Original Research Article

Effect of traditional fertilizer, nano fertilizer and micronutrient on growth, yield and quality of Chilli (*Capsicum annum* L.).

ABSTRACT

The present investigation entitled on **Effect of traditional fertilizer, nano fertilizer and micronutrient on growth, yield and quality of Chilli (*Capsicum annum* L.)** was carried out at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during *Kharif* season 2022 on variety TMPH-409. The experiment was laid out in Randomized block design with 11 treatments and 3 replications with different combination in nano fertilizers. Among the treatments tested, T_2 (75% N (through traditional method), 100% PK, 100% $ZnSO_4$, and 25% N as foliar spray through Nano urea) showed the most favorable results in terms of plant height (99.69 cm at 90 DAT), number of primary branches (8.18 branches at 90 DAT), and early flowering (38.16 DAT) and maturing (72.14 DAT). T_2 also demonstrated superior performance in terms of fruit weight (2.72 g), length of fruit (7.52 cm), fruit girth (2.76), number of fruits per plant (260.10 fruits), and yield per plant (173.07 g/plant) and fruit yield per hectare (23.37 q/ha).

Keywords: *Nano urea, foliar spray, zinc sulphate.*

1.INTRODUCTION

Chilli (vernacular name: Mirchi), botanically known as *Capsicum annuum* (L.) is one of the well-known plants belonging to Solanaceae. It is a diploid cross-pollinated dicot plant species with chromosome number 2n=2x=24 **(Haque, 2016)**. Capsicum plants originated in modern-day Bolivia and have been a part of human diets since about 7,500 BC **(Pickersgill, 1971)**. They are one of the oldest cultivated crops in the Americas. Origins of cultivating chili peppers have been traced to east-central Mexico some 6,000 years ago, although, according to research by the New York Botanical Garden press in 2014, chili plants were first cultivated independently across different locations in the Americas including highland Bolivia, central Mexico, and the Amazon (Katherine, 2014). They were one of the first self-pollinating crops cultivated in Mexico, Central America, and parts of South America.

Nano fertilizers play a crucial role in agriculture by enhancing crop growth, yield, and quality while improving nutrient use efficiency and reducing fertilizer wastage and cultivation costs. These fertilizers can be applied to the soil or leaves, making foliar application possible even in unfavourable soil and weather conditions. Nano fertilizers have shown great potential in improving the growth and productivity of chili crops. They offer several advantages, including enhanced nutrient uptake, increased nutrient use efficiency (NUE), and reduced fertilizer wastage **(Saranya *et al.,* 2019)**. Traditional fertilizers play a crucial role in chili crop production by providing essential nutrients necessary for plant growth and development. These fertilizers typically consist of macro and micronutrients such as nitrogen (N), phosphorus (P), and potassium (K), along with secondary and trace elements. They contribute to improved plant vigour, flower formation, fruit set, and overall yield **(Yadav *et al.,* 2020)**. Nanoparticles, due to their high reactivity and small size, can penetrate plant tissues and increase the efficiency of nutrient uptake. Nano-fertilizers can be engineered for controlled nutrient release, ensuring a steady supply of nutrients over time, leading to better growth and yield. Directly targeting plant roots with nano-fertilizers and nano-zinc can reduce the amount of fertilizer required, decreasing the environmental impact of excess fertilizer application. Additionally, studies have shown that nano-fertilizers and nano-zinc can improve the ability of plants to resist various environmental stresses, such as drought and disease, leading to better growth and yield even under adverse conditions. Overall, the use of nanoparticles in agriculture has the potential to increase efficiency, reduce environmental impact, and improve plant growth and yield. Keeping these above point the present investigation was undertaken with aim to study the effect of different concentration of traditional fertilizer, nano fertilizer, and micronutrient on growth, yield and quality of chilli.

