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Effect of Nano Nitrogen and Nano Zinc on the Growth and Yield of Sweetcorn

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To study the effect of nano nitrogen and nano zinc on the growth and yield of sweetcorn (variety KSP-5389) in Inceptisol of Odisha.

Experimental design: The experiment was laid out in randomized block design (RBD) with three replications and eight treatments. The treatments details were T_1-Absolute control, T_2- RDF (Recommended dose of N: P2O5: K2O :: 80: 40: 40), T_3- RDF + Zn @ 5 kg ha-1 , T_4- 50 % N + N foliar spray (Vegetative Stage), T_5- 50% N + N foliar spray (Vegetative Stage + Tasselling), T_6- 50% N + N foliar spray (Vegetative Stage + Tasselling) + Zn foliar spray (Silking stage), T_7- 50% N + N foliar spray (Vegetative Stage + Tasselling) + Zn foliar spray (Silking+Milking), T_8- N spray (Veg+ Tasselling) + Zn spray (Silking+ Dough). P & K was common to all treatment except control.

Place and duration of study: A field experiment was conducted during Rabi season, February 2022 at khujimahal, Chandaka, Faculty of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar Odisha.

Results: The results showed that highest biological yield (1685 $kgha^{-1}$) was found in the application of (50% N with two foliar sprays of nano N at vegetative and tasselling stage and two foliar spray of nano Zn @4ml L^{-1} at silking and milking stage). Whereas lowest cobyield (691 kg ha^{-1}) was

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observed in absolute control. Compare with recommended dose of fertilizer with Zn, the application of 50% N with Nano N and Nano Zn as double foliar spray, the yield was increased by 41% whereas 26% yield increase by single foliar application of nano Zn.

Conclusion: Highest harvest index HI was found in the application of 50% N with two foliar sprays of nano N at vegetative and tasselling stage and two sprays of nano Zn @4 ml L^{-1} at silking and milking stage and lowest in control. Application of 50% N with two foliar sprays of nano N at vegetative and tasselling stage and two spray of nano Zn @4ml l-1 at silking and dough stage (T8) helps in increasing the yield of sweet corn as well as nutrient concentration and nutrient uptake followed by T7 (50 % N + N foliar spray at vegetative stage @ 4ml l-1 + Zn spray at Silking and Milking stage).

Keywords: Nano nitrogen; nano zinc; sweet corn; foliar application; yield; uptake.

1. INTRODUCTION

Sustainable agriculture with high productivity is crucial to alleviate the perils of hunger and increase food security. Food production and distribution are under an increased and continuous stress at a globe scale due to climate change, increased human population and decreased fertile land and fresh water resources [1]. Sweet corn (*Zea mays* L. saccharata) is one of the new generation maize types which is the most popular one among the different types of maize available and is extensively used for human consumption. It comes up well under a wide range of soil and climatic conditions, current maize yields have lot of potential to be exploited. Intensive agriculture involving modern technologies with the introduction of high-yielding sweetcorn and the repeated use of high analysis fertilizers has finally led to a deficiency of micronutrients, particularly zinc [2,3]. Nano fertilizer have two potentials to promote sustainable agriculture and increase overall crop productivity mainly increasing Nutrient Use Efficiency of field and green house crop [4].

Adoption of nanotechnology as a source of nitrogen fertilizer could be an appropriate alternative to nitrogen fertilizers at macro scale [4]. The nano size attributes to higher surface to volume ratio therefore optimizes the requirement of fertilizer, comparatively. However, availability of data on relative performance of nano urea over urea on sweetcorn was meager. Therefore, the present investigation was undertaken to appraise the effect of foliar spray of nano urea over urea at two different stages, viz., knee height (vegetative) and tasseling when sprayed in association with two different doses of nitrogen application, respectively. Farmers are using urea and zinc sulphate fertilizers for soil as well as foliar application to crops; however, the efficiency is low. The present study was taken up to investigate the effects of N and Zn nano particles as foliar application on growth and yield of sweet corn. Nano particles with small size and extensive surface area are expected to be the perfect forms for use as a N and Zn fertilizer in plants. Considering all these factors, the objective of the present study were to study the effect of nano nitrogen and nano zinc on growth attributing characterson chlorophyll content at different growth stages, yield, nutrient concentration, nutrient uptake and post-harvest soil properties of sweet corn.

