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# Growth of *Bt* cotton as influenced by time of fertilizer application and farm yard manure levels under rainfed condition

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**Abstract**
Growth of crop may differ with fertilizer application time and farm yard manure levels practices. Hence a field experiment was conducted at Experimental farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.) during *kharif* 2021-2022 season to study the response of *Bt* cotton to time of fertilizer application and farm yard manure levels under rainfed condition. The experiment was laid out in split plot design with three replications. The present investigation consisted of sixteen treatment combinations. Treatments details consist of time of fertilizer application in main plot and in sub plot four levels of FYM. The treatments were allotted randomly in each replication. Result of study revealed that among different time of fertilizer application ($T_1$) application of basal dose at sowing, splitting of N as per recommendation recorded taller plant height, maximum number of functional leaves plant$^{-1}$, highest number of monopodial branches plant$^{-1}$ and highest number of sympodial branches plant$^{-1}$ which was significantly better than ($T_3$) application of basal dose at 30 DAS, splitting of N as 30% each at 45 DAS and 75 DAS and ($T_4$) application of basal dose at 30 DAS, splitting of N as 30% each at 60 DAS and 75 DAS and found at par to ($T_2$) application basal dose at 15 DAS, splitting of N as per recommendation. Among different levels of FYM application ($M_2$) application of hill placement of 75% FYM at sowing recorded taller plant height, maximum number of functional leaves plant$^{-1}$, highest number of monopodial branches plant$^{-1}$ and highest number of sympodial branches plant$^{-1}$ which was significantly better than ($M_1$) recommended dose of FYM by broadcasting before last harrowing and ($M_4$) control and found at par to ($M_3$) application of hill placement of 50% FYM at sowing.

**Keywords:** Time of fertilizer application, FYM levels, growth

## Introduction
Cotton is one of India's most significant cash crops and source of fiber. It is crucial to the nation's industrial and agricultural economics. Since the beginning of the 21st century, Asian countries have experienced a faster increase in cotton production and processing than the rest of the world. In the inevitable future, too, the tendency is anticipated to continue. Cotton is grown in around 80 different nations, although only six of them; China, India, The United States, Pakistan, Brazil and Uzbekistan contributes to 85% of the world's supply. It is grown on 32.19 M ha worldwide, of which 12.95 M ha, or roughly 40% of the total, are in India (AICRP on Cotton, 2021) [1] during the 2020-21 growing season. India produces 371 lakh bales of cotton lint compared to the 1451 lakh bales produced globally.

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The main states that grow cotton on a substantial scale are Maharashtra, Gujarat, and Telangana (68 per cent of the national area and 64 per cent production). With an area of 39.36 lakh hectares, or almost one third of the country's cotton area in 2021-22, Maharashtra state contributes to the largest area in the nation. Only 71.66 percent (388 kg ha$^{-1}$) of the nation's productivity comes from the state's production, which amounts to 89.86 lakh bales (AICRP on

Cotton, 2022) [2]. The Marathwada region has 12.85 lakh ha of cotton area and produced 19.64 lakh bales in the 2021–22 season with a meagre output of 245 kg ha$^{-1}$.

In general, the organic manures recorded higher gross monetary returns compared with inorganic fertilizers and have positive residual effects on succeeding crop (Blaise *et al*., 2005) [4], which leads to an increase in the soil organic carbon, and reduction of soil erosion (Iqbal, 2017) [5]. Furthermore, they also help in improving the soil productivity, and also at same time protecting the soil environment from nitrate ($NO_3$) pollution and soil degradation (Nyakatawa *et al*., 2001; Ali *et al*., 2017) [6, 3]. The useful effects of combined use of organic manures and inorganic improve crop yield as well as keeping soil health. Looking the economic importance of cotton crop and maintenance of fertility and nutrients status of soil, the importance of organic sources effect on cotton growth and to determine the best timing of fertilizer application on seed cotton yield, the purpose of this research was to assess the appropriate levels of FYM with NPK, to optimize the best time of fertilizer application on cotton growth parameters, seed cotton yield, lint yield, and yield components, and to find the optimal time of fertilizer application and level of FYM.

