 60 cm recorded significantly higher net monitory returns than plant geometry 180 cm x 30 cm and 120 cm x 45 cm.

**Nutrient levels:**
Nutrient level 75% RDF + 5 t FYM/ha/ha recorded significantly higher net monitory returns over 80:40:40 and 100:50:50 kg NPK/ha and it was at par with 120:60:60 kg NPK/ha.

**Interaction:**
Interaction effects due to different treatments under study were not significant in respect of net monitory returns per hectare.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Gross monetary returns (Rs.)</th>
<th>Net monetary returns (Rs.)</th>
<th>Cost of cultivation (Rs./ha)</th>
<th>B-C ratio</th>
</tr>
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<tbody>
<tr>
<td><strong>Plant geometry (G)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₁- 90 cm x 60 cm</td>
<td>45780</td>
<td>29190</td>
<td>16570</td>
<td>2.76</td>
</tr>
<tr>
<td>S₂- 120 cm x 45 cm</td>
<td>34200</td>
<td>19330</td>
<td>15845</td>
<td>2.15</td>
</tr>
<tr>
<td>S₃- 180 cm x 30 cm</td>
<td>35000</td>
<td>20450</td>
<td>15920</td>
<td>2.20</td>
</tr>
<tr>
<td>S.E. ±</td>
<td>980</td>
<td>610</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>2910</td>
<td>1830</td>
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<td><strong>Nutrient levels (NPK kg/ha)</strong></td>
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<tr>
<td>F₁- 80:40:40</td>
<td>36690</td>
<td>21280</td>
<td>14980</td>
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<td>38360</td>
<td>22760</td>
<td>15650</td>
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<td>23490</td>
<td>16187</td>
<td>2.41</td>
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<td>39310</td>
<td>24420</td>
<td>17630</td>
<td>2.23</td>
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<tr>
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<td>510</td>
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<td></td>
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<td><strong>Interaction (GxF)</strong></td>
<td></td>
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<tr>
<td>S.E. ±</td>
<td>840</td>
<td>880</td>
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<tr>
<td>C.D. (P=0.05)</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>G.mean</td>
<td>38330</td>
<td>22990</td>
<td>16110</td>
<td>2.37</td>
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</tbody>
</table>

NS=Non-significant

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**Table 6 : Gross monetary returns (Rs./ha), net monetary returns (Rs./ha) and Benefit cost ratio of cotton in different treatments**
study were not significant in respect of gross monitory returns per hectare.

**Cost of cultivation:**

Table 6 revealed that the mean cost of cultivation of Bt cotton was 16110 Rs/ha.

**Benefit : cost ratio :**

The mean benefit:cost ratio of Bt cotton was 2.37.

**Plant geometry :**

90 cm x 60 cm plant geometry recorded higher B:C ratio than plant geometry 180 cm x 30 cm and 120 cm x 45 cm.

**Nutrient levels :**

80:40:40 and 100:50:50 kg NPK/ha recorded higher B:C ratio than other nutrient levels.

The first growth phase started from emergence upto 30 DAS in which growth in terms of plant height, number of functional leaves, leaf area and dry matter/plant were recorded as 19.62 cm, 11.43, 5.06 dm² and 3.54 g/plant, respectively.

The plant height was more in wider inter row and closer intra row spacing i.e. 180 cm x 30 cm. It might be due to competitions for solar radiation in closer spacing for the process of photosynthesis and thereby plants produced more height in search of light. Bastia (2000), Thokale et al. (2004), Narayana et al. (2007) also observed that plant height was highest in closer intra row spacing.

The plant geometry has marked influence on seed cotton yield per plant. The increase in seed cotton yield per plant was observed in plant geometries 90 cm x 60 cm than 180 cm x 30 cm and 120 cm x 45 cm. This might be due to better aeration, adequate interception of light and lesser competition for available nutrient and moisture, which have resulted in synthesis of higher photosynthates and in turn helped to produce higher seed cotton yield per plant under wider intra row spacing. Similar results were reported by Sankaranarayanan et al. (2004), Buttar and Singh (2007) and Singh et al. (2007).

The seed cotton yield per hectare was significantly influenced by plant geometry. The plant geometry of 90 cm x 60 cm had significantly higher yield compared to 180 cm x 30 cm and 120 cm x 45 cm. The increased yield was due to more number of bolls and higher seed cotton yield per plant in 90 cm x 60 cm than 180 cm x 30 cm and 120 cm x 45 cm spacing. Similar findings were reported earlier by Sankaranarayanan et al. (2004), Buttar and Singh (2006), Buttar and Singh (2007) and Singh et al. (2007).

The quality parameters like ginning per cent, lint index, and earliness index was not influenced significantly by plant geometry. Similar results was reported by Dhillon et al. (2006). The benefit:cost ratio was higher in plant geometry 90 cm x 60 cm than 180 cm x 30 cm and 120 cm x 45 cm. Similar results were reported by Rao and Setty (2008).

The plant geometry 180 cm x 30 cm recorded significantly higher nitrogen, phosphorus and potassium uptake than plant geometry 120 cm x 45 cm and 90 cm x 60 cm. because due to closer intra row spacing having greater nutrient uptake than wider intra row spacing. Similar results were reported by Dhillon et al. (2006).