2. MATERIALS AND METHODS

A field experiment entitled “Effect of nano nitrogen and nano zinc on the nutrition of sweetcorn” was conducted during february 2022 at Khujimahal, Chandaka, Faculty of Agricultural Sciences, Siksha ‘O’ Anusandhan (Deemed to be University), Bhubaneswar Odisha. The material used and techniques adopted for collection of soil, plant samples, analytical methodologies followed and statistical methods adopted.

The experiment was laid out in randomized block design (RBD) with three replications. It was consisted of the following eight treatments. The details of treatments were : T_1-Absolute control, T_2- RDF (Recommended dose of N: P2O5: K2O :: 80: 40: 40), T_3- RDF + Zn @ 5 kg ha-1 , T_4- 50 % N + N foliar spray (Vegetative Stage), T_5- 50% N + N foliar spray (Vegetative Stage + Tasselling), T_6- 50% N + N foliar spray (Vegetative Stage + Tasselling) + Zn foliar spray (Silking stage), T_7- 50% N + N foliar spray (Vegetative Stage + Tasselling) + Zn foliar spray (Silking+Milking), T_8- N spray (Veg+ Tasselling) + Zn spray (Silking+ Dough). P & K was common to all treatment except control.

To estimate the various physico-chemical properties of soil, soil samples (0-15 cm depth) were collected from different spots of the experimental field systematically in a zigzag manner from the field and bulked to form a composite sample prior to land preparation and also after harvest of the crop from each plot. The composite soils sample thus collected were air dried, sieved through 2 mm sieve and stored in polythene bag, subjected to mechanical, physical and chemical analysis for obtaining initial analysis data using standard analytical procedure. The soil type belongs to order Inceptisol, with silty loam texture.

The experiment field was ploughed with tractor drawn cultivator followed by harrowing and breaking clods with rotavator to get fine tilth before sowing of crop. Stubbles and weeds were removed and then plots were laid out as per plan of layout. Eight treatments were imposed on the layout with three replications thus making a total of 24 plots. Allotment of each treatment was done by restricted randomization.

Fertilizers were applied as per treatment details. Fertilizers were given in the form of urea, single super phosphate muriate of potash. Indian Farmers Fertilizer Cooperative Ltd. (IFFCO), Nano-Nitrogen spray applied @ 4ml L^{-1} at 30 DAS and 45 DAS and nano Zn was applied at the same rate.

Weeds were removed from the plots by manual labour three weeks after sowing and three such weeding sessions were conducted to maintain weed free condition of the crop. Earthing up was done manually after four weeks of sowing.

After harvesting of crop, the soil samples (0-15cm) were collected from each plot. Sampling was done with the help of spade in order to prevent contamination. The soil samples were air dried, sieved through 2 mm sieve and stored in polythene bag for analysis of various physical and chemical property.

The crop was harvested after attaining physiological maturity at 85 days after sowing. The cobs were collected and dried under sun, recorded the weight and expressed in kg ha^{-1} . The stover from each treatment plot was harvested and sun dried. The weighed stover was recorded and expressed in kg ha^{-1} . The Samples were oven dried in hot air oven at 60° C upto constant weight or till the samples become moisture free. The over dried weight was recorded. The over dried stover and grain samples were then powdered in a grinder and stored for analysis.

3. RESULTS AND DISCUSSION

3.1 Soil Properties of the Experimental Site

A field experiment was conducted in the Khujimahal, Chandaka Village of Khordha district under Institute of Agricultural Sciences, SOADU, Bhubaneswar. The physico-chemical analysis of soil was presented in Table 1. Soil collected was moderately acidic in reaction and pH was found to be 5.42. Electrical conductivity of soil was non saline, silty loam in texture and belongs to Inceptisol. The bulk density of soil was 1.62 g/cc and particle density were 2.6 g/cc. The moisture content of the soil was 27 percent. The CEC of the soil was 5.97 mol (p+) kg^{-1} of soil. The soil was low in organic carbon, low in available nitrogen, available phosphorus and potassium. The available zinc content was low in soil.