## Materials and Methods

A field experiment was conducted during *kharif* 2021-22 at at Experimental farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in Marathwada region of Maharashtra state to evaluate the effect of time of fertilizer application and farm yard manure levels on *Bt.* cotton (*Gossypium hirsutum* L.). The field's topography was reasonably level and homogeneous. The soil was medium black cotton belonging to vertisol. The soil was a slightly alkaline reaction, low levels of organic carbon, the soil available nitrogen was low (159.90 kg ha$^{-1}$), available phosphorus was medium (12.10 kg ha$^{-1}$), available potassium was high (449.10 (kg ha$^{-1}$) and soil organic carbon of 0.55%.

The experiment was laid out in split plot design with three replications. The gross and net plots sizes were 38.88 and 21.60 square meters, respectively. Treatment consists of sixteen treatment combinations comprising four time of fertilizer application ($T_1$ - basal dose at sowing, splitting of N as per recommendation, $T_2$ - basal dose at 15 DAS, splitting of N as per recommendation, $T_3$ - basal dose at 30 DAS, splitting of N as 30% each at 45 DAS and 75 DAS and $T_4$ - basal dose at 30 DAS, splitting of N as 30% each at 60 DAS and 75 DAS) as in the main plot and four levels of FYM application ($M_1$ - recommended dose of FYM by broadcasting before last harrowing, $M_2$ - hill placement of 75% FYM at sowing, $M_3$ - hill placement of 50% FYM at sowing and $M_4$ - control (without FYM) as the sub plot treatments.

The *Bt* cotton was sown by dibbling method on 30-06-2021 after receipt of sufficient monsoon rains. During the experimentation year total quantity of 1604.4 mm of rainfall was received. During the experimental period, the mean relative humidity in the morning and evening hours varied from 79 to 96% and 29 to 79% respectively. During the crop growth period, mean maximum and mean minimum temperature range was 30.5 °C and 19.2 °C. Mean wind velocity during the crop growth season ranges between 2.1 km hr$^{-1}$ to 5.8 km hr$^{-1}$, respectively with bright sunshine hours ranging between 2.2 to 9.4 hours day$^{-1}$, respectively. Evaporation ranging from 1.1 to 5.5 mm day$^{-1}$. At various growth stages, observations on plant growth character were recorded.

## Results and Discussion

The mean plant height(cm), number of functional leaves plant$^{-1}$, monopodial branches plant$^{-1}$ and sympodial branches plant$^{-1}$ of *Bt* cotton was influenced significantly due to different time of fertilizer application and levels of farm yard manure are tabulated in table 1, 3, 5 respectively and interaction effects are tabulated in table 2 and 4.

**Table 1:** Plant height (cm) of *Bt* cotton as influenced by different treatments at various crop growth stages during 2021-2022.

| Treatments | Plant height (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | 120 DAS | 150 DAS | At harvest |
| **Main plot: Time of fertilizer application** | | | | | | |
| $T_1$: Basal dose at sowing, splitting of N as per recommendation | 24.13 | 91.30 | 136.30 | 154.35 | 171.01 | 174.53 |
| $T_2$: Basal dose at 15 DAS, splitting of N as per recommendation | 22.91 | 87.20 | 130.02 | 148.04 | 164.70 | 167.08 |
| $T_3$: Basal dose at 30 DAS, splitting of N as 30% each at 45 DAS and 75 DAS | 21.71 | 82.72 | 121.08 | 137.89 | 153.68 | 154.97 |
| $T_4$: Basal dose at 30 DAS, splitting of N as 30% each at 60 DAS and 75 DAS | 21.68 | 81.97 | 119.49 | 136.29 | 152.45 | 154.12 |
| SE± | 0.74 | 1.75 | 2.07 | 2.15 | 2.71 | 3.23 |
| CD at 5% | N.S. | 6.04 | 7.17 | 7.44 | 9.36 | 11.16 |
| **Sub plot: Levels of FYM application** | | | | | | |
| $M_1$: Recommended dose of FYM by broadcasting before last harrowing | 22.46 | 85.08 | 126.13 | 143.42 | 159.72 | 161.81 |
| $M_2$: Hill placement of 75% FYM at sowing | 23.59 | 90.26 | 134.58 | 152.56 | 169.44 | 171.57 |
| $M_3$: Hill placement of 50% FYM at sowing | 23.19 | 88.38 | 132.65 | 150.20 | 166.67 | 169.65 |
| $M_4$: Control (without FYM) | 21.18 | 79.48 | 113.53 | 130.38 | 146.01 | 147.67 |
| SE± | 0.87 | 1.94 | 1.96 | 2.90 | 3.06 | 3.28 |
| CD at 5% | N.S. | 5.66 | 5.73 | 8.46 | 8.94 | 9.57 |
| **Interaction (T x M)** | | | | | | |
| SE± | 1.74 | 3.88 | 3.92 | 5.79 | 6.13 | 6.56 |
| CD at 5% | N.S. | N.S. | 11.45 | N.S. | N.S. | N.S. |
| GM | 22.61 | 85.80 | 126.72 | 144.14 | 160.46 | 162.66 |