The plant height of cotton was increased continuously as the age of crop advanced. The application of 120:60:60 kg NPK/ha produced taller plant and recorded maximum height at all the stages of crop growth. It was significantly superior over application of 80:40:40 kg NPK/ha and at par with application of 100:50:50 kg NPK/ha at 60, 120and 150 DAS. This might be due to more availability of nutrients because of higher level of fertilizer dose i.e. 120:60:60 kg NPK/ha which might have increased all the vital physiological processes, which facilitated translocation of photosynthates to growing meristematic tissues. It is well documented fact that application of phosphorus assists in absorption of metabolites, water and its further transformation for the growth of plant in terms of height. Application of K₂O helps in activation of enzymes in meristematic tissue and it plays decisive role in cell wall plasticity resulting in increased growth. Halemani et al. (2004), Thokale et al. (2004) and Ram and Giri (2006) also reported similar results.

The substantial increase in seed cotton yield/ha was associated with the improvement in various growth and yield attributes viz., number of sympodial branches, number of picked boll/plant, yield/plant. The increased seed cotton yield per hectare due to application of balanced levels of fertilizers was also found by Bhoite and Thombre (2006), Kaur et al. (2008), Raut et al. (2006), Charjan (2001), Katkar et al. (2002) and Nehara et al. (2004).

The quality parameter like ginning per cent, lint index, and earliness index was not influenced significantly by different nutrient levels. Similar results was reported by Dhillon et al. (2006). The benefit:cost ratio was higher in nutrient levels equally 80:40:40 and 100:50:50 kg NPK/ha than 120:60:60 kg NPK/ha and 75% RDF + 5 t FYM/ha. Similar results were reported by Kaur et al. (2008).

Nutrient levels 120:60:60 NPK kg/ha recorded significantly higher nutrient uptake than nutrient levels 80:40:40, 100:50:50 kg NPK/ha and 75% RDF + 5 t FYM/ha. Increase in nutrient level increased the nutrient uptake by Bt cotton plant. Similar results were reported by Raja Rajan et al. (2005).

**Conclusion:**

**Response of plant geometry:**

The plant geometry show significant effect on various growth characters i.e. plant height leaf area, number of functional leaves monopodias, sympodias, drymatter, per plant except 30 DAS. Among yield contributing characters
boll weight, number of picked bolls per plant, yield per plant was influenced by plant geometry. The plant geometry of 90 cm x 60 cm recorded significantly higher number of sympodias per plant.

The plant geometry 180 cm x 30 cm was recorded higher plant height, number of functional leaves, leaf area per plant and dry matter per plant than other plant geometry. The number of picked bolls per plant and seed cotton yield per plant were significantly higher in plant geometry of 90 cm x 60 cm over than 180 cm x 30 cm and 120 cm x 45 cm. The seed cotton yield per hectare was also higher in plant geometry of 90 cm x 60 cm than 180 cm x 30 cm and 120 cm x 45 cm.

The plant geometry did not show significant effect on various quality parameters like ginning per cent, lint index, earliness index, and test weight, etc. The plant geometry 90 cm x 60 cm recorded higher benefit: cost ratio than plant geometry 180 cm x 30 cm and 120 cm x 45 cm.

Plant geometry 180 cm x 30 cm recorded significantly higher nitrogen, phosphorus and potassium uptake than plant geometry 120 cm x 45 cm and 90 cm x 60 cm. Plant geometry 90 cm x 60 cm recorded significantly higher availability of nitrogen, phosphorus and potassium in soil at harvest than plant geometry 120 cm x 45 cm and 180 cm x 30 cm.

**Response to nutrient levels:**

The application of nutrient level of 75% RDF + 5 t FYM/ha showed significant effect on growth parameters viz., sympodial branches, and they were significantly superior over application of 120:60:60, 100:50:50 and 80:40:40 kg NPK/ha. Plant height, number of functional leaves per plant, leaf area per plant and dry matter per plant were recorded higher in nutrient level 120:60:60 kg NPK/ha.

The yield attributes like number of picked bolls/plant, boll weight and seed cotton yield per plant were improved significantly due to application of 75% RDF + 5 t FYM/ha over application of 120:60:60, 100:50:50 and 80:40:40 kg NPK/ha. The application of 75% RDF + 5 t FYM/ha recorded significantly higher seed cotton yield per hectare over 120:60:60, 100:50:50 and 80:40:40 kg NPK/ha.

The nutrient level did not show significant effect on various quality parameters like ginning per cent, lint index, and earliness index, etc.

The nutrient level 80:40:40 and 100:50:50 kg NPK/ha recorded equally higher benefit:cost ratio than 120:60:60 kg NPK/ha and 75% RDF + 5 t FYM/ha. Nutrient level 120:60:60 NPK kg/ha recorded significantly higher nutrient uptake than nutrient levels 80:40:40, 100:50:50 kg NPK/ha and 75% RDF + 5 t FYM/ha. Nutrient level 120:60:60 NPK kg/ha and 75% RDF + 5 t FYM/ha recorded significantly higher availability of nitrogen and potassium in soil at harvest than nutrient levels 120:60:60, 100:50:50 and 80:40:40 kg NPK/ha and 120:60:60 kg NPK/ha recorded significantly higher availability of phosphorus in soil at harvest than other nutrient level.

**Interaction:**

The complimentary effects of plant geometry and nutrient levels were non-evident as concerned to growth and yield attributes as well as seed cotton yield.

**REFERENCES**