3.2 Growth Attributes

3.2.1 Plant Height

The data pertaining to plant height are presented in Table 2. Significant difference in plant height was observed with nano nitrogen and nano zinc with 50% N through urea to that of absolute control with enhanced growth of crop (Table 2). This may be due to nano fertilizers can release the nutrients in the controlled form to enhance the nutrient use efficiency while preventing the nutrient ions from either getting fixed or lost to the environment [5]. The maximum plant height was observed at 45 and 60 DAS which was significantly increase over the absolute control with the application of nano N and nano Zn with 50% N through urea. This may be due to adequate supply of N and Zn which might have accelerated the activity of enzyme and auxin metabolism in the plant which in turn enlarge the cell and cell elongation resulting the taller plants. This is the conformity with the work of Nithya et al. [6]; Rajesh et al. [7].

3.2.2 Leaf length

The data pertaining to leaf length are presented in Table 3. Results showed that Significant difference in leaf length was observed with N spray at basal and vegetative and Zn spray at tillering and cob initiation stage (Table 3). This may be due to nano fertilizers can release the nutrients in the controlled form to enhance the nutrient use efficiency while preventing the nutrient ions from either getting fixed or lost to the environment [5]. The maximum leaf length was observed at 45 and 60 DAS which was significantly increase over the absolute control with the application of nano N and nano Zn with 50% N through urea. This may be due to adequate supply of N and Zn which might have accelerated the activity of enzyme and auxin metabolism in the plant resulting increase in leaf length. Similar observation was made by Nithya et al. [6]; Rajesh et al. [7].

Table 1. Physico chemical soil properties of initial soil

Soil Properties	Value
pH	5.42
EC (µsm^{-1})	166.04
Organic Carbon (%)	0.42
CEC (Cmol (p+) kg^{-1}	5.97
BD (g/cc)	1.62
PD (g/cc)	2.61
Moisture content (%)	27
Textural class	Silty Laom
Sand (%)	62
Silt (%)	27
Clay (%)	11
Available N (kg ha^{-1})	165.78
Available P (kg ha^{-1})	12.76
Available K (kg ha^{-1})	101.78
DTPA Zn (mg kg^{-1})	0.21

Table 2. Plant height (cm) at different growth stages of sweet corn as influenced by foliar application of nano N and nano Zn

Plant Height(cm)				
Treatment Details	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**
T_1- Absolute control	6.3	38.1	82.2	125.0
T_2- RDF (80:40:40)	6.5	37.5	97.0	149.0
T_3- T_2 + Zn @ 5 kg ha^{-1}	6.7	49.0	86.1	163.0
T_4- 50 % N + N foliar spray (vegetative stage) @ 4ml l^{-1}	7.0	54.1	90.8	144.0
T_5- 50% N + N foliar spray (vegetative + Tasseling)	6.7	50.7	104.7	165.3
T_6- T_5+ Zn foliar spray (silking stage) @ 4ml l^{-1}	6.2	51.7	96.1	163.3
T_7- T_5 + Zn foliarspray (Silking + Milking)	6.7	59.1	92.0	152.3
T_8- Nfoliar spray (Veg+Tasselling) + Zn foliar spray (Silking+Dough)	7.2	63.8	105.1	173.3
CD (5%)	1.70	8.60	9.57	18.03

Table 3. Leaf length (cm) at different growth stages of sweet corn as influenced by foliar application of nano N and nano Zn

