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Soil and plant nutrient status of cotton as influenced by different methods of application of nano ZnO

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Abstract

Purpose: A field experiment was conducted at Dharwad, Karnataka, during 2017-18 to evaluate the effect of seed treatment and foliar application of nano ZnO on nutrient status of Bt cotton.

Method: The experiment was laid out in split plot design with three main treatments (M_1:seed treatment with chelated $ZnSO_4$ @ 4 g kg^{-1} seeds, M_2: nano ZnO @ 1 g kg^{-1} seeds and M_3:seed priming with 1000 ppm nano zinc solution), four sub plot treatments (Foliar application of nano ZnO @ 500, 750, 1000 and 1250 ppm at square initiation and flowering stage) and three uneven control (C_1: RDF + FYM + 0.5 % EDTA $ZnSO_4$ foliar application at square initiation and flowering stage, C_2: C_1 + seed treatment with Fe, Zn, Mg and Mn @ 4g each kg^{-1} seed and C_3 : Only RDF + FYM @ 5.0 t ha^{-1}) treatments replicated thrice.

Result: Among seed treatments, higher seed cotton yield (2842 kg ha^{-1}) recorded with nano ZnO seed treatment than seed priming with nano zinc solution and chelated $ZnSO_4$ seed treatment.

Conclusion: Among all treatment combinations, seed treatment with nano ZnO in combination with foliar application of nano ZnO @ 1000 ppm recorded significantly higher nutrient uptake. Superior treatment combination recorded higher stalk yield and seed index.

Keywords: Cotton, foliar application, micronutrient, nano zinc oxide, nutrient uptake

Introduction

Cotton fibre is preferred in apparel textiles and garments because of its hydrophilic properties and hence despite severe competition from synthetic fibres, cotton continues to enjoy a place of pride in the textile industry. Besides fibre, cotton is also valued for its oil and cottonseed cake and several other by-products (Hashemi *et al*, 2016) [2].

To save the cotton crop from nutrient loss, foliar nutrition with different nutrients at particular intervals has a vital place. The advantages of using foliar feeding of plants are quick plant response, small quantity of the nutrient, compensation for the lack of soil fixation, avoiding root uptake problems, increased yield and fiber quality in cotton. Foliar fertilization is actually a complement to soil fertilization. The efficiency of this fertilization method is a function of crop age, foliar area, time of year, application method and mobility of the mineral in question (Marschner and Cakmak 1989) [3].

It has been conclusively demonstrated that fertilizer contributes to the tune of 35-40% of the productivity of any crop. Supplying of chemical fertilizers in the form of nanoparticles has recently received considerable attention. Indeed, nanotechnology has provided the feasibility of exploiting nanoscale or nanostructured materials as fertilizer carriers or controlled-release vectors for building of so-called “smart fertilizer” as new facilities to enhance nutrient use efficiency and reduce costs of environmental protection.

Nano fertilizers increases the nutrient use efficiency (NUE) by 3 times and it also provides stress tolerating ability. The results of available studies indicate different response of various species of plants to materials in the size of nano.

However, The studies related to seed treatment of nano ZnO on cotton in India is very meager or seldom nil. Hence the present investigation was carried out to know the impact of seed treatment of nano Zinc fertilisers on growth, yield parameters of cotton and soil nutrient status.

