Impacts of liquid copper and zinc nano-fertilizers on potato (*Solanum tuberosum L.*) growth

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Abstract
The field experiment was conducted in an agricultural field north of Babylon Governorate in the spring of 2023 to study the effect of soil fertilization with zinc and copper nano-fertilizers. Potatoes (*Solanum tuberosum*) Arizona type were used in the experiment, and the study groups were as follows: G1: Control (0% Cu and Zn), G2: Control + sprays of water, G3: sprays of 2.5% Cu, G4: sprays of 5% Cu, G5: sprays of 2.5% Zn, G6: sprays of 5% Zn. The results shown: the G5 and G6 groups recorded the highest plant height in all study periods 30, 60 and 90 days, A significant increase was observed for all groups treated with fertilization in the number of leaves per plant, plant branches per plant and days taken for 50% flowering and number of tubers per plant compared to the control groups.

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Introduction

The potato (Solanum tuberosum L.), a starchy tuber and root vegetable, is indigenous to the Americas. The plant is a member of the perennial family, Solanaceae. The vegetative and fruiting parts of the potato contain the toxin solanine, which is dangerous for human consumption. Normal potato tubers produce trace levels of glycoalkaloids that are not harmful to human health when they are grown and cared for appropriately. However, the tuber can accumulate a high enough concentration of glycoalkaloids to affect human health if the plant's green sections are exposed to light.

In 2020, the world produced 359 million tons of potatoes, of which China accounted for 22%. Other major producers included the United States, Russia, Ukraine, and India. Southern and eastern Asia have experienced the biggest growth in recent decades, despite wheat remaining a staple grain in Europe, especially in northern and eastern Europe, where per capita production is still the highest in the world (FAO, 2021). The yields of potatoes vary greatly between nations, even when they are of the same kind. On average, 38 to 44 tons of potatoes are produced per acre in developed economies. China and India, with yields of 14.7 and 19.9 tons per hectare, respectively, generated over one-third of the global total in 2010. The yield disparity between farms in wealthy and developing countries results in the loss of more than 400 million tons of potatoes, which is more than the world's potato production in 2010, Potato crop yield is influenced by the plant environment, crop management practices, seed age and quality, and crop breed. Improving one or more of these yield determinants and reducing the yield gap can greatly boost the food supply and farmer incomes in the developing countries (Foley *et al*., 2011) [6]. The quality and amount of fertilizers applied have a major impact on the growth and output of vegetable crops. Due to financial losses and environmental contamination, the loss of mineral nutrients through leaching and runoff to surface and ground water, as well as widespread volatilization, is becoming a bigger concern. Heavy metal buildup in soil and plant systems is one of the major environmental issues brought on by the recent use of chemical fertilizers (Abdel *et al*., 2019) [1]. Chemical fertilizers are being overdosed due to conventional application

methods.

Using nanomaterials smaller than 100 nm, nanotechnology is a promising topic of study that could present a once-in-a-lifetime chance to create concentrated plant nutrient sources with improved absorption rates, usage efficacy, and reduced losses. Nano fertilizer, which enhances plants' capacity to absorb nutrients, is one of the most significant applications of nanotechnology (Mousavi *et al*., 2011) [13], Zinc increases the resistance of potatoes to diseases and supports their growth (Nazir *et al*., 2024) [14], Copper also increases the resistance of potatoes to fungi and bacteria and increases the growth yield (AlHarethi *et al*., 2024) [2]. Therefore, the current study aims to investigate the effect of soil fertilization by spraying with nano zinc and nano copper on the growth and yield of potatoes.

Materials and methods

The field experiment was conducted in an agricultural field north of Babylon Governorate in the spring of 2023 to study the effect of soil fertilization with zinc and copper nano-fertilizers. Potatoes (*Solanum tuberosum*) Arizona type were used in the experiment, and the study groups were as follows:

G1: Control (0% Cu and Zn)
G2: Control + sprays of water
G3: sprays of 2.5% Cu
G4: sprays of 5% Cu
G5: sprays of 2.5% Zn
G6: sprays of 5% Zn

The land was brought to a fine tilth by tillage and plowing. According to the plan, irrigation systems and bunds were installed. In the field, the sprouted potato tubers were manually planted with a 20 cm plant-to-plant spacing and a 60 cm row-to-row spacing. Light watering was done shortly after planting. Nano manures were applied one week prior to seeding. Twenty-five days after planting, the first spraying was completed; fifteen days later, the second; and ten days after the second, the third. Throughout the crop's growth, all cultural customs were adhered to, and at 30, 60, and 90 days after planting, measurements of the plant's height and number of leaves were made. The observations on yield parameters plant height, number of leaves per plant, number of leaves per plant, Days taken for 50% flowering, and quality parameters

Statistical analysis

The completely randomized design (CRD) was used in the design of the groups with three replicates for each group. The data were statistically analyzed using the GeneStat program, and then the means were compared at the least significant difference at a probability level of 0.05 (Steel *et al*., 1997) [17].

Results and discussion

1. Plant height

Groups G5 and G6 recorded the highest plant height in all study periods 30, 60 and 90 days compared to the control groups.

Table 1: Impacts of liquid copper and zinc nano-fertilizers on plant height (cm) at different growth stages of potato

Groups	30 D	60 D	90 D
G1	20.75	37.57	40.62
G2	21.12	37.79	41.32
G3	20.15	41.55	45.31
G4	23.25	40.21	44.27
G5	24.36	43.61	46.97
G6	24.18	47.63	50.29
S. EM ±	1.52	2.01	1.96
P value : 5%	2.13	3.42	4.01

2. Number of leaves per plant

A significant increase was observed for all groups treated with fertilization in the number of leaves per plant compared to the control group at all periods, and groups G5 and G6 were the best.

