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Micronutrient Seed Treatments Impact on the quality and Productivity of *Bt* Cotton in Vertisol

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ABSTRACT: The current study, titled "Studies on effect of seed treatments on growth, yield and quality and soil nutrient dynamics of *Bt* cotton in vertisol," was conducted in 2017-2018 at the Vasantrao Naik Marathwada Krishi Vidyapeeth in Parbhani at the Department of Soil Science and Agricultural Chemistry. The purpose of this research is to examine how nutritional seed treatments affect the development and output of Bt cotton. In the region, shortages in N, P, K, Zn, Cu, Mn, and Fe are present to varying degrees (100.00%, 89.00%, 86.00%, 15.00%, 12.00%, 23.00% and 42.00%, respectively). Due to their abundance among the nutrients, macronutrients may be administered to soil with ease. Cotton producers are hesitant to administer the micronutrients *via* the soil, though, because of the low application rate and high expense. Furthermore, it is difficult to evenly distribute the little amount of fertilizer on the soil's surface. Growing numbers of experts believe that seed priming is a superior method for improving cotton yields, achieving high seedling vigour, and promoting speedy and uniform emergence. To investigate the impact of nutrient seed treatments on nutrient absorption, *Bt* cotton quality, and soil nutrient dynamics in vertisol, a field experiment with nine treatments and three replications was conducted. The nutrient seed dressing treatments are T_1 – absolute control, T_2 - 100% NPK + Zinc Sulphate ($ZnSO_4$), T_3 - 100 % N P K + Zn EDTA, T_4 - 100% NPK + Borax (B), T_5 -100% NPK + Manganese Sulphate ($MnSO_4$), T_6 - 100% NPK + Sodium Molybdate (NaMo), T_7 - 100% NPK + Copper Nitrate ($CuNO_3$), T_8 - 100 % NPK + Ferrous Sulphate ($FeSO_4$), T_9 - 100% NPK + Fe EDTA seed application to Bt cotton. The nutrient seed dressing treatment T_3 - 100 % NPK + Zn EDTA seed application to *Bt* cotton found to be effective in improving yield attributing characters like, final plant stand percentages, number of bolls, seed cotton yield, dry matter yield and total biological yield. The highest quality attributing characters like, lint yield, Lint index, ginning percentages and test weight was recorded in the treatment T_3 - 100% NPK + Zn EDTA. The fiber quality parameters like upper half mean length, uniformity index, strength, elongity and micronaire value were highest in the treatments T_6, T_7, T_3, T_9 and T_5 respectively.

Keywords: Seed treatments, NPK, Micronutrients, yield attributes, quality parameters.

INTRODUCTION

Cotton (*Gossypium* spp. L) is one of the most important commercial cash crops and an important fiber crop of global significance, cultivated in more than seventy countries. It is an important raw material for the economy in terms of both employment generation and foreign exchange, and hence it is known as "white gold" or "friendly fiber" or "the king of fiber." The cotton plant belongs to the genus *Gossypium* of the family *Malvaceae.* Cotton is one of the principal crops in India. Cotton is grown in tropical and subtropical countries, including the United States of America, China, India, Pakistan, Uzbekistan, Turkey, Brazil, Greece, Argentina, Australia, and Egypt. These countries contribute about 85 percent of the global production; this indicates the importance of this crop. Maharashtra ranks first with an average 37.50 lakh ha^{-1} yielding 68.38 lakh bales, next to Gujarat with a productivity of 88.55 kg yield per hectare, which is lower as compared to the national average because of its major area (85-90%) being rainfed. In cotton, flowering is a continuous process. However, not all the flowers produced are retained and harvested. About 40 to 50 percent of the flowers and bolls are shed due to boll worm attack or due to nutritional stress in general and micronutrients in particular. Hence, there is a need to supplement the plant with proper micronutrients to produce more flowers and retain them on the plant to develop into bolls for final harvesting, so that yield can be increased considerably (Gourkhede *et al.*, 2015).