Leaf length (cm)				
Treatment Details	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**
T_1- Absolute control	5.13	40.20	88.23	123.00
T_2- RDF (80:40:40)	5.43	42.10	88.93	135.00
T_3- T_2 + Zn @ 5 kg ha^{-1}	5.63	42.40	89.20	136.33
T_4- 50 % N + N foliar spray (vegetative stage) @ 4ml l^{-1}	5.53	42.77	89.10	139.00
T_5- T_4 + N spray (vegetative stage + Tasselling)	5.70	43.27	89.30	140.00
T_6- T_4 + Zn spray (silking stage) @ 4ml l^{-1}	5.70	44.10	89.90	139.67
T_7- T_4 + Zn spray (Silking + Milking)	5.80	44.47	90.10	140.00
T_8- N spray (Veg+Tasselling) + Zn spray (Silking+Dough)	6.07	45.03	91.27	143.67
CD (5%)	0.236	0.421	0.224	3.546

3.2.3 Chlorophyll content (SPAD)

The chlorophyll content measured by SPAD meter as influenced by application of nano nitrogen and nano zinc particles with50% of recommended dosed of fertilizer is presented in Table 4. There was significant difference in chlorophyll content of sweet corn at 30DAS with 50% N as urea, two foliar spray of nano N and two foliar sprays of nano Zn @ 4ml/L (49.5) over absolute control and at par with the other treatments except recommended dose of fertilizer. Some observations are also found in 45 and 60 days. Lower SPAD reading was recorded in absolute control. SPAD reading was varied from 27.9 to 49.5, 42.9 to 64.7 and 45.8 to 66.5 with the different treatment combination with 30, 45 and 60 days, respectively. Overall, with increase of growing period the chlorophyll content or the plants increased due to their growth. The measurement with SPAD is an indicative of greenness of the plant which indicate the chlorophyll content of the plant. Increase in chlorophyll content might be due to promotion of the absorption and utilization of nutrient such as N as nano form as concluded by Farnia and Omidi [8].

3.3 Yield of Sweetcorn

The effect of nano N and nano Zn on the yield attributes of sweet corn are presented in Table 5. The results shown that the cob yield of sweet corn ranged from 691 to 1685 $kgha^{-1}$ due to various treatments. Lowest yield (691 $kgha^{-1}$) was found in absolute control whereas highest yield (1685 $kgha^{-1}$) was found in T_7 (i.e., 50% N with two foliar sprays of nano N at vegetative and tasselling stage and two spray of nano Zn @4ml L^{-1} at silking and milking stage). The increase was 2.44 times over absolute control (143.8%). Significant yield in cob was observed in all the treatments. Application of recommended dose of fertilizer produce 1.43 times higher yield over control whereas addition of $ZnSO_4$ @ 20kg ha^{-1} with recommended dose of fertilizer gave 21% higher yield than recommended dose of fertilizer. Compare with conventional fertilizer with Zn, the application of 50% N with Nano N and Nano Zn as double foliar spray , the yield was increased by 41% whereas single spray of Zn, yield and increased by 26 %. The application of 50% N with two foliar sprays of nano N @ 4ml L^{-1} yield was increased by 8% over recommended dose of NPK. The application of 50% N with two foliar sprays of nano N with nano Zn @ 4ml L^{-1} at dough stage, yielded 1551 kg ha^{-1} , which was 3% increase over foliar spray of nano Zn at silking stage. Similarly, lowest stover yield (2648 kg ha^{-1}) was observed in absolute control whereas highest stover yield (3848 kg ha^{-1}) was observed in T8 treatment. All the treatment was significantly high over absolute control. Similar findings were also observed in the biological yield. Highest HI was found in T_7 (0.42) and lowest in control (0.27). The increase in grain yield might be due to the favourable influence of nitrogen and zinc in increasing the source, size and establishing an appropriate source to sink relationship respectively. However, increase in stover yield was attributed due to enhanced morphological characters. Similar findings were observed by Alim Hammadi [9]; Bhuiya et al. [10]; Mohanta et al. [11]; Sammi et al. [12]. Improvement of HI was due to photosynthates to grain filling rather accumulation of straw.

