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# Assessment of nutrient fortification and spacing on yield and economics of *Bt* cotton under protective irrigation

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**Abstract**
The field experiment was conducted in *Kharif* season of 2017 at Agronomy farm, College of Agriculture, Nagpur to assess the effect of nutrient fortification and spacing on yield and economics of *Bt* cotton under protective irrigation. Four nutrient levels and three spacing's were tested in split plot design with three replication and there were twelve treatment combinations. Study revealed that, higher seed cotton yield kg $ha^{-1}$ was recorded with the treatment combination of 125% RDF fortified with humic acid under spacing of 90 cm x 45 cm ($N_4S_1$). But, it was remain at par with the treatment combination of 100% RDF fortified with humic acid under spacing of 90 cm x 45 cm ($N_1S_1$). Also, gross monetary returns, net monetary returns and B:C ratio were highest with the treatment combination of 125% RDF fortified with humic acid under spacing of 90 cm x 45 cm ($N_4S_1$).

**Keywords:** Cotton, nutrient, spacing, humic, acid, yield, economics

## Introduction
Cotton is the king of fiber crops due to its industrial importance, though it is known as "White Gold". India annually cultivates more than 11 M ha area ranks first in the world. Around 6 to 6.5 million farmers grow the crop in about 10 states of India and 60 million people are estimated to depend on it one way or the other to make out their living. Since, the release of *Bt* cotton technology, it has emerged as an effective alternative to traditional cotton varieties by inhibiting bollworm attack, thereby improving yield and income. This has resulted in fast adoption of *Bt* cotton over conventional cotton. Introduction of *Bt* cotton has played a vital role in enhancing cotton production in India. Response of cotton to applied nutrients is governed by environment and cultural factors. It is therefore necessary to study the interacting influence of fertilizer dose with spacing in cotton. Among the agronomical factors, plant spacing is an important factor which influences the growth, fruiting and yield of cotton. Plant population lower than the optimum level is one of the major reason of low yield of cotton in India. Too high plant stand may cause adverse effect on crop yield through inter-plant competition for nutrients, light and moisture. While low plant population may not take full advantage of applied nutrients and moisture which subsequently reflects in low production. Thus, optimum plant population along with proper nutrient management is the basic factor for obtaining higher crop yield. The information on suitable plant density and fertilization is very useful for exploiting its full potentiality to boost up the yield level under protective irrigation. Keeping in mind the struggle between plants for getting more plant nutrients and moisture, it will be essential to find out the appropriate combination between spacing and fertilizer dose to achieve the maximum yield under protective irrigation. There is a need to standardize the plant spacing and fortified nutrient dose for seed production and higher yield quality seed could be achieved. A research framework was made with the purpose to assess the response of *Bt* cotton to nutrient fortification and spacing under protective irrigation and its effect on yield and economics on cotton.

## Material and Methods
The field experiment was conducted during *Kharif* season of 2017 at Agronomy farm, College of Agriculture, Nagpur. The soil of experimental field was medium black. During *Kharif* 2017,

the monsoon commenced from 3rd June (22MW) and was continued up to third week of September and again persists in 2nd and 4th week of October. Total rainfall *w.e.f.* June 2017 to march 2018 was 951.4 mm. Dibbling of *Bt* cotton variety Ajit-155 *Bt* BG-II was done on 3rd July, 2017. Temperature during *Kharif* ranged between 27.7$^0$C to 33.9$^0$C (Max.) and 9.9$^0$C to 23.9$^0$C (Min.) and was favorable to crop growth and germination. Average humidity was 71% (at morning) and 47% (at evening). In the present investigation four nutrient levels and three spacing's were tested in split plot design with three replications and there were twelve treatment combinations. The treatments were allotted randomly at various plots. Appropriate and timely plant protection measures were undertaken as per need to protect the crop from pests and diseases. Hoeing and hand weeding were undertaken to maintain the crop weed free, to keep the soil loose and porous for good aeration and better establishment of root system, crop growth and development. Observations on yield plot$^{-1}$ was recorded and collected were statistically analyzed with split plot design programme by adopting standard statistical technique of analysis of variance. Wherever, the results were significant, critical differences at P=0.05 level were calculated for comparison of treatment means. Data on interaction effect are presented wherever found significant.