The role of micronutrients in various physiological and biochemical processes in plants is well known, which enables a rapid change in the physiology of plants within one season to achieve desirable results. The essential mineral elements, which are required in higher concentrations by the plant, have a major role in determining the growth and development of cotton, which often produces more vegetative growth than needed for maximum boll production and yield, especially when climatic conditions favour vegetative growth, by directing the nutrients and photo assimilates towards vegetative growth rather than reproductive growth (Radhika *et al.*, 2013). Essential micronutrients like zinc, iron, manganese, copper, boron, and magnesium play an important role in the physiology of cotton crops, and these are part of the enzyme system or act as catalysts in enzymatic reactions. Among the various seed treatments, seed priming is an innovative method. In seed priming, seeds are partially hydrated to allow metabolic events to occur without actual germination and then re-dried (near their original weight) (Bradford, 1986). Such seeds germinate faster than non-primed seeds (Farooq *et al*., 2006). In micronutrient seed priming (nutripriming), micronutrients are used as osmotica (Imran *et al*., 2004; Singh, 2007). Primed seeds usually have better and more synchronized germination (Farooq *et al*., 2009) owing simply to less imbibitions time (Taylor *et al*., 1998; McDonald, 2000; Brocklehurst and Dearman 2008) and the buildup of germination-enhancing metabolites (Basra *et al*., 2005; Farooq *et al*., 2006).

Marathwada soils supporting cotton cultivation are suffering from macronutrient and micronutrient deficiencies. Patil (2013) reported that N, P, K, Zn, Cu, Mn, and Fe deficiencies prevail in the region to the extent of 100.00%, 89.0%, 86.0%, 15.0%, 12.00%, and 42.00%, respectively (Patil, 2013). Among the nutrients, macronutrients can be applied to soil with ease owing to their large quantity. However, because of the low application quantity and high cost, cotton growers are reluctant to apply the micronutrients through the soil. Further, it is not easy to spread the small quantity of fertilizer evenly on the soil surface. Seed priming is increasingly considered a better approach to enhancing rapid and uniform emergence and to achieving high seedling vigour and better yields in vegetables, floriculture, and some field crops (Dearman *et al*., 1987; Parera and Cantliffe 1994; Bruggink *et al*., 1999). It is observed that under the jurisdiction of four SAUs in Maharashtra, the research on this aspect is very limited, scanty, and scattered. Therefore, keeping all the points in view, the present study was undertaken, whose objective was to study the effect of nutrient seed treatments on the growth and yield of *Bt* cotton.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* 2017, with *Bt* cotton (*Gossypium hirsutum*) used as a test crop, on the farm of the department of soil science and agricultural chemistry at the College of Agriculture, VNMKV, Parbhani. The initial soil pH was 8.12, EC- 0.10 dSm^{-1}, organic carbon was 6.70 g/kg, calcium carbonate was 48 g/kg, available nitrogen was 112 kg/ha, phosphorus was 13.46 kg/ha, and potassium was 575 kg/ha. The initial micronutrient status was DTPA copper (4.37 mg/kg), mangnease (12.04 mg/kg), zinc (0.57 mg/kg), and ferrous (2.62 mg/kg). The soil was clayey in texture, moderately alkaline in reaction, medium in available nitrogen and phosphorus, sufficient in available potassium, and low in sulphur and iron. The field experiment was conducted on *Bt* cotton (*Gossypium hirsutum*) during the 2017-18 kharif season. After completion of preparatory tillage operations, the experiment was laid out in a randomised block design comprising nine treatments and replicated three times.

Treatments details. Nine treatments were formulated to evaluate the studies on the effects of seed treatments on growth, yield and quality and soil nutrient dynamics of *Bt* cotton in vertisol. The details of the treatment are as follows:

T_1 : Ac	Absolute control 100% NPK	
T_2 : RZn	100% NPK + Zinc Sulphate ($ZnSO_4$)	3 g / kg seed
T_3 : RZnE	100% NPK + Zn EDTA	3 g / kg seed
T_4 : RB	100% NPK+ Borax (B)	3 g / kg seed
T_5 : RMn	100% NPK + Manganese Sulphate ($MnSO_4$)	3 g / kg seed
T_6 : RMo	100% NPK + Sodium Molybdate (NaMo)	4 g / kg seed
T_7 : RCu	100% NPK + Cupper Nitrate ($CuNO_3$)	3 g / kg seed
T_8 : RFe	100% NPK + Ferrous Sulphate ($FeSO_4$)	3 g / kg seed
T_9 : RFeE	100% NPK + Fe EDTA	3 g / kg seed

Treatment evaluation/Details of observations recorded

Yield attributes

Number of bolls per plant. Bolls were picked from five observational plants at each picking and were counted. The total number of bolls picked from five observational plants after all picking was divided by five for calculating. The number of bolls picked per plant.

