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## Foliar application of nutrients in Bt cotton: A means to enhance growth and yield

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### Abstract

An investigation entitled “Response of *Bt* cotton (*Gossypium hirsutum* L.) to the foliar spray of nutrients” was carried out during *kharif* 2021-22 at the Cotton Research Area of Chaudhary Charan Singh Haryana Agricultural University, Hisar. The experiment was laid out in a Randomized Block Design replicated thrice with eight treatments of foliar application of nutrients viz. T<sub>1</sub>: Control, T<sub>2</sub>: MgSO<sub>4</sub> (0.5%), T<sub>3</sub>: ZnSO<sub>4</sub> (0.5%), T<sub>4</sub>: FeSO<sub>4</sub> (0.5%), T<sub>5</sub>: Borax (0.5%), T<sub>6</sub>: ZnSO<sub>4</sub> (0.5%) + Urea (2%), T<sub>7</sub>: DAP (1%), T<sub>8</sub>: Urea (2%) applied at 60, 75, 90 DAS. The results revealed that days to 50% flowering were significantly less in T<sub>8</sub> which was at par with T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, and T<sub>7</sub>, while T<sub>5</sub> recorded the lowest number of days to 50% boll formation. Plant height at 75, 105, and 135 DAS and harvest was recorded significantly higher in T<sub>2</sub>, which was at par with T<sub>6</sub>. Treatment T<sub>6</sub> being at par with T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub> and T<sub>8</sub> produced significantly more bolls per plant (45) than T<sub>1</sub>, T<sub>4</sub> and T<sub>7</sub>. The highest seed cotton yield was recorded in T<sub>6</sub> which was at par with T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>7</sub> and T<sub>8</sub>. Boll weight (g) of *Bt* cotton was highest in T<sub>2</sub> which differed significantly from other treatments except T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub>.

**Keywords:** *Bt* cotton, borax, DAP, foliar spray, MgSO<sub>4</sub>, urea, ZnSO<sub>4</sub>

### Introduction

Cotton (*Gossypium hirsutum* L.) is an indeterminate, perennial plant which is also known as ‘King of fibers’ due to its commercial and industrial importance. Cotton is also the source of edible oil and animal feed. Lint is the most important economical product, provides a source of quality fiber for textile industry. Cotton is a heavy feeder crop and removes large quantities of nutrients from the soil. Among the various factors of cotton production method of sowing and fertilizer application plays a significant role. Secondary (Ca, Mg, S) and micronutrients especially Zn, B are essential for higher productivity of cotton. Besides increasing nutrient use efficiency, Magnesium is essential for the production of the green pigment in chlorophyll, which is the driving force of photosynthesis and also essential for the metabolism of carbohydrates (sugars). Micronutrient deficiencies not only hamper crop productivity but also deteriorate produce quality. Boron plays an essential role in the growth and development of new cells in the growing meristem and also required for protein synthesis where nitrogen and carbohydrates are converted into protein. Furthermore, zinc is an element directly affecting the yield and quality of crop because of its role in activity of biological membrane stability, auxin synthesis and enzyme activation ability.

Full potential of cotton can be exploited by applying fertilizer with appropriate method along with suitable sowing method. Soil application of Zn, B, Fe, Mn, and Cu on calcareous soils is less efficient, as these nutrients remain inaccessible to plant roots due to the higher soil pH (Rashid and Ryan 2004) [9]. However, an alternative approach under such circumstances is foliar application of nutrients (Rab and Haq, 2012) [6] as it eliminates the effects of soil pH on the availability of these nutrients (Ali, 2012) and it is more effective and less costly (Ali *et al.* 2007) [2]. External supplementation of nutrients needs to be therefore emphasized keeping in view their role in improving crop yield. Quantum of micronutrient deficiencies of Zn (49%), B (37%), Fe (12%), Mn (4%) and Cu (30%) reported in Indian soils demand urgent attention (Singh, 2009) [12]. Foliar application also improved the nutrient status of leaves compared to soil applied fertilizers alone.