2.MATERIALS AND METHODS

The present investigation was done to understand the impact of combine application and sole application of traditional fertilizers, nano fertilizers and micronutrients on plant growth, fruit yield and quality of fruit of chilli variety TMPH-409 with spacing 60 x 45 cm (R x P) which was carried out at Horticultural Research Farm (HRF), Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during the *Kharif* season of 2022. The experiment was laid out in Randomized block design with 11 treatments and 3 replications with different combinations of nano fertilizer and micronutrients on plant *viz*. **T_0** (RDF (NPK @ 120:80:80 kg/ha) + FYM @ 10 t/ha); **T_1** (100% NPK traditional Fertilizer + 100% $ZnS0_4$ (as basal); **T_2** (75% N (through traditional method) + 100% PK + 100% $ZnSO_4$ + 25% N as foliar spray through Nano urea); **T_3** (50% N (through traditional method) + 100% PK + 100% $ZnSO_4$ + 50% N as foliar spray through Nano urea); **T_4** (25% N (through traditional method) + 100% PK + 100% $ZnSO_4$ + 75% N as foliar spray through Nano urea); **T_5** (100% NPK + 75% $ZnSO_4$ (through traditional method) + 25% Zn as foliar spray through Nano Zinc); **T_6** (100% NPK + 50% $ZnSO_4$ (through traditional method) + 50% Zn as foliar spray through Nano Zinc); **T_7** (100% NPK + 25% $ZnSO_4$ (through traditional method) + 75% Zn as foliar spray through Nano Zinc); **T_8** (100% Nano urea + 100% PK + 100% $ZnSO_4$ (as basal)); **T_9** (100% Nano Zinc + 100% NPK through traditional method); **T_{10}** (100% Nano urea + 100% Nano Zn + 100% PK (as basal). Observations were recorded at different stages of growth periods and studied for growth parameters like plant height, number of branches per plant, earliness parameters like days to first flowering, days to first fruit picking, yield parameters like fruit length, fruit girth, fruit weight and quality parameters TSS and vitamin C content. The data were statistically analysed by the method suggested by **Fisher and Yates, 1963.** The height of five randomly selected plants from each plot was measured in cm with of a 100 cm meter scale from ground level to tip of the shoot at 90 DAT stage.

3.RESULTS AND DISCUSSION:

3.1 Growth parameters

3.1.1 Influence of traditional fertilizer, nano fertilizer and micronutrient on Plant height (cm)

The maximum plant height at 90 DAT (99.69 cm) was observed with treatment T_2. Minimum plant height at 90 DAT (74.13 cm) was observed in T_0. Nano fertilizers have the potential to enhance plant height in chili crops by improving nutrient uptake and utilization. The small particle size of nano fertilizers facilitates their efficient absorption by plant roots, leading to increased nutrient availability. This can promote vigorous growth and development, resulting in taller chili plants. The enhanced nutrient uptake provided by nano fertilizers can contribute to achieving better plant height in chili crop cultivation. Similar findings were reported by **Ahmed *et al.*, (2021); Parani and Nanthini (2021)**.

3.1.2 Influence of traditional fertilizer, nano fertilizer and micronutrient on number of branches per plant

The maximum number of primary branches at 90 DAT (8.18 branches) was observed with treatment T_2. Minimum number of primary branches at 90 DAT (5.04 branches) was observed in T_0. Nano fertilizers can play a role in enhancing the number of primary branches in chili crops. By improving nutrient availability and uptake, nano fertilizers support the development of a robust root system. This, in turn, promotes the formation of more primary branches in chili plants. The increased nutrient uptake provided by nano fertilizers helps stimulate lateral shoot growth, leading to a higher number of primary branches and ultimately enhancing the overall yield potential of the chili crop. Similar findings were reported by **Mishra *et al.*, (2020); Ahmed *et al.*, (2021)**.

3.2. Earliness parameter

3.2.1 Influence of traditional fertilizer, nano fertilizer and micronutrient on days to first flowering, days to 50% flowering and days to first fruit harvest

The days to first flowering significantly varied among different treatment combinations at harvest. The minimum days to first flowering at harvest (38.16 days) was observed with treatment T_2. Maximum days to first flowering at harvest (46.31 days) was observed in T_0. The days to 50% flowering significantly varied among different treatment combinations at harvest. The minimum days to 50% flowering at harvest (44.59 days) was observed with treatment T_2. Maximum days to 50% flowering at harvest (53.66 days) was observed in T_0. The days to first harvest of fruit significantly varied among different treatment combinations at harvest. The minimum days to first harvest of fruit at harvest (72.14 days) was observed with treatment T_2. Maximum days to first harvest of fruit at harvest (77.34 days) was observed in T_0. Nano fertilizers application regulates early flowering and maturity in chilli by influencing flowering hormone levels and accelerating reproductive development. Moreover, micronutrient such as zinc sulphate can promote flower bud initiation, shorten the time to flowering, and facilitate early fruit set and maturation, leading to an expedited flowering and maturity process in chilli plants. Similar conclusions were inferred by **Yogaraju *et al.*, (2019); Parani and Nanthini (2021)**.