## Results and Discussion

### Seed cotton yield (kg ha$^{-1}$)

#### Fortified nutrient levels

Seed cotton yield kg ha$^{-1}$ was significantly influenced due to different levels of fortified nutrients. Fortified nutrient level, 125% RDF fortified with humic acid ($N_4$) produced highest seed cotton yield (1960 kg ha$^{-1}$) which was significantly superior over rest of the nutrient levels. Further, treatments 100% RDF fortified with humic acid ($N_3$) (1836 kg ha$^{-1}$) and 100% RDF ($N_1$) (1834 kg ha$^{-1}$) were found at par with each other. However, the nutrient level 75% RDF fortified with humic acid ($N_2$) produced significantly lowest seed cotton yield of 1442 kg ha$^{-1}$. Higher seed cotton yield increase with increase in level of fortified nutrient which is the resultant effect due to higher leaf area plant-1, higher number of picked bolls plant-1 resulting in partitioning of more photosynthates towards reproductive part ultimately reflected in higher seed cotton yield. Similar findings were observed by Thokale *et al.* (2004) [18] and Jagtap and Bhale (2011) [7].

#### Spacing

Seed cotton yield was significantly influenced due to different spacing's. Spacing of 90 cm x 45 cm ($S_1$) produced highest seed cotton yield (2133 kg ha$^{-1}$) which was significantly superior over rest of the spacing's. However, spacing of 120 cm x 45 cm ($S_3$) (1590 kg ha$^{-1}$) and 90 cm x 60 cm ($S_2$) (1581 kg ha$^{-1}$) produced at par seed cotton yield. The increase in seed cotton yield in closer plant spacing was due to significantly higher plant population unit$^{-1}$ area as compared to wider spacing. Lower plant population is the major cause for its low seed cotton yield. Similar results were reported by Giri *et al.* (2008) [5], Sisodia and Khamparia (2007) [17], Bhalerao *et al*. (2010) [1], Kaur *et al.* (2010) [9], Devraj *et al.* (2011) [3] and Paslawar *et al.* (2015) [10].

#### Interaction

Interaction effect significantly influenced the seed cotton yield. Highest seed cotton yield was recorded under the treatment combination of 125% RDF fortified with humic acid with the spacing of 90 cm x 45 cm ($N_4S_1$) which was at par with $N_3S_1$ and $N_1S_1$ and found significantly superior over rest of the treatment combinations. Results are in the line with Hiwale *et al.* (2018) [6].

### Gross monetary returns (Rs. ha$^{-1}$)

#### Fortified nutrient levels

Different levels of fortified nutrients significantly influenced gross monetary returns. Highest gross monetary returns was recorded by the nutrient level of 125% RDF fortified with humic acid ($N_4$) (Rs. 80211 ha$^{-1}$) which was significantly superior over nutrient levels 100% RDF fortified with humic acid ($N_3$) (Rs. 75224 ha$^{-1}$), 100% RDF ($N_1$) (Rs. 73445 ha$^{-1}$) and 75% RDF fortified with humic acid ($N_2$) (Rs. 57688 ha$^{-1}$).

#### Spacing

Gross monetary returns significantly influenced due to different spacing's. The spacing of 90 cm x 45 cm ($S_1$) recorded highest gross monetary returns (Rs. 85477 ha$^{-1}$) which was significantly superior over spacing of 120 cm x 45 cm ($S_3$) (Rs. 64766 ha$^{-1}$) and 90 cm x 60 cm ($S_2$) (Rs. 64683 ha$^{-1}$). It was due to higher seed cotton yield under closer plant spacing of 90 cm x 45 cm. Similar results were found by Raut *et al.* (2005) [14], Karle *et al.* (2015) [8] and Pradeepkumar *et al.* (2017) [11].

#### Interaction

Interaction effect of fortified nutrient levels and spacing was found statistically significant in respect of gross monetary returns. The treatment combination of 125% RDF fortified with humic acid with the spacing of 90 cm x 45 cm ($N_4S_1$) recorded significantly highest gross monetary returns which was significantly superior over rest of the treatment combination. However, it was at par with $N_3S_1$ and $N_1S_1$.

### Net monetary returns

#### Fortified nutrient levels

Different levels of fortified nutrient significantly influenced net monetary returns. Highest net monetary return was recorded with the nutrient level of 125% RDF fortified with humic acid ($N_4$) (Rs. 59044 ha$^{-1}$) which was significantly superior over all the other nutrient levels. Similar results were reported by Pinjari *et al.* (2009) [13], Pawar *et al.* (2011) [12], Sankarnarayanan *et al*. (2011) [15], Gadade *et al.* (2015) [4] and Singh *et al.* (2016) [16].

#### Spacing

Net monetary return was significantly influenced due to different spacing. The spacing of 90 cm x 45 cm ($S_1$) was recorded highest net monetary return (Rs. 765352 ha$^{-1}$) which was significantly superior over plant spacing of 120 x 45 cm ($S_3$) and 60 cm x 60 cm ($S_2$).

#### Interaction

Interaction effect of fortified nutrient level and spacing significantly influenced the net monetary return. The treatment combination of 125% RDF fortified with humic acid with the spacing of 90 cm x 45 cm ($N_4S_1$) produced highest net monetary return which was significantly superior over rest of the treatment combinations. But, it was found at par with $N_3S_1$ and $N_1S_1$.