This improvement in nutrient status resulted in an increase in the number of flowers, number of bolls, and ultimately seed-cotton yield. Keeping the point in view, the present investigation has been planned with the objective to study the effect of foliar application of nutrients on growth, yield and quality of *Bt* cotton.

### Materials and Methods

A Field experiment was conducted during conducted at Cotton Research Area of Chaudhary Charan Singh Haryana Agricultural University, Hisar, during the year 2021. Hisar is situated in the sub-tropics at longitude 75°46'E, latitude 29°10'N and altitude of 215.2 m above mean sea level in Haryana state of India. The total rainfall received during the *Kharif* crop growing period was 770.6 mm. Weekly maximum and minimum temperature remained under a suitable range for different crop growth stages, mean weekly maximum and minimum temperature ranged between 28.9-41.4°C and 11.8-28.1°C, during *Kharif* 2021. The experiment was laid out in Randomized Block Design replicated thrice with eight treatments of foliar application of nutrients viz. T<sub>1</sub>: Control, T<sub>2</sub>:MgSO<sub>4</sub> (0.5%), T<sub>3</sub>:ZnSO<sub>4</sub> (0.5%), T<sub>4</sub>:FeSO<sub>4</sub> (0.5%), T<sub>5</sub>: Borax (0.5%), T<sub>6</sub>:ZnSO<sub>4</sub> (0.5%) +Urea (2%), T<sub>7</sub>: DAP (1%), T<sub>8</sub>: Urea (2%) applied at 60, 75, 90 DAS. Pre sowing irrigation was done with canal water 5-6 days before on 21<sup>st</sup> April 2021 and sowing of cotton was done by dibbling method on 27<sup>th</sup> April 2021. Gap filling was done five days after crop emergence. Two post sown irrigations were applied on 3<sup>rd</sup> June and 19<sup>th</sup> August 2021. Two hand pickings were performed on 8<sup>th</sup> October and 3<sup>rd</sup> November 2021. Weeds were removed by hand pulling from time to time in all the plots throughout the crop season. Full dose of P and half

dose of N as per treatments were applied to the field before sowing and rest of N was top dressed after first irrigation. Five representative plants from each plot were selected randomly and tagged for recording the effect of different treatments on yield attributes. All yield attributes were recorded periodically on these randomly selected and tagged plants.

### Results and Discussion

#### Phenological Studies

In attaining different phenological stages of *Bt* cotton, various foliar spray of nutrients have marked effects (Table 1). Number of days to 50% square formation of cotton ranged from 55.49 to 57.71 and various foliar sprays of nutrients fails to significantly influenced days to 50% flowering. But days taken to 50% flowering and days to 50% boll formation of *Bt* cotton were significantly influenced due to various foliar spray of nutrients. Days to 50% flowering were significantly less in treatment T<sub>8</sub> in which Urea (2%) as foliar spray at 60, 75 and 90 DAS was applied which was at par with treatment T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub>. Days taken to 50 percent flowering of cotton were late by 3.5 days in control treatment over T<sub>8</sub>. Among various foliar spray of nutrient treatment T<sub>5</sub> being at par with treatment T<sub>3</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub> recorded lowest number of days to 50% boll formation which was significantly lower than treatment T<sub>1</sub>, T<sub>2</sub> and T<sub>4</sub>. This might be due to the fact that Boron and Magnesium are the essential elements required for the growth and development of crop plant having specific role in cell division and cell metabolism. Venugopalan and Tarhalkar (1998) [14] also observed that short-duration rainfed cotton may suffer from N deficiency during peak flowering, which could be remedied by a foliar spray of 2 percent Urea 75 days after sowing.