Materials and methods

A Field experiment was conducted at Main Agricultural Research Station, Dharwad, India, during *kharif* 2017-2018. The experiment was laid out in split plot design with three main treatments (S_1: seed treatment with chelated $ZnSO_4$ @ 4 g kg^{-1} seeds, S_2: nano ZnO @ 1 g kg^{-1} seeds and S_3: seed priming with 1000 ppm nano zinc solution), four sub plot treatments (Foliar application of nano ZnO @ 500, 750, 1000 and 1250 ppm at square initiation and flowering stage) and three uneven control (C_1: RDF + FYM + 0.5 % EDTA $ZnSO_4$ foliar application at square initiation and flowering stage, C_2: C_1 + seed treatment with micronutrients Fe, Zn, Mg and Mn @ 4g each kg^{-1} seed and C_3: RDF + FYM @ 5.0 t ha^{-1}) treatments replicated thrice. The hybrid Bt Cotton Superb SP7157 (BG-II) was sown in a plot size of 7.2 × 5.4 m for each treatment. Seeds were dibbled as per the specification on 05th July 2017. Two seeds per hill were dibbled to a depth of 5 cm on flat bed in 90 cm rows at 60 cm distance between plant to plant and Recommended dose of fertilizers (RDF) @ 100:50:50 kg N: P_2O_5 : K_2O ha^{-1} + FYM @ 5.0 t ha^{-1} was applied commonly to all treatments. Before starting of the experiment initial soil status were analysed and presented in Table 01 and general view of experimental site presents in figure 1.

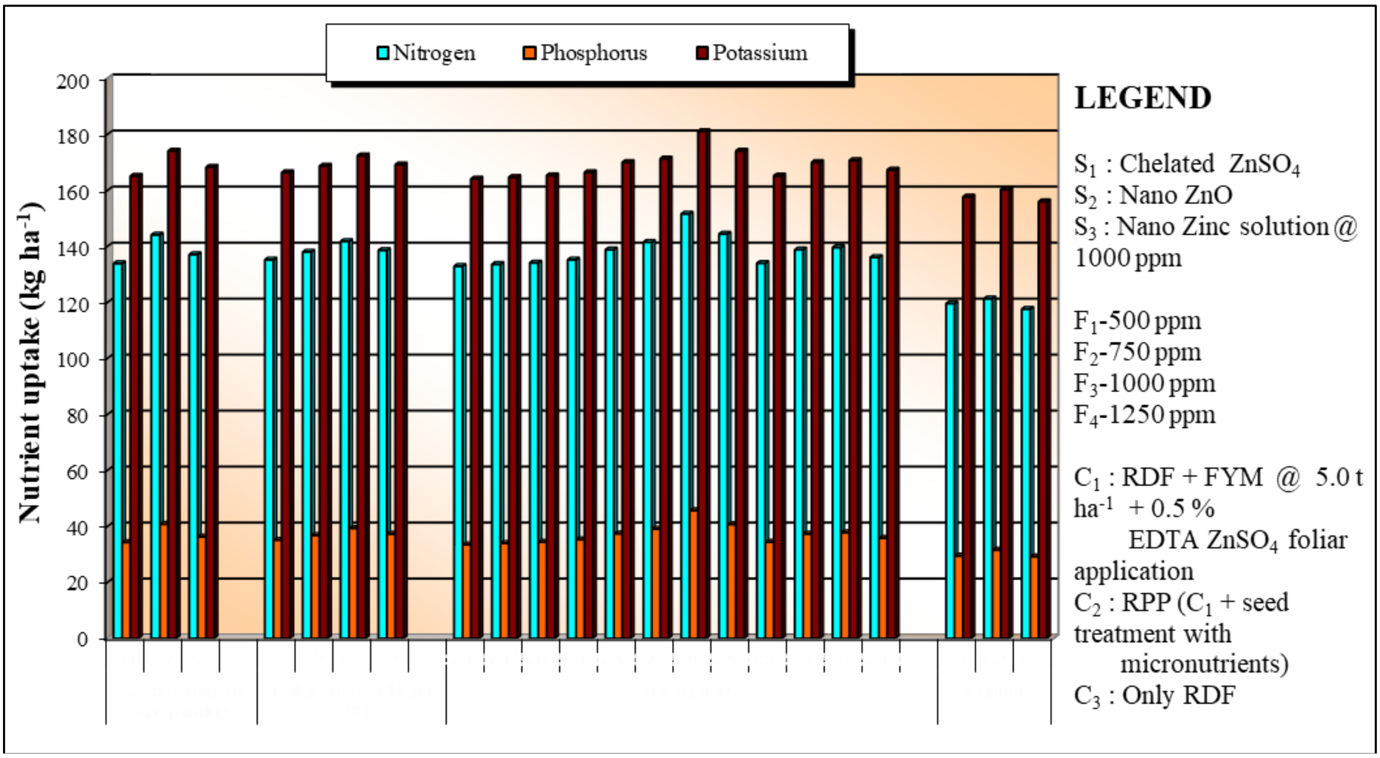

Fig 1: Total major nutrient uptake of Bt cotton at harvest stage as influenced by nano ZnO seed treatment and foliar application

