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Effect of nano-ferltizer on growth and yield of cucumber (*Cucumis sativus* L.)

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Abstract

Nano-fertilizer offers new agricultural chemicals and tools for improving crop productivity. One of the most important applications of nanotechnology in this field is plant fertilization. The study aimed to estimate nano-ferltizer on the growth and yield of *Cucumis sativus.* Three levels of nano-fertilizer have been used, including 1.5, 3, and 6 g/L with a local variety of cucumber. The results showed that foliar application of nano-fertilizer significantly (P≤0.05) increased the number of leaves (plant^{-1}), plant length (cm), leaf area (cm^2), fruit length (cm), and fruit diameter (cm) when using a 6 g/L concentration compared to control plants. As well as the number of fruits (plant^{-1}), weight of fruit, plant yield (kg), and total number of fruit have recorded the highest values when using 6 g/L concentration showed a significant difference with the other treatments, while no significant difference was observed between control treatments, which differed significantly from treatment 1.5 g/L. The study concludes that foliar application of nano-fertilizer significantly increased the number of leaves (plant-1), plant length (cm), leaf area (cm2), fruit length (cm), and fruit diameter (cm) when using a 6 g/L concentration compared to control plants.

Keywords: nano-fertilizer, cucumber, Cucumis sativus, plant length

I. Introduction

Cucumis sativus is rich in essential vitamins and minerals needed in the human diet, such as iron, potassium, magnesium, vitamins B1 and B2, and others. Studies have found that *C. sativus* contains vitamin C in its green leaves, and its beta-carotene content is comparable to that of carrots. Their seeds also contain fiber, which is commonly used in dietary supplements. *C. sativus* is traditionally known for its digestive benefits, as well as for its anticancer and anticonvulsant properties (Huang et al., 2009). The high antioxidant activity of *C. sativus* is attributed to its high content of phenolic acids, with rosmarinic acid being a significant contributor to its medicinal properties. Chicory acids are present in relatively high concentrations. These phenolic acids act oxidative stress as antioxidants, shielding them from free radical damage (Kaur & Sharma, 2022).

Nano fertilizer offers new agricultural chemicals and tools for improving crop productivity. One of the most important applications of nanotechnology in this field is plant fertilization. Nanoferries are a new generation of synthetic fertilizers containing readily available nutrients at the nanoscale. Using nanofertilizers for precise control of plant nutrient release is an effective step towards achieving sustainable and environmentally sound agriculture (Moustafa et al., 2022). Nanoferries are being studied as a way to increase nutrient efficiency and improve plant nutrition compared to conventional fertilizers. The use of nano-fertilizers increases nutrient utilization efficiency, thereby reducing soil toxicity and mitigating the harmful effects of excessive chemical fertilizer use (Kamali Omidi et al., 2022). Using nano-phosphate fertilizers instead of chemical fertilizers can lead to increased crop yields, improved phosphorus utilization efficiency, enhanced economic efficiency and food security, and reduced water pollution. When mineral nutrients required by plants are produced at the nanoscale, they become more readily absorbable and less fixed in the soil. Consequently, soil uptake of insoluble nutrients increases (Sadique et al., 2017). In general, the numerous benefits of using nano-fertilizers include increased efficiency and improved food quality due to rapid absorption; prevention of fertilizer loss through leaching and complete uptake by plants due to availability and controlled release during the growth

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period; and reduction of soil and water pollution, and consequently food contamination, by minimizing fertilizer runoff (Méndez-López et al., 2024).

Calcium plays a crucial role in plant growth and nutrition, as well as in cell wall deposition. Calcium deficiency in plants can be caused by insufficient calcium in the growing medium, but more often it results from reduced transpiration of the entire plant or, more commonly, affected tissues. Fruits and vegetables exhibiting symptoms of calcium-related disorders contain less calcium than the leaves of the plants that bear them (Huang et al., 2009; Moustafa et al., 2022). Generally, new growth and rapidly developing tissues of the plant are affected first. Calcium deficiency disorders tend to occur during early fruit development. Appropriate liming programs, optimal soil moisture, and tillage are essential considerations. The use of resistant varieties, non-ammonium nitrogen fertilizers, and appropriate agricultural practices should be adopted. Therefore, the study aimed to use nano-fertilizer on the growth and yield of *Cucumis sativus.*

II. Materials and Methods:

Cucumis sativus

Cucumis sativus seeds were planted in the in experimental plots at a rate of 2-3 seeds per hole. After germination, the seeds were thinned to one plant per plot, with a spacing of 75 cm between rows and 50 cm between plants, resulting in three rows per experimental unit, for a total of 36 plants per unit. Nano-calcium was added by making a 10 cm deep trench in the soil near the planting rows. The field was then irrigated regularly after the sulfur application until the planting date.