**Table 1:** Phenological observation (DAS) of *Bt* cotton as influenced by various foliar spray of nutrients

| Treatment                                                                                 | Days to 50% square formation | Days to 50% flowering | Days to 50% boll formation |
|-------------------------------------------------------------------------------------------|------------------------------|-----------------------|----------------------------|
| T <sub>1</sub> : Control                                                                  | 56.47                        | 80.16                 | 121                        |
| T <sub>2</sub> :MgSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS             | 57.23                        | 78.77                 | 117                        |
| T <sub>3</sub> : ZnSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS            | 56.08                        | 76.73                 | 115                        |
| T <sub>4</sub> : FeSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS            | 57.71                        | 78.98                 | 118                        |
| T <sub>5</sub> : Borax (0.5%) as foliar spray at 60, 75 and 90 DAS                        | 57.53                        | 76.53                 | 114                        |
| T <sub>6</sub> : ZnSO <sub>4</sub> (0.5%) +Urea (2%) as foliar spray at 60, 75 and 90 DAS | 55.49                        | 77.11                 | 116                        |
| T <sub>7</sub> : DAP (1%) as foliar spray at 60, 75 and 90 DAS                            | 57.14                        | 78.43                 | 116                        |
| T <sub>8</sub> : Urea (2%) as foliar spray at 60, 75 and 90 DAS                           | 56.45                        | 76.27                 | 115                        |
| S.E(m) ±                                                                                  | 1.33                         | 0.64                  | 0.70                       |
| CD at 5%                                                                                  | N.S.                         | 1.86                  | 2.15                       |

### Growth studies

The perusal of data in Table 2 revealed that the final plant population of *Bt* cotton was not influenced significantly due to various foliar sprays of nutrients. The number of

monopods/plant of *Bt* cotton also did not differ significantly due to different foliar spray of nutrients although maximum number of monopods/plant (2.58) was attained in treatment T<sub>2</sub> and lowest in control.

**Table 2:** Final plant population and number of monopods and sympods per plant of *Bt* cotton as influenced by various foliar spray of nutrients

| Treatment                                                                                 | Final plant population | Number of monopods/plant | Number of sympods/plant |
|-------------------------------------------------------------------------------------------|------------------------|--------------------------|-------------------------|
| T <sub>1</sub> : Control                                                                  | 16582                  | 2.23                     | 26                      |
| T <sub>2</sub> :MgSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS             | 16783                  | 2.58                     | 32                      |
| T <sub>3</sub> : ZnSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS            | 17460                  | 2.41                     | 30                      |
| T <sub>4</sub> : FeSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS            | 17588                  | 2.33                     | 29                      |
| T <sub>5</sub> : Borax (0.5%) as foliar spray at 60, 75 and 90 DAS                        | 15551                  | 2.52                     | 36                      |
| T <sub>6</sub> : ZnSO <sub>4</sub> (0.5%) +Urea (2%) as foliar spray at 60, 75 and 90 DAS | 16773                  | 2.26                     | 33                      |
| T <sub>7</sub> : DAP (1%) as foliar spray at 60, 75 and 90 DAS                            | 16736                  | 2.37                     | 33                      |
| T <sub>8</sub> : Urea (2%) as foliar spray at 60, 75 and 90 DAS                           | 15978                  | 2.31                     | 30                      |
| S.E(m) ±                                                                                  | 2169                   | 0.23                     | 1.62                    |
| CD at 5%                                                                                  | N.S.                   | N.S.                     | 5.19                    |

Singh *et al.* (2015) <sup>[11]</sup> while studying the effect of foliar application of nutrients (N, Mg, Fe, Zn, Mn and B) on *Bt* cotton also observed non-significant effects of foliar application of nutrients on monopods per plant.

Among various foliar spray of nutrients number of sympods /plant was highest in treatment T<sub>5</sub> which was at par with T<sub>6</sub> and T<sub>7</sub> but significantly higher than other treatments. Increasing the amount of micronutrients in leaves may have improved the synthesis of synthetic metabolites that help to produce more fruiting branches. Similar trend was found for sympodial branches (22.2) by Eleyan *et al.* (2014) <sup>[3]</sup>. Similar result has been reported by Ramulu *et al.* (2020) who reported higher

sympodial branches of cotton with foliar applications of ZnSO<sub>4</sub> @ 0.2 percent at 30 days, ZnSO<sub>4</sub> + Borax @ 0.2 percent each at 45 days, Borax @ 0.2 percent + MgSO<sub>4</sub> @ 1 percent at 60 days, and MgSO<sub>4</sub> @ 1 percent at 75 days after sowing along with soil application of recommended dose of fertilizers.

