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Effect of organic manures and nano-zinc on growth and yield of sweetcorn

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Abstract
A field experiment was conducted during *Kharif* season of 2023 at Crop Research Farm Department of Agronomy. The treatments consisted of 3 different treatment of organic manures (Farm yard manure, poultry manure and vermicompost) and 3 levels of nano-zinc foliar spray (100 ppm, 250 ppm and 500 ppm), control (120-60-40 kg N-P-K/ha). The experiment was laid out in a Randomized Block Design with 10 treatments and replication thrice. Application of vermicompost 4 t/ha along with 500 ppm foliar spray of Nano-Zinc (Treatment 9) recorded highest plant height (182.48 cm), maximum plant dry weight (138.02 g), highest no. cobs per plant (2.71), highest no. of grains per row (36.94), highest no. of rows per cob (15.75), cob-length (17.26 cm), cob yield (6.93 t/ha), green fodder yield (14.92 t/ha). The aforesaid treatment 9 also recorded maximum gross return (INR 1,63,050), net return (INR 1,14,065) and B:C ratio (2.33).

Keywords: Organic manures, nano-zinc, sweet corn

Introduction
Sweetcorn, scientifically known as *Zea mays* convar. *saccharata* var. *rugosa*, plays a pivotal role in India's agricultural sector, both in terms of cultivation area and production volumes. This cereal crop, esteemed for its sweetness and versatility, contributes significantly to the nation's culinary traditions, economic prosperity, and food security objectives.

In recent years, India has witnessed a notable expansion in the cultivation area dedicated to sweetcorn. As per agricultural statistics, the total area under sweetcorn cultivation has increased substantially, reaching approximately 200,000 hectares in the most recent reporting period. This expansion underscores the growing importance of sweetcorn within India's cropping systems, reflecting favorable agronomic conditions and increasing demand.

Accompanying the expansion in cultivation area is a significant rise in sweetcorn production levels. India ranks among the top producers of sweetcorn globally, with annual production volumes surpassing 1.5 million metric tons. This robust production output not only meets domestic consumption needs but also supports export markets, contributing to India's agricultural exports and foreign exchange earnings.

The distribution of sweetcorn cultivation and production is diverse across various states of India. States such as Karnataka, Uttar Pradesh, Maharashtra, and Andhra Pradesh are among the leading producers, accounting for a substantial share of the total production. This geographical diversity highlights the adaptability of sweetcorn to different agro-climatic conditions and its significance in enhancing agricultural livelihoods across multiple regions.

Organic manures, such as Farm Yard Manure (FYM), poultry manure, and vermicompost, have gained increasing attention in agricultural practices due to their role in enhancing soil fertility, improving crop productivity, and promoting sustainable agriculture. These natural fertilizers, derived from organic sources, offer a range of essential nutrients and beneficial microorganisms that support plant growth and development.

In addition to traditional organic amendments, modern agricultural techniques have introduced innovative approaches like nano zinc foliar spray, which involves the application of nano-sized zinc particles directly onto plant foliage. This method aims to address zinc deficiency in plants, a common nutritional constraint that can significantly impact crop yield and quality.

Both organic manures and nano zinc foliar spray hold promise in augmenting plant nutrition, fostering environmentally friendly farming practices, and mitigating the adverse effects of conventional chemical fertilizers. Through comprehensive analysis and experimentation, this study aims to elucidate the potential of organic manures and nano zinc foliar spray in promoting sustainable agriculture and enhancing crop productivity in sweetcorn cultivation.

Materials and Methods

During the *Kharif* season of 2023, field experiment was carried out in alluvial soil at the Crop Research Farm of the Department of Agronomy, SHUATS, Prayagraj, Uttar Pradesh. The soil of experimental plot was sandy loamy, having a nearly neutral soil reaction (pH 6.8), electrical conductivity (0.296 ds/m).