3.3 Yield Parameters

3.3.1 Influence of traditional fertilizer, nano fertilizer and micronutrient on number of fruits per plant

The number of fruits per plant of fruit significantly varied among different treatment combinations at harvest. The maximum number of fruits per plant of fruit at harvest (260.10 fruits) was observed with treatment T_2. Minimum number of fruits per plant of fruit at harvest (97.09 fruits) was observed in T_0. Nano fertilizers application enhances the number of fruits per plant in chilli by stimulating flower initiation, improving pollination and fertilization, and increasing fruit set. Nano fertilizers, such as nano urea along with micronutrient zinc promote flower bud differentiation, enhance flower viability, and ultimately contribute to an increased yield of fruits per plant in chilli crops. Similar conclusions were inferred by **Malik *et al.*, (2020); Mishra *et al.*, (2020)**.

3.3.2 Influence of traditional fertilizer, nano fertilizer and micronutrient on fruit length (cm) and fruit girth (cm)

The maximum average fruit length of fruit at harvest (7.52 cm) was observed with treatment T_2. Minimum average fruit length of fruit at harvest (6.07 cm) was observed in T_0. The maximum average fruit girth of fruit at harvest (2.76 cm) was observed with treatment T_2. Minimum average fruit girth of fruit at harvest (2.15 cm) was observed in T_0. Nano fertilizers, along with micronutrients, play a significant role in enhancing fruit length and fruit girth in chili crops. Nano fertilizers with their small particle size ensure efficient nutrient absorption and uptake, providing essential elements for fruit development. Micronutrients, such as zinc are crucial for various physiological processes that influence fruit growth. Their balanced application in nano form enhances nutrient availability, leading to improved fruit length and quality in chili crops, thereby increasing overall yield potential. These results are in close conformity with the findings of **Parani and Nanthini (2021); Rather *et al.*, (2022)**.

3.3.3 Influence of traditional fertilizer, nano fertilizer and micronutrient on fruit weight (g), fruit yield per plant (g/plant) and fruit yield per hectare (q/ha)

The maximum average fruit weight of fruit at harvest (2.72 g) was observed with treatment T_2. Minimum average fruit weight of fruit at harvest (2.21 g) was observed in T_0. The maximum fruit yield per plant of fruit at harvest (173.03 g/plant) was observed with treatment T_2. Minimum fruit yield per plant of fruit at harvest (64.90 g/plant) was observed in T_0. The maximum fruit yield per hectare of fruit at harvest (23.37 q/ha) was observed with treatment T_2 (75% N (through traditional method) + 100% PK + 100% $ZnSO_4$ + 25% N as foliar spray through Nano urea). Minimum fruit yield per hectare of fruit at harvest (8.80 q/ha) was observed in T_0 (RDF (NPK @ 120:80:80 kg/ha) + FYM @ 10 t/ha). The combined application of nano fertilizers and micronutrients can significantly enhance fruit yield per plant in chili crops. Nano fertilizers, with their small particle size, facilitate efficient nutrient uptake, ensuring optimal nutrient availability for plant growth and development. Micronutrients, such as zinc, play crucial roles in various physiological processes related to flowering, fruit set, and overall plant productivity. Their balanced application in nano form promotes higher fruit yield per plant by improving nutrient assimilation, reproductive processes, and overall plant health in chili crops. These results are in close conformity with the findings of **Yogaraju *et al.*, (2019); Malik *et al.*, (2020); Mishra *et al.*, (2020); Thennakoon *et al.*, (2020); Ahmed *et al.*, (2021); Parani and Nanthini (2021); Rather *et al.*, (2022)**.