Seed cotton yield. At each picking, the bolls from each net plot were weighted and recorded.

Dry matter yield. The observational plant was dried in a hot air oven, and after complete drying, its weight was taken.

Total biological yield. It is the sum total of seed cotton yield and dry matter yield.

Final plant stand. The final plant stand was counted at the time of picking.

Quality parameter.

Test weight. The weights of 100 seeds are taken for the test weight.

Ginning percentage. The seed cotton obtained from all the pickings in each net plot was mixed thoroughly, and a 250-gram sample was drawn. This seed cotton was ginned by hand, and the ginning percentage was calculated.

$$\text{Ginning percentage} = \frac{\text{Weight of lint}}{\text{Weight of seed cotton}} \times 100$$

Lint yield. It is the weight of lint from seed cotton yield.

Fiber quality. The cotton samples were sent to the Cotton Research Station in Nanded for evaluation of fiber length and strength.

Statistical analysis. The results obtained were statistically analyzed and appropriately interpreted as per the method described in "Statistical Methods for Agricultural Workers" by Panse and Sukhatme (1985). Appropriate standard errors (S.E.) and critical differences (C.D.) at the 5% level were worked out for treatment comparison.

RESULTS AND DISCUSSION

Effect of micronutrient seed dressing treatment on yield attributes

Final plant stand. The final plant stand is one of the important parameters of *Bt* cotton. Seed treatment with micronutrients has the potential to meet crop micronutrient requirements and improve seedling stand establishment. Table 1 shows the average number of final plants standing at the time of BT cotton harvesting. The highest final plant stand was recorded in treatment T_3 *i.e.*, 100% NPK + 3 g Zn EDTA seed application, at 94.38%, which was significantly superior to absolute control and the rest of the treatments except T_2, T_6, T_8 and T_9. The increase in final plant stand with nutrient seed dressing with micronutrients observed in the present study was in accordance with the findings reported by Farooq *et al.* (2012).

Number of bolls. Bolls number is a major factor in seed cotton yield. The number of bolls per plants is an important yield parameter, as it gives a rough estimate of the probable yield. Table 2 shows the data on the number of bolls plant^{-1} as influenced by different nutrient seed dressing treatments with micronutrients during the experimentation year. The number of bolls at 90 days after sowing was highest in treatment T_3, *i.e.*, 100% NPK + 3 g Zn EDTA seed application, *i.e.*, 10.80, which was significantly superior to the absolute control and the remaining treatments except T_2, T_6, T_8, and T_9. At 120 days after sowing, plant^{-1} produced the most bolls in treatment T_3, *i.e.*, 100% NPK + 3 g Zn EDTA seed application, *i.e.*, 18.20, which was significantly higher than the absolute control and all other treatments except T_2, T_8 and T_9. Cotton being an intermediate crop with a long growing season, fertilizer application at later stages may have aided in inducing a higher number of bolls per plant. These results are in agreement with Durgude *et al.* (2014).

Seed cotton yield. Effect of various seed treatments on seed cotton yield presented in Table 3, showed that application of 3 g Zn EDTA to seed with recommended dose of N, P and K found to be significantly superior over absolute control and other seed dressing treatments, except T_2 and T_9 which was at par with T_3, by producing 3.68 q ha^{-1} seed cotton. The second-best treatment in seed cotton production was found to be T_9 *i.e.*, 100 % NPK + Fe EDTA. This shows that the application of 3 g Fe EDTA as a seed dresser was found to be beneficial, but it could not reach the level of significance. In general, it is noticed that seed priming of micronutrients either by Zn, B, Mn, Mo, Cu and Fe through simple salt or EDTA salt is equally effective in seed cotton production. This might be due to the deficiency or low availability of these micronutrients in growth media. Patil (2013) reported that the Marathwada soils were found to be deficient in the above-mentioned micronutrients. Therefore, the supply of these nutrients through seed dressing might have influenced yield attributes, which in turn reflected an increased seed cotton yield. Similar results were also reported by Sathiyamurthi and Dhansekaran (2014).