Tallest plant at 105 and 135 DAS were recorded in treatment T<sub>6</sub> followed by T<sub>5</sub>. Tallest plant at harvest was recorded with T<sub>6</sub> followed by T<sub>7</sub> (Table 3). This may be due to significant elongation of the intermodal distance in each main stem which caused the plant to grow taller. This result agrees with those obtained by Eleyan *et al.* (2014) <sup>[3]</sup>, More *et al.* (2018) <sup>[5]</sup> and Raj and Chandrasekar (2019) <sup>[7]</sup>.

**Table 3:** Plant height of *Bt* cotton at different crop growth stages as influenced by various foliar spray of nutrients

| Treatment                                                                                 | Plant height (cm) |        |         |         |            |
|-------------------------------------------------------------------------------------------|-------------------|--------|---------|---------|------------|
|                                                                                           | 45 DAS            | 75 DAS | 105 DAS | 135 DAS | At harvest |
| T <sub>1</sub> : Control                                                                  | 33                | 90     | 148     | 164     | 174        |
| T <sub>2</sub> :MgSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS             | 32                | 101    | 164     | 182     | 192        |
| T <sub>3</sub> : ZnSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS            | 34                | 94     | 160     | 176     | 188        |
| T <sub>4</sub> : FeSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS            | 32                | 93     | 157     | 168     | 177        |
| T <sub>5</sub> : Borax (0.5%) as foliar spray at 60, 75 and 90 DAS                        | 34                | 99     | 162     | 176     | 187        |
| T <sub>6</sub> : ZnSO <sub>4</sub> (0.5%) +Urea (2%) as foliar spray at 60, 75 and 90 DAS | 33                | 100    | 163     | 177     | 189        |
| T <sub>7</sub> : DAP (1%) as foliar spray at 60, 75 and 90 DAS                            | 35                | 97     | 162     | 174     | 187        |
| T <sub>8</sub> : Urea (2%) as foliar spray at 60, 75 and 90 DAS                           | 34                | 96     | 159     | 174     | 185        |
| S.E(m) ±                                                                                  | 0.42              | 2.5    | 3.2     | 3.8     | 4.2        |
| CD at 5%                                                                                  | N.S.              | 7.6    | 9.7     | 11.9    | 12.8       |

### Yield attributes and yield

The perusal of data in Table 4 revealed that application of ZnSO<sub>4</sub> (0.5%) +Urea ((T<sub>6</sub>) being at par with T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub> and T<sub>8</sub> produced significantly more number of bolls per plant (45) than T<sub>1</sub>, T<sub>4</sub> and T<sub>7</sub>. The number of bolls per plant recorded in treatment T<sub>1</sub>, T<sub>4</sub> and T<sub>7</sub> were at par with each other. Foliar spray of ZnSO<sub>4</sub> (0.5%) +Urea (2%) recorded 12.50 and 18.42% higher number of bolls per plant than control and foliar spray of DAP (1%). Higher number of bolls per plant of *Bt* cotton due to additional nutrition through foliar feeding might be due to fact that foliar spray of nutrients provides a method of delivering fundamental nutrients at key growth stages when the plants are at peak nutrient requirements and could not be made available through soil application. Micronutrients have a favourable relationship with the quantity of cotton bolls produced per plant, according to Eleyan *et al.* (2014) <sup>[3]</sup> and Iqbal *et al.* (2022) <sup>[4]</sup>. Among various foliar spray of nutrients boll weight (g) of *Bt* cotton was highest in treatment T<sub>2</sub> which differ significantly over other treatments except T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub>. Our findings coincide with results of Singh *et al.* (2015) <sup>[11]</sup> who reported increase in boll weight by foliar application of MgSO<sub>4</sub> + Zn SO<sub>4</sub>. The perusal of data in Table 4 revealed that highest seed cotton yield was recorded in