The experiment was conducted in Randomised Block Design consisting of 10 treatment and 3 replications. The treatment consist of 3 different organic manures (Farm Yard Manure 10 t/ha, Poultry manure 3 t/ha, Vermicompost 4 t/ha) and 3 levels of Nano-Zinc foliar application (100, 250 and 500 ppm).

The combine treatment are as follows, T_1 : Nano-Zinc at 100 ppm + FYM 10 t/ha, T_2 : Nano-Zinc at 250 ppm + FYM 10 t/ha, T_3 : Nano-Zinc at 500 ppm + FYM 10 t/ha, T_4 : Nano-Zinc at 100 ppm + Vermicompost 4 t/ha, T_5 : Nano-Zinc at 250 ppm + Vermicompost 4 t/ha, T_6 : Nano-Zinc at 500 ppm + Vermicompost 4 t/ha, T_7 : Nano-Zinc at 100 ppm + Poultry-manure 3 t/ha, T_8 : Nano-Zinc at 250 ppm + Poultry-manure 3 t/ha, T_9 : Nano-Zinc at 500 ppm + Poultry-manure 3 t/ha, T_{10} : 120:60:40 NPK kg/ha (control). Plant growth parameters, such as plant height (cm), plant dry weight (g/plant) were measured at 20 days intervals from germination till harvest and yield and yield attributes, such as No. of cobs/plant, No. of rows/cob, No. of grains/row, cob length (cm), green fodder yield (t/ha) and harvest index (%) were measured at harvest. The observed data were statistically analysed using analysis of variance (ANOVA) as applicable to Randomized Block Design.

Results and Discussion

Growth Parameters

The data presented in Table 1 demonstrates the influence of various treatments on growth parameters of sweetcorn. Significant variations were observed in plant height, dry weight, crop growth rate, and relative growth rate among the different treatments.

Treatments combining different concentrations of nano zinc foliar spray with organic manures exhibited notable effects on plant height (80 DAS). For instance, treatment 9, involving nano zinc at 500 ppm with vermicompost 4 t/ha, resulted in the tallest plants with a height of 182.48 cm, followed closely by treatment 6, with a height of 169.51 cm. This indicates a positive impact of higher concentrations of nano zinc in conjunction with vermicompost on plant height.

Similarly, the dry weight of plants (80 DAS) also showed significant variation across treatments. Treatment 9, comprising nano zinc at 500 ppm with vermicompost 4 t/ha, exhibited the highest dry weight of 138.02 g per plant, while treatment 10, the control, recorded the lowest dry weight of 115.81 g per plant. This suggests that the combined application of higher concentrations of nano zinc and vermicompost resulted in increased plant biomass accumulation.

Crop growth rate (during 40-60 DAS) and relative growth rate (during 60-80 DAS) were also influenced by the treatments. Treatment 9, with nano zinc at 500 ppm and vermicompost 4 t/ha, demonstrated the highest crop growth rate of 28.67 g/m2/day and a relative growth rate of 0.0224 g/g/day during the respective periods. Conversely, treatment 10, the control, exhibited the lowest crop growth rate and relative growth rate, indicating the beneficial effects of nano zinc and vermicompost on the growth dynamics of sweetcorn.

Overall, the results suggest that the combined application of nano zinc foliar spray and organic manures, particularly at higher concentrations, positively influenced the growth parameters of sweetcorn, highlighting the potential of these treatments in enhancing crop productivity and yield.

Yield Attributes

Sweetcorn production is influenced by various factors, including nano-zinc supplementation and organic-manure application. In our study, we focused on evaluating the yield attributes of sweetcorn under different treatments, with a particular emphasis on the combined effect of nano-zinc and vermicompost.

Our analysis revealed compelling insights into the impact of nano-zinc at varying concentrations (100 ppm, 250 ppm, and 500 ppm) combined with Vermicompost (4 t/ha) on key yield attributes:

Nano-zinc at 500 ppm combined with vermicompost 4 t/ha exhibited the highest average number of cobs per plant, with approximately 2.71 cobs observed. This suggests a significant improvement in reproductive success and yield potential compared to other treatments.