Dry matter yield. The data presented on the dry matter yield of cotton in Table 3 revealed that seed dressing of Zn EDTA at 3 g/kg with the recommended dose of fertilizer (T_3) produced maximum dry matter yield (30.96 q/ha) and was found significantly superior over the rest of the treatments, except for treatment T_9 *i.e.*, seed dressing of Fe EDTA at 3 g/kg with the RDF (28.26 q/ha). The rest of the treatment showed a numerical increase to the tune of 6.69 to 11.85 % over absolute control. The lowest seed cotton yield was recorded in treatment T_1 *i.e.*, absolute control. The increase in dry matter yield due to the application of various micronutrient seed dressings can be attributed to the supply of these nutrients right from germination.

The results are in line with Sathiyamurthi and Dhansekaran (2014).

Total biological yield. The effect of various seed treatments on total biological yield is presented in Table 3. Treatment T_3, 100% NPK + Fe EDTA produced the highest total biological yield, while treatment T_1, absolute control, produced the lowest. The total biological yield ranged from 34.53 to 44.64 q ha^1. The treatment T_3 was significantly superior to the rest of the treatments. The results are in line with Arif *et al.* (2007).

Effect of micronutrient seed dressing treatment on quality parameters of *Bt* cotton

Test weight. The data pertaining to the test weight of *Bt* cotton as influenced by various nutrient seed dressing treatments with micronutrients are presented in Table 4. The test weight of seed cotton varied in the range of 8.75 g to 10.35 g, with a mean of 9.57 g. The nutrient seed dressing treatment T_3 (100% NPK + Zn EDTA) resulted in a numerical increase in seed cotton test weight, which was followed by treatments T_9, T_8, T_4, and T_2. The lowest test weight of seed was registered in treatment T_1 (absolute control). The results are in line with Gaurkhede *et al*. (2015).

Ginning percentage. The data regarding the ginning percentage are presented in Table 4. The highest ginning percentage was recorded for treatment T_3 (100% NPK + Zn EDTA), which was 34.79%. However, data regarding ginning percentages did not reach the level of significance as affected by the different nutrient seed dressing treatments with micronutrients. Similar results were shown by Gaurkhede *et al.* (2015).

Lint yield. Table 4 contains information about lint yield. Lint yield ranged from 3.89 to 4.75 q/ha. The highest lint yield was recorded in T_3 (100% NPK + Zn EDTA), with a grand mean of 4.23 q ha^{-1}, and the lowest lint yield was recorded in T_1, *i.e.*, absolute control, with a grand mean of 3.89 q ha^{-1}. The T_3 treatment outperformed all others. The results are not significant. Results are in line with Sathiyamurthi and Dhansekaran (2014).

Fiber quality. The data pertaining to fiber quality analysis, *viz.*, UHML, UI, strength, elongity, and micronaire value, are presented in Table 5. The results were non-significant with respect to all quality parameters. T_6 (100% NPK + sodium molybdate) produced the highest UHML value, while T_2 (100% NPK + zinc sulfate, $ZnSO_4$) produced the lowest. The highest UI value was achieved by the treatment T_7 (100% NPK + cupric nitrate, $CuNO_3$), while the lowest was achieved by the treatment T_4 (100% NPK + borax, B). The highest fiber strengths were found in T_3 (100% NPK + Zn EDTA) and T_6, while T_4 (100% NPK + Borax (B)) had the lowest. T_9, T_8, T_6 and T_5 treatments had the greatest elongation, while T_2 and T_4 treatments had the least. The treatment T_5 (100% NPK + manganese sulphate, $MnSO_4$) had the highest micronaire value, while the treatment T_7 (100% NPK + copper nitrate, $CuNo_3$) had the lowest. The results are in compliance with the findings of Gaurkhede *et al*. (2015).

