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Research Article

IMPACT OF ZINC MOBILIZING MICROORGANISMS ON GROWTH ENHANCEMENT IN *BT* COTTON GROWN ON VERTISOL

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Abstract- The present investigation was undertaken during *kharif* season of 2013-14 at the Research farm, Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani to find out efficient strains of zinc mobilizing microorganism for the growth, yield and zinc availability in soils of *Bt* cotton grown on Vertisol. Results revealed that inoculation of microbial cultures *Trichoderma viride* along with recommended dose of fertilizer (NPK) significantly improved the growth and root parameters. Seed cotton and Dry matter yield was also significantly increased with the inoculation of RDF + *Trichoderma viride* followed by RDF + *Pseudomonas striata*. Inoculation of microbial cultures along with RDF increased zinc availability in soil as compared to RDF alone.

Keywords- Bt cotton, DTPA Zn, Root characters, Zinc mobilizing microorganisms.

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Introduction

Zinc is one of the 17 essential elements required for growth and metabolism of microorganisms and plants. The water soluble zinc applied as zinc sulphate gets transformed into different forms like Zn(OH) and $Zn(OH)_2$ at a pH of 7.7 and above; zinc carbonate in calcium rich alkali soils; zinc phosphate in near neutral to alkali soils of high phosphorus application; and zinc sulphide under reduced conditions. Microbes are potential alternate that could cater plant zinc requirement by solubilising the complex zinc in soil. In soil it undergoes a complex dynamic equilibrium of solubilization and precipitation that is greatly influenced by the soil pH and micro flora and that ultimately affects their accessibility to plant roots for absorption. The basic principle behind this approach is decreasing the pH and making zinc soluble and as a consequence the available zinc will get increased in the soil system [13]. Cotton suffers from zinc deficiency on alkaline calcareous soils [12]. Zinc deficiency symptoms includes: small leaves, shortened internodes, a stunted appearance, reduced boll set and small bolls size in cotton. Since, zinc is a limiting factor in a crop production and cotton is seen as a potential cash crop for many farmers. Keeping this in the view present study was undertaken in field condition for evaluating the impact of zinc mobilizing microorganisms already found efficient in zinc solubilization in laboratory studies [9] on growth, yield of *Bt* cotton and zinc availability in soil.

Material and Methods

The field experiment was conducted during *kharif* season of 2013-14 at the Research farm, Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani to assess the influence of zinc mobilizer on the growth, yield and zinc availability in soil under field conditions grown on Vertisol. The treatments consist of seven promising zinc mobilizing microbial inoculants such as *Burkholderia cepacia, Burkholderia cenocepacia*, *Pseudomonas fluorescens, Pseudomonas striata, Trichoderma viride, Trichoderma harzianum* and *Bacillus megaterium* in combination with recommended dose of fertilizer (120:60:60 NPK kg ha^{-1}) and one control treatment (Only RDF). The experiment was laid out in randomized block design (RBD). The pre-sowing soil samples were collected, air dried, thoroughly mixed, sieved and analyzed for various physico-chemical characteristics. The soil pH was found as 8.12, total soluble salt concentration 0.235 dSm^{-1}, organic carbon 5.02 g kg^{-1} and calcium carbonate 41.08 g kg^{-1}. Available N content 150.90 kg ha^{-1}, available P_2O_5 content 20.20 kg ha^{-1}, available K_2O content 570 kg ha^{-1} and DTPA extractable zinc was found as 0.523 mg kg^{-1}. *Bt* Cotton was raised in the field during *kharif* as per recommended package of practices. Adequate plant protection measures were taken as per recommendations. Data regarding seed cotton yield, Dry matter yield, plant height and boll number per plant were recorded. Root characteristics such as oven dry weight of root, shoot and root shoot ratio were recorded from randomly selected and labelled five plants in each plot. Samples for DTPA Zn were collected at 30, 60, 90 and 120 days after sowing. Zinc was estimated as per procedure described by Lindsay and Norvell [5] on Atomic Absorption Spectrophotometer (AAS) at specified wavelengths. The obtained data was subjected to statistical analysis by following Randomised Block Design using standard procedures as described in "Statistical Methods for Agricultural Workers" by Panse and Sukhatme, [8]. Appropriate standard error (S.E.) and critical differences (C.D.) at 5% level were worked out as and when necessary.