3.4. Quality Parameters

3.4.1. Influence of traditional fertilizer, nano fertilizer and micronutrient on TSS (° Brix)

The maximum TSS of fruit at harvest (4.62 °Brix) was observed with treatment T_2. Minimum TSS of fruit at harvest (2.91 °Brix) was observed in T_0. The combined application of nano fertilizers and micronutrients can contribute to the enhancement of Total Soluble Solids (TSS) in chili crops. Nano fertilizers, with their small particle size, ensure efficient nutrient uptake and utilization, providing essential elements for metabolic processes. Micronutrients, such as zinc and sulphur, play vital roles in TSS accumulation. Their balanced application in nano form improves nutrient availability, leading to increased TSS content in chili fruits. This enhancement in TSS contributes to improved fruit quality and overall market value of chili crops. Similar inferences were also concluded by **Mishra *et al.*, (2020)**.

3.4.2. Influence of traditional fertilizer, nano fertilizer and micronutrient on Ascorbic Acid (mg/100g)

The maximum ascorbic acid content of fruit at harvest (146.73 mg/100g) was observed with treatment T_2. Minimum ascorbic acid content of fruit at harvest (121.10 mg/100g) was observed in T_0. The combined application of nano fertilizers and micronutrients like zinc sulphate can play a role in enhancing the ascorbic acid content in chili crops. Nano fertilizers with their small particle size ensure efficient nutrient uptake, while zinc sulphate provides the essential micronutrient zinc. Zinc is known to be involved in the biosynthesis of ascorbic acid. Its balanced application in nano form improves zinc availability, leading to increased ascorbic acid levels in chili fruits. This enhancement in ascorbic acid contributes to improved nutritional value and quality of chili crops. Similar inferences were also concluded by **Ahmed *et al.*, (2021)**.

4.CONCLUSION

The current study found that the use of nano fertilizers on the growth, yield and quality of chilies. Among the treatments tested, T_2 showed the most favorable results in terms of plant height (99.69 cm at 90 DAT), number of primary branches (8.18 branches at 90 DAT), and early flowering (38.16 DAT) and maturing (72.14 DAT). T_2 also demonstrated superior performance in terms of fruit weight (2.72 g), length of fruit (7.52 cm), fruit girth (2.76), number of fruits per plant (260.10 fruits), and yield per plant (173.07 g/plant). T_2 was composed of 75% N (through traditional method), 100% PK, 100% $ZnSO_4$, and 25% N as foliar spray through Nano urea.

REFERENCE

Ahmed, T., Sanjida, M., Akon, M.R., Malek, M.A., & Howlader, J. (2021). Effects of Varieties and Zinc on Physico-Chemical Quality of Chilli. *International Journal of Innovative Research*, 6(2), 21-27.

Choudhary, B. (2013). Vegetables-Cucurbits, Cucumber nutritional quality. National Book Trust India. *Reprint edition.* 142 pp.

Fisher, R.A. and Yates, F. (1967). "The Design of Experiments: Statistical Principles for Practical Applications." New York: *Hafner Publishing Company*.

Haque, A. N. (2016). Chilli (*Capsicum annuum* L.). In: Handbook of Cucurbits: Growth, Cultural Practices, and Physiology (pp. 131-137). *CRC Press.*

Haque, M. S. K., Paul, S. and Ghosh, B. (2016). Karyological studies of two hot chilli pepper cultivars from two different geographical regions of India: Bhut jolokia, Capsicum Chinese Jacq. and Bullet Lanka, *Capsicum annuum* L. *The Nucleus*. 59: 227–233.

Malik, A. A., Narayan, S., Magray, M. M., Shameem, S. A., Hussain, K., & Bangroo, S. (2020). Effect of foliar application of micronutrients on growth, yield, quality and seed yield of chilli (*Capsicum annuum* L.) under temperate conditions of Kashmir Valley. *International Journal of Chemical Studies*, 8(4), 2781-2784.

Mishra, S. S., Sharma, S., & Singh, A. K. (2020). Effect of inorganic fertilizers on growth, yield and quality of chilli under greenhouse conditions. *International Journal of Chemical Studies.* 7(3), 1300-1303.

NHB (2021). National Horticultural Board, Ministry of Agriculture & Farmers Welfare (DAC & FW), Government of India, 2020-21.

Parani, K., & Nanthini, M. (2021). Effect of Inorganic Fertilizers on Growth of Chilli (*Capsicum annuum* L.). *Research Journal of Agricultural Sciences*, 12(4), 1298-1301.

Pickersgill, B. (1971). "Relationships Between Weedy and Cultivated Forms in Some Species of Chili Peppers (Genus *Capsicum*)". *Evolution; International Journal of Organic Evolution.* 25(4): 683–691.