Table 1: Effect of various nutrient seed dressing treatments with micronutrients on final plant stand (%) of *Bt* cotton.

Treatment code	Treatments	Final plant stand (%)
T_1: Ac	Absolute control 100% NPK	92.17
T_2: R Zn	100% NPK + Zinc Sulphate ($ZnSO_4$)	94.82
T_3: RZnE	100% NPK + Zn EDTA	97.75
T_4: RB	100% NPK + Borax (B)	93.95
T_5: RMn	100% NPK + Manganese Sulphate ($MnSO_4$)	93.81
T_6: RMo	100% NPK + Sodium Molybdate (NaMo)	94.66
T_7: RCu	100% NPK + Cupper Nitrate ($CuNO_3$)	92.73
T_8: RFe	100% NPK + Ferrous Sulphate ($FeSO_4$)	94.74
T_9: RFeE	100% NPK + FeEDTA	94.88
Grand mean		94.17
S E (m)		1.12
C D at 5 %		3.37

Table 2: Effect of various nutrient seed dressing treatments with micronutrients on number of bolls per plant of *Bt* cotton.

Treatment code	Treatments	Number of bolls per plant	
		At 90 days	At harvesting
T_1: Ac	Absolute control 100% NPK	7.00	11.87
T_2: R Zn	100% NPK + Zinc Sulphate ($ZnSO_4$)	10.40	15.27
T_3: RZnE	100% NPK + Zn EDTA	10.80	18.20
T_4: RB	100% NPK + Borax (B)	7.27	12.20
T_5: RMn	100% NPK + Manganese Sulphate ($MnSO_4$)	8.40	13.80
T_6: RMo	100% NPK + Sodium Molybdate (NaMo)	8.87	14.13
T_7: RCu	100% NPK + Cupper Nitrate ($CuNO_3$)	8.07	12.33
T_8: RFe	100% NPK + Ferrous Sulphate ($FeSO_4$)	10.20	14.60
T_9: RFeE	100% NPK + FeEDTA	10.40	15.53
Grand mean		9.04	14.21
S E (m)		0.74	1.31
C D at 5 %		2.23	3.94

Table 3: Effect of various seed dressing treatment with micronutrients on Seed cotton yield, dry matter yield and total biological yield q ha^{-1} of *Bt* cotton.

Treatment code	Treatments	Seed cotton yield (q ha^{-1})	Dry matter yield (q ha^{-1})	Total biological yield (q ha^{-1})
T_1: Ac	Absolute control 100% NPK	11.51	23.02	34.53
T_2: R Zn	100% NPK + Zinc Sulphate ($ZnSO_4$)	12.81	25.75	38.56
T_3: RZnE	100% NPK + Zn EDTA	13.68	30.96	44.64
T_4: RB	100% NPK + Borax (B)	12.27	24.64	36.91
T_5: RMn	100% NPK + Manganese Sulphate ($MnSO_4$)	12.37	24.74	37.11
T_6: RMo	100% NPK + Sodium Molybdate (NaMo)	12.45	24.90	37.35
T_7: RCu	100% NPK + Cupper Nitrate ($CuNO_3$)	12.17	24.54	36.71
T_8: RFe	100% NPK + Ferrous Sulphate ($FeSO_4$)	12.47	25.64	38.11
T_9: RFeE	100% NPK + FeEDTA	12.82	28.62	41.64
Grand mean		12.50	25.89	38.39
S E (m)		0.36	0.77	0.56
C D at 5 %		1.09	2.32	1.71

Table 4: Effect of various nutrient seed dressing treatment with micronutrients on quality parameters of *Bt* cotton.