Influence of NZnO seed treatment and foliar application of NZnO on chemical properties of soil

The data on soil chemical properties analyzed after harvesting of crop namely organic carbon, pH, and EC as influenced by seed treatment and foliar application of NZnO are presented in Table 01.

Soil (pH), Electrical conductivity (EC dS m^{-1}) and Organic matter (OM %)

The data on pH, EC and OM content of soil as influenced by seed treatment and foliar application of NZnO are presented in Table 01. The soil parameters like pH, EC and OM content of soil did not show any significant difference between seed treatment and foliar application of NZnO at different concentrations and their interactions as well as between all treatment combinations and control treatments.

Influence of NZnO seed treatment and foliar application of NZnO on available major and micronutrients in soil

The data on soil chemical properties analyzed after harvesting of crop namely nitrogen, phosphorous, potassium and micronutrients as influenced by seed treatment and foliar application of NZnO are presented in Table 1-2.

Available nitrogen (N), phosphorus (P) and potassium (K)

The available N, P and K (kg ha^{-1}) in soil after harvest of cotton did not show any significant difference between seed treatments and foliar application of NZnO at different concentrations. Similarly, available N, P and K data on interaction between seed treatment and foliar application were also found to be non significant. The overall interaction data revealed that there was no significant difference between all treatment combinations and control treatments.

Available zinc (Zn), iron (Fe), manganese (Mn) and copper (Cu)

The available Zn, Fe, Mn and Cu (ppm) in soil after harvest of cotton did not show any significant difference between seed treatments and foliar application of NZnO at different concentrations. The micronutrient data on interaction between seed treatment and foliar application were found to be non significant. The overall interaction data on micronutrients revealed that there was no significant difference between all treatment combinations and control treatment.

Table 1: Soil nutrient status of Bt cotton after harvest as influenced by nano ZnO seed treatment and foliar application

Treatment	Major nutrients											
	Nitrogen (kg ha^{-1})				Phosphorus (kg ha^{-1})				Potassium (kg ha^{-1})			
Foliar spray of nano ZnO	Seed treatment and priming				Seed treatment and priming				Seed treatment and priming			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1-500 ppm	269.7	253.7	244.8	256.1	25.7	25.3	25.1	25.3	283.3	270.5	270.9	274.9
F_2-750 ppm	259.4	240.0	255.1	251.5	24.0	22.3	24.7	23.7	286.9	255.7	257.2	266.6
F_3-1000 ppm	270.7	223.9	250.9	248.5	23.2	20.4	25.2	22.9	274.9	236.5	270.5	260.7
F_4-1250 ppm	243.4	237.0	270.7	250.4	25.4	24.0	19.8	23.0	273.3	251.5	261.3	262.1
Mean	260.8	238.6	255.4	251.6	24.5	23.0	23.7	23.73	279.6	253.6	265.0	266.06
Control	C_1	C_2	C_3		C_1	C_2	C_3		C_1	C_2	C_3	
	267.6	273.9	272.8		23.3	25.6	23.2		282.5	265.3	299.1	
Source of variation		S. Em±	C.D. (P=0.05)		S. Em±		C.D. (P=0.05)		S. Em±		C.D. (P=0.05)	
Seed treatment (S)		9.38	NS		0.34		NS		22.91		NS	
Foliar spray (F)		9.12	NS		0.31		NS		21.96		NS	
Between F at same S		16.76	NS		1.59		NS		41.53		NS	
Between S at same or diff. F		17.28	NS		1.79		NS		45.85		NS	
To compare control with other treatment combinations		20.12	NS		2.01		NS		49.10		NS	