Irrigation Method:

Water was added to each experimental unit in a fixed quantity, according to the moisture content, throughout the plant's growth period until physiological maturity. Water was supplied to the field from a lined underground water tank, which served as the irrigation water source for the college. Irrigation was carried out using a flexible plastic pipe connected to a diesel-powered pump. Water was added to all experimental units according to the moisture content at 50% depletion at planting. Each experimental unit was irrigated individually, and drainage was fixed within the experimental unit before each irrigation. A total of 15 irrigations were administered from planting until the weaning irrigation.

Method and Timing of Chemical Fertilizer Application

Nano-calcium was used at a rate of 150 kg p ha^{-1} as follows: 1.5, 3 and 6 g/L have used in the experiments.

First Application: This includes adding all the fertilizer at planting to all experimental units, and half the fertilizer and half the fertilizer to the experimental units two weeks after germination.

Second Application: The remaining nitrogen and fertilizer were added next month to the experimental units.

The study trials include:

Plant length (cm)

The height of five plants was randomly selected for each experimental unit. A graduated measuring ruler was used, measuring from the soil surface to the leaf tip. The average plant height was then calculated.

Leaf area (cm^2/plant)

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The leaf area was calculated from the same plants used for height measurement, and the average was calculated using the following equation:

$$\text{Leaf area} = (\text{Length of leaf below main ear leaf})^2 \times 0.75$$

Relative chlorophyll content in leaves (SPAD)

Chlorophyll content was estimated using a SPAD chlorophyll meter. Readings were taken from four leaves per plant, and the average was calculated for five plants.

Plant yield (ton ha^{-1})

This was calculated by multiplying the average grain yield per plant (g plant^{-1}) × plant density. The weight was adjusted for moisture content and converted to tons. ha^{-1}.

Statistical Analysis

Data was statistically analyzed using a computer and the Genstat software, according to the method used in analysis of variance mentioned in. The modified Least Significant Difference (LSD) test was used to compare the treatment rates at a significance level of 0.05.

III. Results and Discussion

The results show that foliar application of nano-fertilizer significantly increased the number of leaves when using a 6 g/L concentration, compared to control plants. The 6 g/L concentration showed a significant difference from the other treatments, while no significant difference was observed between control treatments, which differed significantly from treatment 1.5 g/L. The number of leaves recorded was 65.10, 66.24, 67.55, and 78.50 plant^{-1} at control, 1.5, 3, and 6 g/L nano-fertilizer respectively. The results also indicated a significant effect of nano-fertilizer in plant length (cm). The resulted in a non-significant increase in plant length, with the highest increase (344.10 cm) observed at a 6 g/L concentration, while the lowest (245.50 cm) was observed at control treatment, while the highest length of the the nano-fertilizer was (344.10) cm at a concentration of (6) g/L, compared to the control treatment, which was (245.50) cm.

The results show that foliar application of nano-fertilizer significantly increased leaf area when using a 6 g/L concentration, compared to control plants. The 6 g/L concentration showed a significant difference from the other treatments, while no significant difference was observed between control treatments, which differed significantly from treatment 1.5 g/L. The leaf area recorded that 4110, 4213, 4425, and 6214 at control, 1.5, 3, and 6 g/L nano-fertilizer respectively. In addition, results show that foliar application of nano-fertilizer significantly increased fruit length when using a 6 g/L concentration, compared to control plants. The 6 g/L concentration showed a significant difference from the other treatments, while no significant difference was observed between control treatments, which differed significantly from treatment 1.5 g/L. The fruit length has been recorded as 16.90, 17.10, 18.33, and 18.90 for control, 1.5, 3, and 6 g/L nano-fertilizer respectively. Finally, the fruit diameter has been indicated that the 6 g/L concentration has recorded the highest value of fruit diameter, and the lowest was 1.5 g/L concentration. They were 2.41, 2.55, 2.89, and 2.99 cm at control, 1.5, 3, and 6 g/L, respectively.

This also increases the metabolic rate, leading to increased dry matter synthesis and accumulation, and consequently, an overall increase in plant growth rate. The effect of fertilizer may be attributed to the fact that the active compounds in reduce oxidative stress within plant cells, thus increasing the efficiency of physiological processes such as photosynthesis. The current results are consistent with (Al-Bayati et al., 2023; Dahham et al., 2025; Javadimoghadam et al., 2015), who found that the use of nano-fertilizer significantly affected the stem diameter of plants. Also, demonstrated that nano-fertilizer affected most growth characteristics of plants under greenhouse conditions. Furthermore, the current results are consistent with Ahmadi et al. (2020), who indicated that the increase in stem diameter in plants was due to the effect of nano-fertilizer.