Results and Discussion

Microbial inoculation significantly improved the growth characters. Cotton plant height was significantly influenced by zinc mobilizing microbial inoculants [Table-1]. The RDF + *Trichoderma viride* inoculation produced significantly higher plant height (114.12 cm) than their respective controls and found at par with the inoculation of *Pseudomonas striata*, *Bacillus megaterium*, *Trichoderma harzianum* and *Pseudomonas fluorescens*. The increased growth response of plants caused by *Trichoderma* depends on the ability of the fungus to survive and develop in the rhizosphere. These results are corroborate with the findings[15]. *Trichoderma* sp. have been also shown to exhibit plant growth promoting activity on numerous.

cultivated plants as reported by Altomare [1] and Nakkeeran [7]. The number of bolls in *Bt* cotton were also found to alter by inoculation of zinc mobilizers [Table-1]. Fungal inoculation of *Trichoderma viride* also has significant influence on the number of bolls plant^{-1}. Highest number of bolls plant^{-1} i.e. 31.20 were observed with the inoculation of RDF + *Trichoderma viride* which were statistically at par with *Pseudomonas fluorescens* and *Pseudomonas striata* inoculation. These findings are similar with the results of Ramalakshmi and Anthoni Raj [11] who also reported that the inoculation of biofertilizers significantly increases number of bolls per plant in cotton.

Table-1 *Effect of zinc mobilizing microorganisms on growth and root characters of Bt cotton*

Treatments	Plant height (cm)	Bolls/plant	Oven dry wt. of root (g plant^{-1})	Oven dry wt. of shoot (g plant^{-1})	Root volume	Root shoot ratio	Root density (g/cc)
T_1:Only RDF	89.48	19.43	1.90	21.55	11.50	11.40	0.166
T_2:RDF + *Burkholderia cepacia*	99.93	22.43	2.07	28.92	13.33	14.03	0.158
T_3:RDF + *Burkholderia cenocepacia*	98.57	21.73	2.03	23.72	12.35	11.75	0.166
T_4:RDF+ *Pseudomonas fluorescens*	106.61	28.33	2.18	26.70	14.57	12.28	0.151
T_5:RDF + *Pseudomonas striata*	111.83	27.40	2.33	34.59	15.10	14.86	0.155
T_6:RDF + *Trichoderma viride*	114.12	31.20	2.40	39.31	15.57	16.49	0.154
T_7:RDF + *Trichoderma harzianum*	107.72	25.60	2.01	26.93	13.80	13.49	0.147
T_8:RDF + *Bacillus megaterium*	109.68	26.70	2.26	37.73	15.17	16.69	0.150
GM	104.74	25.35	2.15	29.93	13.92	13.87	0.156
SE+	4.34	1.48	0.07	1.30	0.76	0.86	0.003
CD at 5%	13.17	4.48	0.22	3.94	2.31	2.61	0.009
CV	7.18	10.08	5.78	7.52	9.46	10.76	3.370

Microbial inoculation also has significant influence on root characteristics and data regarding presented in [Table-1]. Highest oven dry weight of root (2.40 g), oven dry weight of shoot (39.31g), root volume (15.57) and root shoot ratio (16.49) were observed with the inoculation of *Trichoderma viride* along with RDF which were noted statistically at par with the treatment RDF + *Pseudomonas striata* and RDF + *Bacillus megaterium*. Further, highest root density of plant was noticed in control treatment (0.166 g/c) with only RDF. Harman [3] concluded that *Trichoderma spp.* are opportunistic plant colonizers that affect plant growth by promoting abundant and healthy plant roots, possibly *via* the production or control of plant hormones. The enhancement in root growth due to inoculation of *Trichoderma* application was also noticed by Mazhabi [6]. Zinc mobilizing microbial strains also influenced the seed cotton yield. *Trichoderma viride* significantly enhanced the seed cotton yield [Table-2]. The highest seed cotton yield was produced with RDF + *Trichoderma viride* inoculant (2224 kg ha^{-1}) followed by RDF + *Pseudomonas striata* (2130 kg ha^{-1}). While, the lowest yield was obtained in control treatment (1803 kg ha^{-1}) with only RDF. However, The magnitude of increase in seed cotton yield under *Trichoderma viride* and *Pseudomonas striata* along with RDF being about 23.35 and 18.13 per cent over control treatment. The increase in yield of cotton obtained in the present exploration are full conformity with those reported in the past. Enhancement of yield of cotton due to the inoculation of biofertilizers was reported by many researchers [14, 11, 2] noted that an average seed cotton yield was enhanced due to the application of biofertilizers in cotton. Dry matter yield of cotton was increased due to application of zinc mobilizing microbial inoculants along with recommended dose of fertilizers and data is narrated in [Table-2]. Microbial inoculant *Trichoderma viride* with RDF was found to increase dry matter yield of cotton showing significantly highest (3785 kg ha^{-1}) followed by RDF + *Pseudomonas striata* (3694 kg ha^{-1}), RDF + *Burkholderia cepacia* (3472 kg ha^{-1}) and RDF + *Bacillus megaterium* (3381 kg ha^{-1}). The magnitude of increase in yield was 41.54 per cent respectively over only RDF. Whereas, lowest dry matter yield (2674 kg ha^{-1}) was obtained in control treatment receiving only RDF. When the effects of microbial inoculation without fertilization was compared with one other or with the control plants, all the microbial inoculations increased the yield parameters compared to un-inoculated but *Trichoderma viride* performed better relatively to all other treatments. The results are in conformity with Thakur [16] who showed that application of nitrogen along with *Trichoderma viride* increased the cane yield.