DAS: Days after sowing
S_1: Seed treatment with chelated $ZnSO_4$ @ 4 g kg^{-1} seeds in 8 ml polymer
C_1: RDF + FYM @ 5.0 t ha^{-1} + 0.5 % EDTA $ZnSO_4$ foliar application
S_2: Seed treatment with nano ZnO @ 1 g kg^{-1} seeds in 8 ml polymer
C_2: RPP (C_1 + seed treatment with micronutrients (Fe, Zn, Mg & Mn @ 4g each kg^{-1} seed)
S_3: Seed priming with nano Zinc solution @ 1000 ppm (8 hours)
C_3: RDF (100:50:50 kg N: P_2O_5: K_2O ha^{-1}) + FYM @ 5.0 t ha^{-1}

Table 2: Soil nutrient status of Bt cotton after harvest as influenced by nano ZnO seed treatment and foliar application

Treatment	Micronutrients															
	Zinc (ppm)				Iron (ppm)				Manganese (ppm)				Copper (ppm)			
Foliar spray of nano ZnO	Seed treatment and priming				Seed treatment and priming				Seed treatment and priming				Seed treatment and priming			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1-500 ppm	0.300	0.237	0.217	0.251	3.04	2.89	2.67	2.87	4.68	4.77	4.80	4.75	0.34	0.31	0.33	0.33
F_2-750 ppm	0.287	0.203	0.170	0.220	3.19	1.99	3.08	2.75	4.72	4.44	4.64	4.60	0.33	0.34	0.35	0.34
F_3-1000 ppm	0.183	0.190	0.223	0.199	2.72	2.44	2.65	2.60	4.69	4.29	4.65	4.54	0.32	0.35	0.35	0.34
F_4-1250 ppm	0.220	0.200	0.257	0.226	2.60	3.12	2.45	2.72	4.75	4.75	4.23	4.58	0.35	0.32	0.35	0.34
Mean	0.248	0.208	0.217	0.224	2.89	2.61	2.71	2.73	4.71	4.56	4.58	4.61	0.34	0.33	0.34	0.33
Control	C_1	C_2	C_3		C_1	C_2	C_3		C_1	C_2	C_3		C_1	C_2	C_3	
	0.240	0.210	0.233		2.960	2.867	2.577		4.71	4.67	4.66		0.33	0.33	0.33	
Source of variation		S. Em±	C.D. (P=0.05)		S. Em±		C.D. (P=0.05)		S. Em±		C.D. (P=0.05)		S. Em±		C.D. (P=0.05)	
Seed treatment (S)		0.02	NS		0.17		NS		0.03		NS		0.02		NS	
Foliar spray (F)		0.01	NS		0.14		NS		0.01		NS		0.01		NS	
Between F at same S		0.06	NS		0.41		NS		0.05		NS		0.03		NS	
Between S at same or diff. F		0.06	NS		0.44		NS		0.08		NS		0.03		NS	
To compare control with other treatment combinations		0.1	NS		0.4		NS		0.1		NS		0.1		NS	

DAS: Days after sowing
S_1: Seed treatment with chelated $ZnSO_4$ @ 4 g kg^{-1} seeds in 8 ml polymer
C_1: RDF + FYM @ 5.0 t ha^{-1} + 0.5 % EDTA $ZnSO_4$ foliar application
S_2: Seed treatment with nano ZnO @ 1 g kg^{-1} seeds in 8 ml polymer
C_2: RPP (C_1 + seed treatment with micronutrients (Fe, Zn, Mg & Mn @ 4g each kg^{-1} seed)
S_3: Seed priming with nano Zinc solution @ 1000 ppm (8 hours)
C_3: RDF (100:50:50 kg N: P_2O_5: K_2O ha^{-1}) + FYM @ 5.0 t ha^{-1}