Table 2: Impacts of liquid copper and zinc nano-fertilizers on number of leaves per plant at different growth stages of potato

Groups	30 D	60 D	90 D
G1	26.47	80.21	26.13
G2	28.34	84.16	33.14
G3	29.46	92.47	31.26
G4	28.74	91.33	35.89
G5	33.41	100.09	40.87
G6	32.51	91.41	37.52
S. EM ±	1.69	1.56	1.23
P value : 5%	2.14	1.56	1.69

3. Number of branches per plant

A significant improvement was observed in the plant branches per plant for groups G3, G4, G5, and G6 compared to groups G1 and G2 during the age of 30 days, and no significant difference appeared at the age of the plant 60 and 90 days.

Table 3: Impacts of liquid copper and zinc nano-fertilizers on number of branches per plant at different growth stages of potato

Groups	30 D	60 D	90 D
G1	2.13	5.46	5.36
G2	2.59	5.45	5.24
G3	3.56	5.32	5.89
G4	3.47	5.15	5.37
G5	4.15	5.44	5.45
G6	5.47	6.09	5.42
S. EM ±	0.52	0.48	0.64
P value : 5%	1.75	N.S	N.S

4. Days taken for 50% flowering

A significant increase was observed for all groups treated with fertilization in the days taken for 50% flowering compared to the control group at all periods, and group G3 was the best.

Table 4 : Impacts of liquid copper and zinc nano-fertilizers on Days taken for 50% flowering of potato

Groups	Days taken for 50% flowering
G1	49.12
G2	44.56
G3	51.23
G4	45.26
G5	44.23
G6	46.39
S. EM ±	0.41
P value : 5%	3.47

5. Number of tubers per plant

A significant increase was observed for all groups treated with fertilization in the number of tubers per plant compared to the control group at all periods, and groups G3, G5 and G6 were the best.

Table 5 : Impacts of liquid copper and zinc nano-fertilizers on Number of tubers per plant of potato

Groups	Number of tubers per plant
G1	4.21
G2	3.69
G3	5.78
G4	4.96
G5	5.25
G6	6.33
S. EM ±	0.50
P value : 5%	2.63

6. Quality parameters of potato

There are not significant deference between groups in quality parameters of potato.

Table 6 : Impacts of liquid copper and zinc nano-fertilizers on quality parameters of potato

Groups	TSS	Reducing sugar%	Non reducing sugar%
G1	5.14	0.21	1.09
G2	5.26	0.23	1.11
G3	5.59	0.24	1.18
G4	5.41	0.20	1.12
G5	5.78	0.22	1.31
G6	5.33	0.20	1.24
S. EM ±	0.28	0.03	0.11
P value : 5%	N.S	N.S	N.S

The higher plant heights seen in G5 and G6 may be related to the administration of copper and zinc nanofertilizers. When G6 was administered inorganically to the soil and foliarly sprayed with Nano Zn and Nano Cu, the plant height reached its maximum and was considerably different from the control treatment. G1 had the smallest plant height. Jyothi and Hebsur (2017) [10] showed similar results on the increase in plant height The results of Abdel Wahab *et al*. (2019) [1]. are supported by the current findingsin tomato, Khaveh *et al*. (2015) [11]. in red radish, Ekinci *et al*. (2012) [4] Tantawy *et al*. (2014) [18] in tomato,

The early application of liquid fertilizer containing nano zinc and nano copper may be responsible for the increase in leaves, as it aids in the development of the canopy's leaf count and size. Due to the presence of chlorophyll, the quantity and area of leaves are essential markers of photosynthesis. An

increase in the number of leaves signifies a high rate of photosynthesis, which in turn causes the plant growth rate to increase. This study's concentration-dependent rise demonstrates that liquid fertilizers containing copper and zinc increase the number of leaves, which in turn increases the rate of photosynthesis. Similar results by Hafeez *et al*. (2015) [8] demonstrated that applying CuO NPs to the soil increased leaf area. Variations in the accumulation of these nanoparticles within the plants may be the cause of the erratic trend in the number of leaves on plants treated with nanozinc. According to a study by Kisan *et al*. (2015) [12], applying ZnO NP increased the leaf area in a concentration-dependent manner. Consequently, ZnO and CuO NPs' antagonistic effect increased the number of B. nigra leaves. Cu and Zn NP application increased the number of leaves per plant, per another study on Pistia stratiotes (Olkhovych *et al*., 2016) [15]. The increase in leaves in this study indicates that nano copper and zinc positively affect leaf count and growth.

The treatments that got nano fertilizer would have increased the number of potato crop branches by facilitating the mineralization of nutrients for the plant to absorb. With the aid of several enzymes released from organic sources and aiding in RNA synthesis, nano fertilizers are designed to release on demand and help regulate plant growth. This enhances photosystems, allowing the plant to observe and absorb more nutrients, leading to a notable increase in branch count when compared to the control. DeRosa *et al*. (2010) [3], Nair *et al*. (2010), and Sheykhbaglou *et al*. (2010) [16].

Researchers (Harish and Gowda, 2017; El Metwally *et al*., 2018) [9]. the improvement of days taken for 50% flowering number tubers per plant may be due to the combined application of nano zinc and copper liquid fertilizers as foliar spray. The presence of zinc stimulates plant growth by activating the synthesis of tryptophan, the precursor of ascorbic asid.

Conclusion

From the results obtained, it is concluded that the process of fertilizing the soil with nano-copper and zinc fertilizer improves the growth and yield of potatoes. A more comprehensive and broader study is needed to better investigate the effect of fertilization with nano-copper and zinc on potatoes.

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