Ranganna, S. (1986). Handbook of Analysis and Quality Control of Fruit and Vegetable Products. *2nd Edition, Tata McGrow-Hill Education*, New York.

Rather, A. M., Narayan, S., Hussain, K., Khan, F. A., Mir, S. A., Malik, A. A., & Bhat, J. I. A. (2022). Influence of nitrogen, copper and zinc nano fertilizers on growth characteristics of chilli (*Capsicum annuum* var. annuum L.). *The Pharma Innovation Journal*, 11(12), 946-949.

Saranya, K. K., Vimala, R., & Poornima, K. (2019). Nano fertilizers: An emerging tool for sustainable agriculture. *In Advances in Plant and Crop Physiology* (pp. 1-19). Springer.

Thennakoon, S. D., Renuka, K. A., Amarasekara, M. G. T. S., & Jayawardhane, J. A. M. H. (2020). Effect of foliar application of manganese, zinc, and copper on growth and yield of chilli (*Capsicum annum*. L). *Resources and Environment*, 10(3), 41-45.

Yogaraju, M., Srinivasa, V., Mahadevprasad, Y. M., & Devaraju. (2019). Integrated Nutrient Management Studies on Growth, Yield and Quality Attributes in Chilli (*Capsicum annuum* L.). *International Journal of Current Microbiology and Applied Sciences*. 8(2), 2518-2526.

Yadav, R. K., Mahajan, P., & Yadav, A. (2020). Effect of different sources and levels of nitrogen and phosphorus on growth and yield of chili (*Capsicum annuum* L.). *International Journal of Chemical Studies*, 8(3), 2644-2647.

Table 1 Effect of Nano fertilizers on different treatments for various growth, earliness, yield and quality parameters of Chilli.

Treatment details	Plant height (cm) [90 DAT]	Number of primary branches [90 DAT]	Days to first flowering	Days to 50% flowering	Days to first fruit harvest	No. of fruits per plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit yield per plant (g/plant)	Fruit yield per hectare (q/ha)	TSS [°Brix]	Ascorbic acid content (mg/100g)
T_0	74.13	5.04	46.31	53.66	77.34	97.09	6.07	2.15	2.21	64.90	8.80	2.91	121.10
T_1	89.34	7.44	40.16	46.61	76.36	202.50	7.30	2.67	2.60	133.23	17.96	3.03	123.41
T_2	99.69	8.18	38.16	44.59	72.14	260.10	7.52	2.76	2.72	173.07	23.37	4.62	146.73
T_3	92.71	7.78	39.54	46.00	72.50	253.70	7.46	2.74	2.67	169.63	22.90	4.56	145.41
T_4	85.28	6.72	39.93	46.15	75.47	122.50	7.41	2.67	2.38	80.73	10.84	4.22	136.66
T_5	85.48	6.78	43.44	49.89	76.47	128.90	7.41	2.71	2.49	86.83	11.67	4.31	138.30
T_6	83.85	7.12	42.24	48.70	73.14	100.10	7.15	2.73	2.41	68.13	9.13	4.35	138.63
T_7	81.09	7.72	43.65	50.11	73.79	144.70	7.10	2.69	2.58	95.60	12.86	4.48	137.28
T_8	82.77	5.38	44.82	51.28	74.69	117.50	7.29	2.67	2.53	80.00	10.74	4.52	133.66
T_9	76.22	6.58	42.32	48.78	75.26	134.10	7.35	2.70	2.43	87.90	11.81	4.08	133.66
T_{10}	92.71	7.25	39.75	46.38	73.49	191.10	7.39	2.72	2.60	124.93	16.84	4.19	135.23
F test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S.E (d) (±)	**0.93**	**0.46**	**0.13**	**0.13**	**0.22**	**0.07**	**0.04**	**0.03**	**0.01**	**0.04**	**0.04**	**0.02**	**0.07**
$CD_{0.05}$	**1.96**	**0.97**	**0.28**	**0.27**	**0.47**	**0.15**	**0.08**	**0.02**	**0.02**	**0.09**	**0.01**	**0.05**	**0.14**
C.V.	**1.30**	**7.86**	**0.39**	**0.33**	**0.37**	**0.06**	**0.69**	**0.06**	**0.04**	**0.05**	**0.04**	**0.06**	**0.07**