The periodical DTPA Zn content in soil was significantly influenced with different zinc mobilizing strains but marginal periodical changes were noted from 30 days after sowing (DAS) till to harvest [Table-3]. The magnitude of increase in DTPA Zn in soil under *Trichoderma viride* along with RDF was 11.51, 15.55, 19.48 and 22.59 per cent as compared to only RDF at various sampling intervals. Among the various sampling intervals soil zinc content was found to be increased from 30 to 90 DAS (0.570 to 0.701 mg kg^{-1}) and thereafter decreased at 120 DAS (0.690 mg kg^{-1}) respectively. Significantly greater values of DTPA Zn in soil were obtained with RDF + *Trichoderma viride* (0.591, 0.639, 0.742 and 0.738 mg kg^{-1}, respectively) followed by *Pseudomonas striata, Bacillus megaterium* and *Pseudomonas fluoroscens* strain at 90 and 120 DAS.

Table-2 *Effect of zinc mobilizing microorganisms on yield of Bt cotton*

Treatments	Seed cotton yield (kg ha^{-1})	Dry matter yield (kg ha^{-1})
T_1:Only RDF	1803	2674
T_2:RDF + *Burkholderia cepacia*	1949	3472
T_3:RDF + *Burkholderia cenocepacia*	1826	3163
T_4:RDF + *Pseudomonas fluorescens*	1846	3239
T_5:RDF + *Pseudomonas striata*	2130	3694
T_6:RDF + *Trichoderma viride*	2224	3785
T_7:RDF + *Trichoderma harzianum*	1878	3298
T_8:RDF + *Bacillus megaterium*	1881	3381
GM	1942	3338
SE+	67	147
CD at 5%	204	446
CV	5.98	7.63

Whereas, lowest value was noted with only RDF treatment (0.530, 0.553, 0.621 and 0.602 mg kg^{-1}, respectively) at respective sampling intervals. These results are corroborate with the findings of Harman [4] who explained the mechanisms employed by *Trichoderma* spp. in enhancing nutrient availability by solubilization and chelation of minerals, increased plant metabolism leading to the enhancement of plant physiological activity. The promotion of growth and yield by *Trichoderma* spp. may also be a result of increased root area allowing the roots to explore larger volumes of soil to access nutrients, and increased solubility of insoluble compounds as well as increased availability of micronutrients [1, 17, 6].

Table-3 *Effect of zinc mobilizing microorganisms on periodical DTPA Zn availability in soil*

Treatments	DTPA Zn (mg kg^{-1})			
	30 DAS	60 DAS	90 DAS	120 DAS
T_1: Only RDF	0.530	0.553	0.621	0.602
T_2:RDF + *Burkholderia cepacia*	0.573	0.588	0.689	0.688
T_3:RDF + *Burkholderia cenocepacia*	0.556	0.575	0.670	0.657
T_4:RDF + *Pseudomonas fluorescens*	0.577	0.598	0.726	0.698
T_5:RDF + *Pseudomonas striata*	0.585	0.635	0.733	0.729
T_6:RDF + *Trichoderma viride*	0.591	0.639	0.742	0.738
T_7:RDF + *Trichoderma harzianum*	0.565	0.599	0.694	0.680
T_8:RDF + *Bacillus megaterium*	0.581	0.636	0.734	0.728
GM	0.570	0.603	0.701	0.690
SE+	0.011	0.012	0.014	0.016
CD at 5%	0.034	0.036	0.043	0.049
CV	3.440	3.44	3.470	4.040

Conclusion

Results showed that zinc mobilizing microorganisms *Trichoderma viride* followed by *Pseudomonas striata* and *Bacillus megaterium* strain improved growth and yield of cotton as well as enhances the DTPA zinc availability in soil.

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Abbreviations: RDF- Recommended Dose of Fertilizer, DTPA-- Diethyl Triamine Penta Acetate, DAS- Days After Sowing, RBD- Randomised Block Design.

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