3.4 Nutrient Concentration of Sweetcorn

The effect of nano N and nano Zn with conventional fertilizer in the nutrient concentration of sweet corn are presented in Table 6. The results shown that nitrogen concentration in cob was varied from 1.28 to 2.85% whereas in stover N concentration varied from 1.90 to 4.67%. Lowest concentration was found in control and highest N concentration was found in T_8 treatment. The concentration was found to be more in stover than cob.

The P concentration in cob was varied from 0.26 to 0.40 percent whereas the stover concentration varied from 0.28 to 0.36%. The P concentration was more in cob than stover. The P concentration of cob was lower in control and highest in T_8 treatments. Similar results were found in case of stover.

The K concentration in cob was ranged from 0.54 to 0.62% whereas in stover it was 0.49 to 0.57%. The K concentration was more in cob than in stover.

Zn concentration in the cob varied from 24.3 to 42 ppm whereas in stover it was found to be 20.7 to 50.2 ppm. Lowest Zn concentration was found in control and highest concentration was found in T_8 treatment.

3.5 Nutrient Uptake of Sweetcorn

The effect of nano N and nano Zn on the nutrient uptake by sweet corn are presented in Table 7.

The results shown that the uptake of N was in the range of 8.88 to 44.16 kg ha^{-1} in the cob whereas in stover content was in the range of 50.82 to 181.43 kg ha^{-1}. The uptake of P in the cob was varied from 1.94 to 6.25kg ha^{-1}whereas in stover it was varied from 7.32 to 13.37 kg ha^{-1}. But K uptake of cob was varied from 3.74 to 10.17 kg ha^{-1} whereas in stover it was found to be 12.88 to 21.83 kg ha^{-1}. The increase in content and uptake of nutrients may be the proposed vegetative growth and crop growth. Therefore, activating absorption of nutrients which resulted in N, P & K uptake by sweet corn. Similar observation was made by Sipai et al. [13].

Zinc had a beneficial effect of nutrient NPK content and uptake by sweet corn may be attributed to higher uptake on account of correcting deficiency of Zn which is the limiting factor for growth and uptake. The uptake was significantly increased due to addition of Zn. Zn uptake in cob was varied from 16.76 to 69.37 g ha^{-1} whereas in stover it was found that it varied from 54.74 to 193.16 g ha^{-1}. It was observed that Zn uptake was more in case of stover than cob, may be due to balanced nutrition to crop which stimulate the metabolic activity resulting better growth which helping in utilization of nutrients absorbed by plant leading to dry matter production[14-24].

Table 4. Soil Plant Analysis Development (SPAD) reading at different growth stages of sweet corn

Soil Plant Analysis Development (SPAD)			
Treatment Details	**30 DAS**	**45 DAS**	**60 DAS**
T_1- Absolute control	27.9	42.9	45.8
T_2- RDF (80:40:40)	46.0	59.9	62.2
T_3- T_2 + Zn @ 5 kg ha^{-1}	46.8	60.7	63.5
T_4- 50 % N + N foliar spray (vegetative stage) @ 4ml l^{-1}	47.7	62.2	62.3
T_5- T_4 + N spray (vegetative stage + Tasselling)	48.0	63.7	63.1
T_6- T_4 + Zn spray (silking stage) @ 4ml l^{-1}	48.5	62.2	62.3
T_7- T_4 + Zn spray (Silking + Milking)	49.5	61.5	66.5
T_8- N spray (Veg+Tasselling) + Zn spray (Silking+Dough)	47.9	64.7	64.0
CD (5%)	3.10	7.39	5.98

Table 5. Cob weight (g), Stover weight (kg), Cob yield (kg/ha), Stover yield (kg/ha) Harvest index of Sweet corn as influenced by foliar application of nano nitrogen and nano Zn