**Table 2:** Interaction effect of T X M for plant height (cm) at 90 DAS during 2021-2022.

| Time of fertilizer application | Levels of FYM application | | | |
|---|---|---|---|---|
| | **$M_1$: Recommended dose of FYM by broadcasting before last harrowing** | **$M_2$: Hill placement of 75% FYM at sowing** | **$M_3$: Hill placement of 50% FYM at sowing** | **$M_4$: Control (without FYM)** |
| $T_1$: Basal dose at sowing, splitting of N as per recommendation | 134.93 | 140.97 | 138.64 | 130.67 |
| $T_2$: Basal dose at 15 DAS, splitting of N as per recommendation | 131.45 | 133.57 | 131.82 | 123.23 |
| $T_3$: Basal dose at 30 DAS, splitting of N as 30% each at 45 DAS and 75 DAS | 119.90 | 132.23 | 130.57 | 101.60 |
| $T_4$: Basal dose at 30 DAS, splitting of N as 30% each at 60 DAS and 75 DAS | 118.23 | 131.57 | 129.57 | 98.60 |
| SE± | 3.92 | | | |
| CD at 5% | 11.45 | | | |

**Table 3:** Number of functional leaves plant$^{-1}$ of *Bt* cotton as influenced by different treatments at various crop growth period during 2021-2022.

| Treatments | Number of functional leaves plant$^{-1}$ | | | | |
|---|---|---|---|---|---|
| | **30 DAS** | **60 DAS** | **90 DAS** | **120 DAS** | **150 DAS** |
| **Main plot: Time of fertilizer application** | | | | | |
| $T_1$: Basal dose at sowing, splitting of N as per recommendation | 22.09 | 117.94 | 228.93 | 299.93 | 169.47 |
| $T_2$: Basal dose at 15 DAS, splitting of N as per recommendation | 21.41 | 109.94 | 219.71 | 290.39 | 160.49 |
| $T_3$: Basal dose at 30 DAS, splitting of N as 30% each at 45 DAS and 75 DAS | 19.71 | 98.49 | 206.89 | 274.90 | 151.55 |
| $T_4$: Basal dose at 30 DAS, splitting of N as 30% each at 60 DAS and 75 DAS | 19.63 | 92.25 | 204.07 | 275.07 | 145.43 |
| SE± | 0.75 | 2.63 | 2.86 | 2.83 | 2.92 |
| CD at 5% | N.S. | 9.09 | 9.89 | 9.78 | 10.09 |
| **Sub plot: Levels of FYM application** | | | | | |
| $M_1$: Recommended dose of FYM by broadcasting before last harrowing | 20.37 | 103.31 | 210.88 | 281.88 | 153.50 |
| $M_2$: Hill placement of 75% FYM at sowing | 21.47 | 112.94 | 227.40 | 297.46 | 168.84 |
| $M_3$: Hill placement of 50% FYM at sowing | 21.42 | 111.84 | 221.23 | 292.23 | 162.48 |
| $M_4$: Control (without FYM) | 19.57 | 90.53 | 200.11 | 268.73 | 142.12 |
| SE± | 0.66 | 1.69 | 3.80 | 3.77 | 3.43 |
| CD at 5% | N.S. | 4.93 | 11.08 | 10.99 | 10.02 |
| **Interaction (T x M)** | | | | | |
| SE± | 1.32 | 3.49 | 7.59 | 7.53 | 6.86 |
| CD at 5% | N.S. | 10.19 | N.S. | N.S. | N.S. |
| GM | 20.71 | 104.66 | 214.90 | 285.07 | 156.74 |