Discussion

Response of cotton for seed treatment and foliar application of Nano ZnO

The higher seed cotton yield from seed treatment with nano ZnO was attributed to higher yield parameters namely, seed cotton yield plant^{-1} (153.4 g), lint yield hectare^{-1} (1029 kg), seed yield hectare^{-1} (1812 kg), stalk yield hectare^{-1} (7084 kg) than seed priming with nano zinc solution (133.8 g, 895 kg, 1584 kg and 6725 kg, respectively) and seed treatment with chelated $ZnSO_4$ (124.7 g 782 kg, 1526 kg and 6550 kg, respectively). The increase in yield attributes in seed treatment of nano ZnO was 14.6, 14.97, 14.39 and 5.3 percent, and, 23.0, 31.58, 18.74, 8.15 percent over chelated $ZnSO_4$ and seed priming in seed cotton yield plant^{-1}, lint yield hectare^{-1}, seed yield hectare^{-1} stalk yield hectare^{-1}, respectively). The increased yield and yield attributes were due to Zn, it is involved in chlorophyll synthesis through its influence on protein, carbohydrate and energy metabolism further, if it is of nano size then speed of action is more. Rahmani *et al*. 2016 [5] reported that many enzymes require Zn ion for their activity, and Zn may be required for chlorophyll biosynthesis in plants that in turn contributes for yield.

The nutrient uptake indicates many physiological processes, control growth and development in plant. Seed treatment with nano ZnO recorded higher uptake of total N (144.1 kg ha^{-1})

than seed priming with nano ZnO (137.1 kg ha^{-1}) and seed treatment with chelated $ZnSO_4$ (133.9 kg ha^{-1}) at harvest stage of crop. Similar trend was observed in P, K, Mn, Fe and Cu uptake. Nano zinc seed treatment recorded significantly higher zinc uptake (198.4 g ha^{-1}) than seed priming (191.4 g ha^{-1}) and chelated zinc seed treatment (188.2 g ha^{-1}). The increase in zinc uptake in seed treatment with nano ZnO was 3.6 percent over seed priming with nano zinc solution and 5.4 per cent over seed treatment with chelated $ZnSO_4$. Besides that, nano Zn plays a key role in photosynthesis, affecting the activity of enzymes such as carbonic anhydrase and also due to its small size uptake is more as well as it affects chlorophyll concentration and stomatal conductance (Ramegowda *et al*. 2013) [6].

Nutrient uptake also plays an important role in determination of yield potential in cotton. In the present investigation, seed treatment with nano ZnO along with 1000 ppm foliar spray recorded significantly higher nitrogen (151.6 kg ha^{-1}), phosphorus (45.7 kg ha^{-1}), potassium (181.1 kg ha^{-1}), iron (1000.7 g ha^{-1}), manganese (536.7 g ha^{-1}) and zinc (205.9 g ha^{-1}) uptake as compared to other treatment combinations. The nanoparticles as fertilizers potentially benefits uptake system, they have showed better catalytic ability with increased surface area. They are highly dispersible and have high water adsorbing properties. Therefore nano fertilizers can increase the efficiency of nutrient uptake which can improve yield and nutrient content in the edible parts of the plants. Under moisture stress conditions uptake of Zn is limited due to the down regulation of many transporters. From this context the ZnO nano could provide an option to improve uptake of Zn under drought conditions. ZnO-NPs can strongly attach to soil colloids. They exhibit low mobility at various ionic strengths (Zhao *et al*., 2012) [10], and show higher sorption compared to ionic Zn2+. Sorption of both forms of metal stronger with an increase in pH values. The pH also influenced the toxicity of both ZnO-NPs and ionic Zn2+ to the soil collembolans Folsomia candida, the latter being more toxic (Waalewijn-Kool *et al*., 2013) [9]. Shen *et al*. (2015) [8] reported that toxicity of ZnO-NPs was higher in acidic soil than in neutral soil and that toxicity is lowest in alkaline soil. Several nano-products are being developed to increase crop yields and improve pesticide efficacy, which increased their application to the soil (Petosa *et al*., 2017) [4]. Boonyanitipong *et al*. (2011) [1] observed that ZnO-NPs reduced the number of roots and stunted the length of rice seedlings (Oryza sativa L) whereas Raskar and Laware (2014) [7] found that ZnO-NPs inhibited chlorophyll biosynthesis as well as the efficiency of photosynthesis in Arabidopsis.

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