Treatment Details	**Cob Weight (g)**	**Stover Weight (Kg)**	**Cob yield (kg/ha)**	**Stover yield (kg/ha)**	**Biological yield (kg/ha)**	**Harvest Index**
T_1- Absolute control	212.10	11.12	691	2648	4137.22	0.27
T_2- RDF (80:40:40)	275.93	12.82	986	3053	4651.43	0.34
T_3- T_2 + Zn @ 5 kg ha^{-1}	278.07	12.94	1192	3081	4868.23	0.37
T_4- 50 % N + N foliar spray (vegetative stage) @ 4ml l^{-1}	282.40	13.07	964	3111	5150.77	0.40
T_5- T_4 + N spray (vegetative stage + Tasselling)	285.23	13.78	1064	3281	5497.66	0.40
T_6- T_4 + Zn spray (silking stage) @ 4ml l^{-1}	287.37	14.38	1505	3424	5840.32	0.41
T_7- T_4 + Zn spray (Silking + Milking)	290.87	14.73	1685	3506	6024.37	0.42
T_8- N spray (Veg+Tasselling) + Zn spray (Silking+Dough)	296.17	16.16	1551	3848	6551.49	0.41
CD (5%)	9.52	0.49	10.48	11.73	--	--

Table 6. Nutrient concentrationof sweet corn as influenced by foliar application of nano N and nano Zn

Treatment Details	N conc (%)		P conc (%)		K conc (%)		Zn conc (ppm)	
	Cob	Stover	Cob	Stover	Cob	Stover	Cob	Stover
T_1- Absolute control	1.28	1.90	0.26	0.28	0.54	0.49	24.3	20.7
T_2- RDF (80:40:40)	1.34	2.21	0.30	0.31	0.58	0.50	29.6	27.8
T_3- T_2 + Zn @ 5 kg ha^{-1}	1.48	2.32	0.33	0.32	0.59	0.53	32.1	28.4
T_4- 50 % N + N foliar spray (vegetative stage) @ 4ml l^{-1}	1.66	2.53	0.33	0.31	0,57	0.53	37.8	32.1
T_5- T_4 + N spray (vegetative stage + Tasselling)	2.03	3.27	0.33	0.36	0.58	0.51	38.4	34.2
T_6- T_4 + Zn spray (silking stage) @ 4ml l^{-1}	2.19	4.52	0.34	0.30	0.55	0.55	40.5	40.3
T_7- T_4 + Zn spray (Silking + Milking)	2.57	4.01	0.36	0.34	0.60	0.57	41.2	43.1
T_8- N spray (Veg+Tasselling) + Zn spray (Silking+Dough)	2.85	4.67	0.40	0.35	0.62	0.57	42.0	50.2
CD (5%)	0.45	0.72	0.002	0.06	0.006	0.08	1.21	4.76

Table 7. Nutrient uptake (kg ha^{-1}) of sweet corn as influenced by foliar application of nano N and nano Zn

Treatment Details	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})		Zn uptake (g ha^{-1})	
	Cob	Stover	Cob	Stover	Cob	Stover	Cob	Stover
T_1- Absolute control	8.88	50.82	1.80	7.32	3.74	12.88	16.76	54.74
T_2- RDF (80:40:40)	13.33	67.48	2.94	9.34	5.71	15.41	29.20	84.74
T_3- T_2 + Zn @ 5 kg ha^{-1}	17.61	71.42	3.91	9.87	6.99	16.27	38.19	87.37
T_4- 50 % N + N foliar spray (vegetative stage) @ 4ml l^{-1}	15.99	78.65	3.20	9.54	5.49	16.38	36.45	100.02
T_5- T_4 + N spray (vegetative stage + Tasselling)	21.69	107.45	3.55	11.94	6.13	16.86	40.90	112.24
T_6- T_4 + Zn spray (silking stage) @ 4ml l^{-1}	32.88	154.49	5.15	10.26	8.24	18.86	60.88	138.46
T_7- T_4 + Zn spray (Silking + Milking)	43.17	140.53	6.07	11.91	10.17	20.01	69.37	151.08
T_8- N spray (Veg+Tasselling) + Zn spray (Silking+Dough)	44.16	181.43	6.25	13.37	9.55	21.83	65.13	193.16
CD (5%)	5.27	23.19	0.33	1.98	0.59	2.79	0.30	1.88

Table 8. Effect of nano N and nano Zn with conventional fertilizer on post-harvest soil of sweet corn