**Table 4:** Interaction effect of T X M for functional leaves plant$^{-1}$ at 60 DAS during 2021-2022.

| Time of fertilizer application | Levels of FYM application | | | |
|---|---|---|---|---|
| | **$M_1$: Recommended dose of FYM by broadcasting before last harrowing** | **$M_2$: Hill placement of 75% FYM at sowing** | **$M_3$: Hill placement of 50% FYM at sowing** | **$M_4$: Control (without FYM)** |
| $T_1$: Basal dose at sowing, splitting of N as per recommendation | 115.67 | 128.42 | 126.66 | 101.00 |
| $T_2$: Basal dose at 15 DAS, splitting of N as per recommendation | 111.75 | 114.12 | 113.78 | 100.10 |
| $T_3$: Basal dose at 30 DAS, splitting of N as 30% each at 45 DAS and 75 DAS | 93.56 | 105.54 | 103.56 | 91.30 |
| $T_4$: Basal dose at 30 DAS, splitting of N as 30% each at 60 DAS and 75 DAS | 92.27 | 103.68 | 103.35 | 69.71 |
| SE± | 3.38 | | | |
| CD at 5% | 9.85 | | | |

**Table 5:** Number of monopodial and sympodial branches plant$^{-1}$ of *Bt* cotton as influenced by different treatments at various crop growth period during 2021-2022.

| Treatments | No. of monopodial branches plant$^{-1}$ | | No. of sympodial branches plant$^{-1}$ | | | |
|---|---|---|---|---|---|---|
| | 60 DAS | 90 DAS | 60 DAS | 90 DAS | 120 DAS | 150 DAS |
| **Main plot: Time of fertilizer application** | | | | | | |
| $T_1$: Basal dose at sowing, splitting of N as per recommendation | 2.22 | 2.22 | 10.60 | 16.09 | 19.04 | 20.21 |
| $T_2$: Basal dose at 15 DAS, splitting of N as per recommendation | 2.16 | 2.16 | 10.30 | 14.99 | 17.90 | 18.89 |
| $T_3$: Basal dose at 30 DAS, splitting of N as 30% each at 45 DAS and 75 DAS | 2.07 | 2.07 | 10.15 | 12.31 | 14.65 | 15.82 |
| $T_4$: Basal dose at 30 DAS, splitting of N as 30% each at 60 DAS and 75 DAS | 1.98 | 1.98 | 9.92 | 12.11 | 14.59 | 15.77 |
| SE± | 0.04 | 0.04 | 0.39 | 0.29 | 0.38 | 0.63 |
| CD at 5% | 0.14 | 0.14 | N.S. | 1.00 | 1.32 | 2.20 |
| **Sub plot: Levels of FYM application** | | | | | | |
| $M_1$: Recommended dose of FYM by broadcasting before last harrowing | 2.07 | 2.07 | 10.30 | 13.03 | 15.96 | 17.13 |
| $M_2$: Hill placement of 75% FYM at sowing | 2.20 | 2.20 | 10.53 | 15.93 | 18.88 | 20.06 |
| $M_3$: Hill placement of 50% FYM at sowing | 2.14 | 2.14 | 10.34 | 15.10 | 18.14 | 19.08 |
| $M_4$: Control (without FYM) | 2.02 | 2.02 | 9.80 | 11.44 | 13.20 | 14.42 |
| SE± | 0.04 | 0.04 | 0.37 | 0.59 | 0.58 | 0.65 |
| CD at 5% | 0.12 | 0.12 | N.S. | 1.71 | 1.70 | 1.88 |
| **Interaction (T x M)** | | | | | | |
| SE± | 0.08 | 0.08 | 0.75 | 1.17 | 1.17 | 1.29 |
| CD at 5% | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |
| GM | 2.11 | 2.11 | 10.24 | 13.88 | 16.55 | 17.67 |

**Time of fertilizer application**

The growth characters *viz*. plant height (cm), number of functional leaves plant$^{-1}$, number of monopodial and sympodial branches plant$^{-1}$ were substantially influenced by time of fertilizer application. Significantly taller plants was recorded with application of basal dose at sowing, splitting of N as per recommendation ($T_1$) which was at par with application of basal dose at 15 DAS, splitting of N as per recommendation ($T_2$) and significantly superior over rest of the treatment. This results are similar to Verma *et al*. (2016) [8]. This might be due to availability of nutrients to crop from initial growth period might have resulted in increasing plant height.