**Benefit cost ratio**

**Fortified nutrient levels**

Fortified nutrient level125% RDF fortified with humic acid ($N_4$) recorded highest benefit cost ratio (3.78) than nutrient level 100% RDF ($N_1$) (3.73), 100% RDF fortified with humic acid ($N_3$) (3.73) and 75% RDF fortified with humic acid ($N_2$) (2.93). Similar results were recorded by Chavan *et al.* (2011) [2].

**Spacing**

It was observed that, the spacing 90 cm x 45 cm ($S_1$) produced highest benefit cost ratio (4.22) than other spacing's. Spacing of 90 cm x 60 cm ($S_2$), and 120 cm x 45 cm ($S_3$) produced similar benefit cost ratio of 3.27. The results are in the line with the result of Chavan *et al.* (2011) [2] who reported higher B:C ratio with the spacing of 60 cm x 60 cm which was highest over 60 cm x 90 cm and 90 cm x 90 cm.

**Table 1:** Yield and economics of *Bt* cotton as influenced by different treatments

| | Treatments | Seed cotton yield kg ha$^{-1}$ | GMR Rs. ha$^{-1}$ | NMR Rs. ha$^{-1}$ | B:C Ratio |
|---|---|---|---|---|---|
| A. | **Nutrient levels (N)** | | | | |
| | $N_1$- 100% RDF 120:60:60 NPK kg ha$^{-1}$ | 1834 | 73445 | 54278 | 3.73 |
| | $N_2$- 75% RDF fortified with humic acid | 1442 | 57688 | 38688 | 2.93 |
| | $N_3$- 100% RDF fortified with humic acid | 1836 | 75224 | 55057 | 3.73 |
| | $N_4$- 125% RDF fortified with humic acid | 1960 | 80211 | 59044 | 3.78 |
| | S.E. (m) ± | 31.94 | 1164 | 1164 | - |
| | CD at 5% | 93.68 | 3416 | 3416 | - |
| B. | **Spacing (S)** | | | | |
| | $S_1$- 90 cm x 45 cm | 2133 | 85477 | 65352 | 4.22 |
| | $S_2$- 90 cm x 60 cm | 1581 | 64683 | 44933 | 3.27 |
| | $S_3$- 120 cm x 45 cm | 1590 | 64766 | 45016 | 3.27 |
| | S.E. (m) ± | 27.66 | 1008 | 1008 | - |
| | CD at 5% | 81.13 | 2958 | 2958 | - |
| C. | **Interaction (NxS)** | | | | |
| | S.E. (m) ± | 55.33 | 2017 | 2017 | - |
| | CD at 5% | 162.26 | 5917 | 5917 | - |

Market rate of cotton is Rs. 4050 q$^{-1}$.

**Table 2:** Seed cotton yield (kg ha$^{-1}$) as influenced by interaction effect

| NxS | Seed cotton yield (kg ha$^{-1}$) | | |
|---|---|---|---|
| | $S_1$ | $S_2$ | $S_3$ |
| $N_1$ | 2266 | 1612 | 1625 |
| $N_2$ | 1662 | 1338 | 1327 |
| $N_3$ | 2277 | 1601 | 1633 |
| $N_4$ | 2330 | 1776 | 1776 |
| S.E. (m) ± | 55 | | |
| CD at 5% | 162 | | |

**Table 3:** Gross monetary return (Rs. ha$^{-1}$) as influenced by interaction effect

| NxS | Seed cotton yield (kg ha$^{-1}$) | | |
|---|---|---|---|
| | $S_1$ | $S_2$ | $S_3$ |
| $N_1$ | 91162 | 64493 | 64680 |
| $N_2$ | 66493 | 53507 | 53067 |
| $N_3$ | 91067 | 67040 | 67567 |
| $N_4$ | 93187 | 73693 | 73753 |
| S.E. (m) ± | 2018 | | |
| CD at 5% | 5918 | | |

**Table 4:** Net monetary return (Rs. ha$^{-1}$) as influenced by interaction effect

| NxS | Seed cotton yield (kg ha$^{-1}$) | | |
|---|---|---|---|
| | $S_1$ | $S_2$ | $S_3$ |
| $N_1$ | 71662 | 45493 | 45680 |
| $N_2$ | 47493 | 34507 | 34067 |
| $N_3$ | 70567 | 47040 | 47567 |
| $N_4$ | 71687 | 52693 | 52753 |
| S.E. (m) ± | 2018 | | |
| CD at 5% | 5918 | | |

**Conclusions**

Seed cotton yield (kg ha$^{-1}$), gross monetary return, net monetary return and benefit cost ratio were recorded highest with the treatment combination of 125% RDF fortified with humic acid under spacing of 90 cm x 45 cm ($N_4S_1$) in *Bt* cotton under protective irrigation.

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