Treatment Details	pH	EC (µs m^{-1})	OC (%)	Avail N (kg ha^{-1})	Avail P (kg ha^{-1})	Avail K (kg ha^{-1})	Avail Zn (mg kg^{-1})
T_1- Absolute control	5.21	171.82	0.45	183.98	13.32	131.45	0.31
T_2- RDF (80:40:40)	5.10	177.07	0.52	200.70	16.98	146.94	0.34
T_3- T_2 + Zn @ 5 kg ha^{-1}	5.15	231.93	0.60	217.43	17.24	151.16	0.35
T_4- 50 % N + N foliar spray (vegetative stage) @ 4ml l^{-1}	5.64	286.67	0.62	267.61	19.33	153.96	0.40
T_5- T_4 + N spray (vegetative stage + Tasselling)	5.80	248.07	0.65	309.42	22.46	162.51	0.40
T_6- T_4 + Zn spray (silking stage) @ 4ml l^{-1}	5.98	322.23	0.69	317.78	24.55	170.65	0.45
T_7- T_4 + Zn spray (Silking + Milking)	6.07	352.20	0.70	326.14	24.81	169.79	0.46
T_8- N spray (Veg+Tasselling) + Zn spray (Silking+Dough)	6.21	367.13	0.72	393.05	26.12	179.57	0.45
Initial Status	**5.42**	**166.04**	**0.42**	**165.78**	**12.76**	**101.78**	**0.21**
CD (5%)	0.88	16.19	0.07	16.12	4.23	34.12	0.04

3.6 Post harvest Soil Analysis

The effect of nano N and nano Zn on post-harvest soil of sweet corn are presented in Table 8. After harvesting of plant, it was observed that the range of the pH varied from 5.21 to 6.21 which was higher than the initial value (i.e., 5.42). Similarly, the value of EC varied from 171.82 to 367.13 µs m^{-1} which was also higher than the initial value (i.e., 166.04 µs m^{-1}). It was observed that the organic carbon in sweet corn was varied from 0.45% to 0.72% which was also higher than the initial value (i.e., 0.42%). It may be due to the incorporation of plant materials to the soil. The results showed that available nitrogen in sweetcorn was varied from 183.98 to 393.05 kg ha^{-1}. The highest value (393.05 kg ha^{-1}) was found in the treatment of T_8 and lowest value (183.98 kg ha^{-1}) in control. Available N content of soil was increase over initial N. Similarly, results of available phosphorus were varied from 13.32 to 26.12 kg ha^{-1}. The highest value (26.12 kg ha^{-1}) was found in T_8 and lowest value (13.32 kg ha^{-1}) was in control. Available K ranges varied from 131.45 to 179.57 kg ha^{-1}. Like available N and P, the highest value (179.57 kg ha^{-1}) of available K was found in the treatment of T_8whereas lowest value (131.45 kg ha^{-1}) was found in control. Available Zn the ranges varied from 0.31 to 0.46mg kg^{-1}. Highest value was observed in the treatment of T_7 (0.46 mg kg^{-1}) followed by T_8 (0.45 mg kg^{-1}) and lowest value was observed in control.

4. CONCLUSION

Application of nanomaterials in agriculture as nutrients is promising. In field conditions, different parameters of sweetcorn like physiological parameters, yield and yield attributes were highly influenced by nano fertilizers. In the above field experiment, application of 50% N with two foliar sprays of nano N at vegetative and tasselling stage and two spray of nano Zn @4ml l^{-1} at silking and dough stage (T_8) helps in increasing the yield of sweet corn as well as nutrient concentration and nutrient uptake followed by T_7 (50 % N + N foliar spray at vegetative stage @ 4ml l^{-1} + Zn spray at Silking and Milking stage). Physical properties of soil after harvest of sweetcorn maintaining the soil fertility status with sustaining soil health. Foliar application of nano fertilizer helps in delivery of nutrients into the plant system can be effective and through agronomic bio-fortification micronutrient deficiencies could be corrected which can reflect in human health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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