Treatments with nano-zinc at 500 ppm alongside vermicompost 4 t/ha also resulted in an increased number of rows per cob, averaging around 15.75 rows. This indicates enhanced kernel arrangement and potential for higher yield per cob.

Notably, the treatment combination of nano-zinc at 500 ppm with vermicompost 4 t/ha demonstrated a higher number of grains per row, with an average of approximately 36.94 grains. This signifies improved kernel development and overall yield potential.

Our findings indicate that sweetcorn cobs under the nano-zinc at 500 ppm and vermicompost 4 t/ha treatment combination displayed longer cob lengths, averaging around 17.26 cm. This suggests improved growth and development, contributing to higher marketable yields.

The most significant impact was observed in cob yield, with the treatment combination of nano-zinc at 500 ppm and vermicompost 4 t/ha resulting in the highest cob yield, averaging approximately 6.93 tons per hectare. This highlights the potential for increased productivity and economic returns with optimized nutrient management practices.

Also in term of green-fodder production was found significantly higher after the treatment of nano-zinc 500 ppm along with vermicompost 4 t/ha was applied, the green-fodder yield was noted around 14.92 t/ha. Harvest index was noticeably higher than other when compared in (Table no. 2) of around 31.71%.

Overall, our study underscores the importance of nano-zinc supplementation, particularly at higher concentrations in conjunction with poultry manure, in enhancing yield attributes crucial for sweetcorn production. These findings provide valuable insights for farmers and researchers aiming to optimize cultivation practices and achieve sustainable sweetcorn yields.

Table 1: Application of Organic-Manures and Nano-Zinc on growth parameters of Sweetcorn.

S. No.	Treatments	Plant height (cm) (80 DAS)	Dry weight (g/plant) (80 DAS)	Crop Growth Rate ($g/m^2/day$) (During 40-60 DAS)	Relative Growth rate (g/g/day) (During 60-80 DAS)
1.	Nano-Zinc at 100 ppm + FYM 10 t/ha	157.21	122.26	26.05	0.0215
2.	Nano-Zinc at 250 ppm + FYM 10 t/ha	165.28	128.84	26.25	0.0210
3.	Nano-Zinc at 500 ppm + FYM 10 t/ha	167.32	126.94	26.18	0.0211
4.	Nano-Zinc at 100 ppm + Poultry manure 3 t/ha	157.34	125.06	26.63	0.0201
5.	Nano-Zinc at 250 ppm + Poultry manure 3 t/ha	165.58	126.78	25.43	0.0219
6.	Nano-Zinc at 500 ppm + Poultry manure 3 t/ha	169.51	128.84	27.03	0.0198
7.	Nano-Zinc at 100 ppm + Vermicompost 4 t/ha	167.84	129.11	25.83	0.0216
8.	Nano-Zinc at 250 ppm + Vermicompost 4 t/ha	169.40	127.72	25.93	0.0217
9.	Nano-Zinc at 500 ppm + Vermicompost 4 t/ha	182.48	138.02	28.67	0.0224
10.	Control (120:60:40 kg/ha NPK)	153.14	115.81	23.82	0.0220
	SEm(±)	0.54	0.69	0.43	0.02
	CD (P=0.05)	1.10	1.44	0.89	-

Table 2: Application of Organic-Manures and Nano-Zinc on yield and yield attributes of Sweetcorn.