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Table 1. Effect of Nano-fertilizer on vegetative growth of *Cucumis sativus*

Concentration (g/L)	**No. of leaves (plant^{-1})**	**Plant length (cm)**	**Leaf area (cm^2)**	**Fruit length (cm)**	**Fruit diameter (cm)**
Control	65.10	245.50	4110	16.90	2.41
1.5	66.24	288.90	4213	17.10	2.55
3	67.55	310.26	4425	18.33	2.89
6	78.50	344.10	6214	18.90	2.99
Average	70.76	314.42	4950.66	18.11	2.81
LSD	2.99	1.18	12.88	2.78	2.89

The results shows that foliar application of nano-fertilizer significantly increased number of fruits (plant^{-1}) when using a 6 g/L concentration, compared to control plants. The 6 g/L concentration showed a significant difference with the other treatments, while no significant difference was observed between control treatments, which differed significantly from treatment 1.5 g/L. the number of leaves recorded that 20.70, 22.67, 23.65 and 27.90 plant^{-1} at control, 1.5, 3 and 6 g/L nano-fertilzer, respectively. The results also have been indicated a significant interaction between nano-fertilzer in weight of fruit (kg). The interaction resulted in a non-significant increase in weight of fruit (kg), with the highest increase (106.65) observed at a 6 g/L concentration, while the lowest was 87.99 kg was observed at control treatment.

The results shows that foliar application of nano-fertilizer significantly increased plant yield (kg) when using a 6 g/L concentration, compared to control plants. The 6 g/L concentration showed a significant difference with the other treatments, while no significant difference was observed between control treatments , which differed significantly from treatment 1.5 g/L. the plant yield (kg) recorded that 2.01, 2.80, 2.88 and 2.98 at control, 1.5, 3 and 6 g/L nano-fertilzer, respectively. In addition, results shows that foliar application of nano-fertilizer significantly increased plant yield (kg) when using a 6 g/L concentration, compared to control plants. The 6 g/L concentration showed a significant difference with the other treatments, while no significant difference was observed between control treatments, which differed significantly from treatment 1.5 g/L. the plant yield (kg) has been recorded that 14.99, 15.60, 15.87 and 16.78 for control, 1.5, 3 and 6 g/L nano-fertilzer.

This is because increasing the concentrations of nano-fertilizer stimulated the plant to increase its auxin levels, which significantly boost meristematic apex activity, cell division, and elongation. This is attributed to the availability of essential building blocks for plant growth, such as amino acids. The current results are consistent with (Hussein & Khalaf, 2022), who found that nano-fertilizer significantly increased the number of leaves in plants. They also align with the findings of (Ahmadi et al., 2020), who concluded that nano-phosphorus increased the number of leaves in pepper plants. Furthermore, it improves the plant's absorption of nutrients (N, P, K), leading to increased vegetative growth, including a higher number of leaves. The current results are consistent with those of (Sadique et al., 2017) in their study on the effect of three levels of nano-fertilizer on the leaf count. This findings are also consistent with Bozorgi's (2012) study on *Solanum melongena*. Finally, the current results are consistent with those of Shaker and Al-Rawi (2017), who found that garlic extract increased the leaf count of Pyrus communis. These findings are similar to (Jaysawal & Sureshkumar; Kamali Omidi et al., 2022; Méndez-López et al., 2024; Moustafa et al., 2022).

Table 2. Effect of Nano-fertilizer on yield of *Cucumis sativus*

Concentration (g/L)	**No. of fruits (plant^{-1})**	**Weight of fruit**	**Plant yield (kg)**	**Total number of fruit**
Control	20.70	87.99	2.01	14.99

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1.5	22.67	99.20	2.80	15.60
3	23.65	103.50	2.88	15.87
6	27.90	106.65	2.98	16.78
Average	55.62	238.25	6.673333	37.06333
LSD	0.89	1.19	0.06	0.07

IV. Conclusions

The study concludes that foliar application of nano-fertilizer significantly increased the number of leaves ($plant^{-1}$), plant length (cm), leaf area (cm^2), fruit length (cm), and fruit diameter (cm) when using a 6 g/L concentration compared to control plants. As well as the number of fruits ($plant^{-1}$), weight of fruit, plant yield (kg) and total number of fruit have recorded the highest values when using 6 g/L concentration, which showed a significant difference with the other treatments, while no significant difference was observed between control treatments, which differed significantly from treatment 1.5 g/L.

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