treatment T<sub>6</sub> which was significantly superior to T<sub>4</sub> and T<sub>1</sub> (Control) but at par with rest all treatments (T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>7</sub> and T<sub>8</sub>). Treatment T<sub>6</sub> (ZnSO<sub>4</sub> (0.5%) +Urea (2%) as foliar spray) recorded 25.91% higher seed cotton yield than control treatment which might be due better yield attributes in these treatments. Higher yield of cotton might be due to the fact that Zinc has important functions in carbohydrate and protein metabolism which directly affecting the yield and quality of crop because of its role in activity of biological membrane stability, auxin synthesis and enzyme activation ability. This increase in seed cotton yield might be due to increase in yield contributing parameters such as number of bolls and boll weight (Table 4.5). These results confirm the findings of Yaseen *et al.* (2013) <sup>[15]</sup>; Ali *et al.* (2007) <sup>[2]</sup>; Eleyan *et al.* (2014) <sup>[3]</sup>; Shivamurthy and Biradar (2014) <sup>[10]</sup> and Iqbal *et al.* (2022) <sup>[4]</sup> who found a significant increase in yield of cotton by foliar use of micronutrients in cotton. Highest seed index (8.98 g) was recorded in treatment T<sub>7</sub> (DAP (1%) as foliar spray) which was 13.09% higher than control treatment. These results are in conformity with the finding of Swetha *et al.* (2020) <sup>[13]</sup> and Iqbal *et al.* (2022) <sup>[4]</sup>.

**Table 4:** Yield attributes and yields of *Bt* cotton as influenced by various foliar spray of nutrients

| Treatment                                                                                 | No. of bolls per plant | Boll weight (g) | Seed cotton yield (kg/ha) | Seed index (g) |
|-------------------------------------------------------------------------------------------|------------------------|-----------------|---------------------------|----------------|
| T <sub>1</sub> : Control                                                                  | 40                     | 4.13            | 1648                      | 7.94           |
| T <sub>2</sub> :MgSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS             | 42                     | 4.93            | 2073                      | 8.12           |
| T <sub>3</sub> : ZnSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS            | 43                     | 4.16            | 1901                      | 8.10           |
| T <sub>4</sub> : FeSO <sub>4</sub> (0.5%) as foliar spray at 60, 75 and 90 DAS            | 38                     | 4.22            | 1710                      | 8.35           |
| T <sub>5</sub> : Borax (0.5%) as foliar spray at 60, 75 and 90 DAS                        | 44                     | 4.80            | 2072                      | 8.51           |
| T <sub>6</sub> : ZnSO <sub>4</sub> (0.5%) +Urea (2%) as foliar spray at 60, 75 and 90 DAS | 45                     | 4.75            | 2075                      | 8.73           |
| T <sub>7</sub> : DAP (1%) as foliar spray at 60, 75 and 90 DAS                            | 38                     | 4.58            | 1942                      | 8.98           |
| T <sub>8</sub> : Urea (2%) as foliar spray at 60, 75 and 90 DAS                           | 42                     | 4.81            | 1954                      | 8.74           |
| S.E(m) ±                                                                                  | 1.45                   | 0.21            | 71                        | 0.23           |
| CD at 5%                                                                                  | 4.38                   | 0.64            | 218                       | 0.71           |

## Conclusion

It may be concluded that in *Bt* cotton, foliar spray of ZnSO<sub>4</sub> (0.5%) + Urea (2%) being at par with foliar spray of 1% DAP, 0.5% MgSO<sub>4</sub>, 0.5% Borax and 0.5% ZnSO<sub>4</sub> gave 25.91% higher seed cotton yield and 11.78% higher ginning out turn (%) than control and hence foliar spray of these nutrients in cotton can be considered as a beneficial practice for enhanced cotton production and monetary returns.

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