Application of basal dose at sowing, splitting of N as per recommendation ($T_1$) recorded maximum increased number of functional leaves plant$^{-1}$ which was at par with application of basal dose at 15 DAS, splitting of N as per recommendation ($T_2$) and significantly superior over rest of the treatment. Higher plant height, a greater number of sympodial and monopodial branches plant$^{-1}$ in application of basal dose at sowing, splitting of N as per recommendation ($T_1$) and application of basal dose at 15 DAS, splitting of N as per recommendation ($T_2$) treatments might be created a chance to produce maximum number of leaves plant$^{-1}$. Macronutrients (NPK) enhances cell division and cell elongation during grand growth period. Phosphorus and potassium play an important role to prevent senescence and nitrogen boost up production of leaf.

Application of basal dose at sowing, splitting of N as per recommendation ($T_1$) recorded maximum increased number of functional leaves, number of monopodial and sympodial branches plant$^{-1}$ which was at par with application of Basal dose at 15 DAS, splitting of N as per recommendation ($T_2$) and significantly superior over rest of the treatment. This results are similar with Verma *et al*. (2016) [8]. This might be due to increased nutrient availability and uptake that improves photosynthesis, leaf growth and transfer of the nutrients to the reproductive parts. Increased and continued vegetative growth of cotton plant may be cause of the highest number of sympodial branches plant$^{-1}$.

**Levels of FYM application**

The growth characters *viz*. plant height (cm), number of functional leaves plant$^{-1}$, number of monopodial and sympodial branches plant$^{-1}$ were substantially influenced by levels of FYM application. Significantly taller plants was recorded with application of hill placement of 75% FYM at sowing ($M_2$) which was at par with application of hill placement of 50% FYM at sowing ($M_3$) and lower plant height recorded with control ($M_4$). This results are similar to Shivamurthy *et al*. (2020) [7]. This might be due to hill placement of FYM might have increased availability of considerable amounts of different essential macronutrients and small amounts of micronutrients. Hence, spot application of FYM might have resulted in increasing plant height.

Application of hill placement of 75% FYM at sowing ($M_2$) recorded maximum number of functional leaves plant$^{-1}$ which was at par with application of hill placement of 50% FYM at sowing ($M_3$) and minimum number of functional leaves plant$^{-1}$ recorded with control ($M_4$). Higher number of monopodial and sympodial branches plant$^{-1}$ and more photosynthetic activity due to availability of nutrients from site specific application of FYM which provides macronutrients as well as micronutrients might be attributed to significant improvement in number of functional leaves per plant

Application of hill placement of 75% FYM at sowing ($M_2$) recorded maximum number of monopodial and sympodial branches plant$^{-1}$ which was at par with application of hill placement of 50% FYM at sowing ($M_3$) and minimum number of monopodial and sympodial branches plant$^{-1}$ recorded with control ($M_4$). This might be due to increased nutrient availability (macronutrient and micronutrient) and uptake that improves photosynthesis, leaf growth and transfer of the nutrients to the reproductive parts. Increased and continued vegetative growth of cotton plant may be cause of the highest number of sympodial branches plant$^{-1}$. Similar kind of results are found with Blaise *et al.* (2005) [4] Shivamurthy *et al*. (2020) [7]

**Interaction effect**

The interaction effect of time of fertilizer application and levels of FYM application found to be significant for plant height were at 90 DAS and for number of functional leaves plant$^{-1}$ were found to be significant at 60 DAS. The interaction effect were found to be non-significant for monopodial branches plant$^{-1}$ and sympodial branches plant$^{-1}$. Treatment combination $T_1M_2$ (Basal dose at sowing, splitting of N as per recommendation with hill placement of 75% FYM at sowing) produced significantly taller plant height at 90 DAS. Treatment combination $T_1M_2$ (Basal dose at sowing, splitting of N as per recommendation with hill placement of 75% FYM at sowing) produced significantly higher number of functional leaves plant$^{-1}$ at 60 DAS.

**Conclusion**

It can be concluded that-

Among the time of fertilizer application ($T_1$) application of basal dose at sowing, splitting of N as per recommendation recorded significantly higher growth characters than other treatment and found at par with application of basal dose at 15 DAS, splitting of N as per recommendation ($T_2$).

Among the levels of FYM application ($M_2$) hill placement of 75% FYM recorded significantly higher growth characters than other levels of FYM and found at par with treatment ($M_3$) hill placement of 50% FYM.

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