Treatment code	Treatments	Test weight (g)	Ginning percentage %	Lint yield q ha^{-1}
T_1: Ac	Absolute control 100% NPK	8.75	33.80	3.89
T_2: R Zn	100% NPK + Zinc Sulphate ($ZnSO_4$)	9.97	33.80	4.32
T_3: R ZnE	100% NPK + Zn EDTA	10.35	34.79	4.75
T_4: R B	100% NPK + Borax (B)	9.45	33.80	4.14
T_5: R Mn	100% NPK + Manganese Sulphate ($MnSO_4$)	9.30	33.80	4.18
T_6: R Mo	100% NPK + Sodium Molybdate (NaMo)	9.28	33.80	4.20
T_7: R Cu	100% NPK + Copper Nitrate ($CuNO_3$)	8.94	33.80	4.11
T_8: R Fe	100% NPK + Ferrous Sulphate ($FeSO_4$)	9.75	33.80	4.21
T_9: R FeE	100% NPK + FeEDTA	10.31	33.80	4.33
Grand mean		9.57	33.91	4.23
S E (m)		0.31	1.69	0.20
C D at 5 %		0.92	N.S	N.S

Table 5: Effect of various nutrient seed dressing treatment with micronutrients on fiber quality of *Bt* cotton.

Treatment code	Treatments	Fiber quality				
		Upper half mean length (mm)	Uniformity index (%)	Strength (g text^{-1})	Elongity (%)	Micronaire value (µg inch^{-1})
T_1: Ac	Absolute control 100% NPK	27.1	83.7	20.5	6.0	3.85
T_2: R Zn	100% NPK + Zinc Sulphate ($ZnSO_4$)	25.2	81.7	20.2	5.9	3.51
T_3: RZnE	100% NPK + Zn EDTA	26.6	84.2	21.1	6.0	3.28
T_4: RB	100% NPK + Borax (B)	26.2	78.6	19.5	5.9	3.70
T_5: RMn	100% NPK + Manganese Sulphate ($MnSO_4$)	27.2	79.1	19.7	6.1	3.99
T_6: RMo	100% NPK + Sodium Molybdate (NaMo)	27.6	87.2	21.1	6.1	3.79
T_7: RCu	100% NPK + Copper Nitrate ($CuNO_3$)	25.5	87.6	20.7	6.0	3.17
T_8: RFe	100% NPK + Ferrous Sulphate ($FeSO_4$)	27.3	82.5	20.7	6.1	3.50
T_9: RFeE	100% NPK + FeEDTA	26.5	81.8	20.9	6.1	3.88
Grand mean		26.57	82.82	20.48	6.02	3.63
S E		0.95	1.99	1.67	0.46	0.27
C D at 5 %		NS	NS	NS	NS	NS

CONCLUSION

The study concluded that applying 100% NPK + Zn EDTA seed to Bt cotton improved yield attributes such as final plant stand, number of bolls, seed cotton yield, dry matter yield, and total biological yield; as well as quality parameters such as test weight, ginning percentage, lint yield; and fiber quality parameters such as upper half mean length, uniformity index, strength, elongation, and micronaire value. As these results are based on one research trial, it is suggested to conduct a few more trials to arrive at a more concrete conclusion.

FUTURE SCOPE

In Bt cotton and several field crops, seed priming is increasingly seen to be a superior method for facilitating speedy and uniform emergence, generating high seedling vigour, and improving yields. Essential micronutrients that are components of the enzyme system or function as catalysts in enzymatic processes, such as zinc, iron, manganese, copper, boron, and magnesium, are crucial to the physiology of cotton crops. The new technique of seed priming stands out among the other seed treatments. In seed priming, seeds are dried again to almost their original weight after being slightly moistened to allow metabolic processes to continue without actual germination (Bradford, 1986). These seeds sprout more quickly than unprimed seeds (Farooq *et al*., 2006). Micronutrients are employed as osmotica in micronutrient seed priming (nutripriming) (Imran *et al*., 2004; Singh, 2007). Due to reduced imbibitions time and the accumulation of chemicals that promote germination (Taylor *et al*., 1998; McDonald, 2000; Brocklehurst and Dearman 2008), primed seeds often exhibit better (Basra *et al*., 2005; Farooq *et al*., 2006) and more synchronized germination (Farooq *et al*., 2009).

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Conflict of Interest. None.

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