S. No.	Treatments	Cobs/ Plant (No.)	No. of rows/cob	No. of grains/row	Cob length (cm)	Cob yield (t/ha)	Green fodder yield (t/ha)	Harvest index %
1.	Nano-Zinc at 100 ppm + FYM 10 t/ha	2.13	15.13	36.20	15.18	5.23	12.24	29.93
2.	Nano-Zinc at 250 ppm + FYM 10 t/ha	2.06	14.87	35.20	15.42	5.04	13.46	27.24
3.	Nano-Zinc at 500 ppm + FYM 10 t/ha	2.22	15.33	36.00	16.06	5.54	11.79	31.96
4.	Nano-Zinc at 100 ppm + Poultry manure 3 t/ha	2.26	14.93	35.93	15.39	5.47	12.32	30.74
5.	Nano-Zinc at 250 ppm + Poultry manure 3 t/ha	2.00	15.67	35.92	15.78	4.84	12.45	27.99
6.	Nano-Zinc at 500 ppm + Poultry manure 3 t/ha	1.93	15.33	36.31	16.37	4.73	11.77	28.66
7.	Nano-Zinc at 100 ppm + Vermicompost 4 t/ha	2.13	15.00	36.07	15.22	5.18	13.59	27.59
8.	Nano-Zinc at 250 ppm + Vermicompost 4 t/ha	2.00	15.20	36.87	16.20	5.01	12.85	28.05
9.	Nano-Zinc at 500 ppm + Vermicompost 4 t/ha	2.71	15.75	36.94	17.26	6.93	14.92	31.71
10.	Control (120:60:40 kg/ha NPK)	1.91	14.13	34.65	13.96	4.26	10.23	29.39
	SEm(±)	0.12	0.33	0.32	0.43	0.14	0.34	0.41
	CD (P=0.05)	-	0.67	0.66	0.87	0.29	0.72	0.87

Table 3: Application of Organic-Manures and Nano-Zinc on economics of Sweetcorn

S. No.	Treatments	Cost of cultivation (INR /ha)	Gross return (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	Nano-Zinc at 100 ppm + FYM 10 t/ha	48,845	1,22,500	73,655	1.51
2.	Nano-Zinc at 250 ppm + FYM 10 t/ha	49,535	1,28,500	78,965	1.59
3.	Nano-Zinc at 500 ppm + FYM 10 t/ha	51,830	1,37,900	86,070	1.66
4.	Nano-Zinc at 100 ppm + Poultry manure 3 t/ha	42,880	1,36,400	93,250	2.18
5.	Nano-Zinc at 250 ppm + Poultry manure 3 t/ha	43,140	1,38,300	95,160	2.21
6.	Nano-Zinc at 500 ppm + Poultry manure 3 t/ha	43,850	1,34,700	90,850	2.07
7.	Nano-Zinc at 100 ppm + Vermicompost 4 t/ha	47,930	1,28,300	80,370	1.68
8.	Nano-Zinc at 250 ppm + Vermicompost 4 t/ha	48,390	1,44,700	96,310	1.99
9.	Nano-Zinc at 500 ppm + Vermicompost 4 t/ha	48,985	1,63,050	1,14,065	2.33
10.	Control (120:60:40 kg/ha NPK)	40,450	1,01,500	61,050	1.50

Economics
The data pertaining to the economics of different treatments presented in the Table no. 3 showed that maximum gross return (INR 1,63,050), net returns (INR 1,14,065), and benefit to cost ratio (2.33) was obtained in the treatment 9 of Nano-Zinc at 500 ppm + vermicompost 4 t/ha and the minimum gross returns (1,01,500), net returns (40,450), and benefit to cost ratio (1.50) was obtain from treatment 10.

Conclusions
In summary, our study demonstrates the significant benefits of integrating nano-zinc with organic manures in sweetcorn cultivation. Nano-zinc treatments consistently improved growth parameters and yield attributes compared to conventional methods, particularly when combined with vermicompost. Economically, these integrated approaches showed higher returns and cost-effectiveness. This highlights their potential for sustainable and profitable sweetcorn production, offering both agronomic and economic advantages. Moving forward, wider adoption of these strategies could enhance crop productivity while promoting environmental sustainability in agriculture.

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