Response of Growth and Yield of Pickling Cucumber Hybrids to Foliar Spraying With Traditional and Nano Potassium and Calcium

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Abstract

The experiment was conducted during the spring season of 2024 in a private field in Al-Azawiya area, Al-Musayyib District, Babylon Governorate, to evaluate the effect of two cucumber hybrids (Russian and BOBY) and foliar spraying with traditional and nano potassium and calcium fertilizers on the growth and yield of pickling cucumber. The experiment followed a split-plot arrangement within a Randomized Complete Block Design (RCBD). Results showed that the Russian hybrid significantly outperformed in vegetative traits such as plant height (231.1 cm), number of leaves (34.5 leaves. plant), leaf area (6665.5 cm^2. plant), and chlorophyll content (45.1 SPAD units). Nano potassium and calcium spraying led to the highest values for these traits. In yield traits, the BOBY hybrid gave the highest fruit number (30.83 fruits.plant), single plant yield (382.7 g), and total yield (478.4 kg. greenhouse), while the Russian hybrid showed the highest fruit weight (12.49 g). Nano spraying resulted in the best values for number of fruits (32.6), yield per plant (409.5 g), and total yield (511.8 kg). The interaction of Russian hybrid with nano spraying gave the highest vegetative values, while the BOBY hybrid with nano spraying achieved the highest yield. The control treatment gave the highest fruit weight (12.72 g) with the Russian hybrid.

Keywords: Cucumber Hybrids, Nano Potassium, Nano Calcium, foliar spraying.

Introduction

Cucumber (Cucumis sativus L.) is considered one of the important agricultural crops widely cultivated in tropical and subtropical regions, belonging to the Cucurbitaceae family. It is characterized by its high-water content (96%), making it ideal for healthy dietary regimens and the pickling industry, reflecting its economic importance [1]. Hybrid cucumber results from crossing two different strains, providing disease resistance, increased productivity, improved fruit quality, and adaptation to environmental conditions, thus contributing to meeting increasing demand [2]. Some hybrids focus on improving productivity through increasing fruit number and size, enhancing the efficiency of agricultural resource utilization. Improved hybrids can produce larger and more abundant fruits, contributing to increased economic returns. Productivity enhancement is not limited to increasing crop quantity but extends to quality improvement, which enhances the competitiveness of these hybrids in the market. This improvement in quality and productivity is considered essential to address the challenges facing agriculture today, especially in light of climate change and population growth.

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The classification of cucumber hybrids based on physiological characteristics and growth is vital for achieving sustainable agriculture. This classification helps farmers select suitable varieties for their environmental conditions, contributing to improved production efficiency and increased yield. Understanding these categories assists researchers in developing new hybrids that meet market needs and address environmental challenges. Continuing the development of these hybrids is an important step toward achieving food security, as these hybrids represent an effective tool for improving physiological characteristics and growth in modern agriculture [3.[

Nano fertilizers are characterized by their small particle size, which increases their efficiency in improving the absorption of nutrients such as calcium and potassium, which are essential for fruit quality and growth. Calcium supports cell walls, while potassium helps regulate cell pressure and improve drought resistance [4], Nano fertilizers have several disadvantages: Possible plant and soil toxicity, High cost, Limited research on long-term effects, Environmental risks and Lack of regulations. Calcium deficiency leads to the appearance of spongy pulp in cucumber fruits, reducing their quality, while potassium deficiency leads to irregular fruit shape, a phenomenon known as "Crooking," which is also associated with poor pollination or fertilization (Hammoud, 2021-2022.(

Potassium contributes to increased vegetative growth, productivity, yield components, and fruit quality of cucumber plants, leading to the highest average plant height, number of leaves per plant, chlorophyll content (SPAD) in leaves, fruit weight, and total plant production [5]. The application of nano calcium contributes to increasing the average growth characteristics, yield, and quality of cucumber plants (Cucumis sativus L.) under protected cultivation conditions. Results showed that when spraying nano calcium, the highest average plant height was recorded. Nano calcium spraying also achieved an increase in fresh weight, an increase in dry weight, and an increase in the number of branches was recorded [6.[

Materials and Methods

The experiment was conducted in a private field in Al-Azawiya area - Al-Musayyib district north of Babylon Governorate center, at longitude 44.5°E and latitude 32.7°N during the spring growing season of 2024. The study aimed to investigate the response of pickling cucumber hybrids' growth and yield to foliar application of traditional and nano potassium and calcium.

A plastic greenhouse condition are Temperature: It can be 30 to 40°C higher than the outside during the day and may decrease at night. Relative humidity: It is usually high, ranging from 25% to over 90%, especially in the morning or after irrigation. with an area of (508 m²). A plastic greenhouse was prepared, performing necessary field operations including plowing, soil pulverization, and leveling. Subsequently, soil samples were randomly collected from different locations at depths ranging from surface to (30 cm) before planting and analyzed to determine various chemical and physical properties of the field soil, with results presented in Table 1.

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The land was divided into ridges, each (60 cm) wide with (70 cm) spacing between adjacent ridges. The ridges were distributed as replications, with each replication consisting of 2 ridges containing 18 experimental units, with 10 plants per experimental unit. Drip irrigation pipes were placed along the ridges, with two lines on each side of the ridge.

Seeds were sown in the nursery on January 28, 2024, and after complete germination, seedlings were transplanted to the field on February 14, 2024, for the spring season. Planting was conducted within the ridges with 10 seedlings per experimental unit, distributed alternately on both sides of the line. Service operations, irrigation, and pest control were performed as recommended [7.[

The experiment was implemented according to a Randomized Complete Block Design (RCBD) within a Split-Plot system with three replications, The study samples were randomly selected. The main factor was cultivars (Main Plots), while the foliar application of traditional and nano potassium and calcium was the secondary factor (Sub-Plots), considering both factors of equal importance. The experiment included two factors:

First Factor: Pickling Cucumber Hybrids

The first factor included two pickling cucumber hybrids:

- A_1 : Russian hybrid with spiny exterior appearance
- A_2 : Boby hybrid with smooth exterior appearance

Second Factor: Foliar Application

This factor comprised three levels:

B_0 : Control treatment

B_1 : Traditional potassium and calcium foliar application

B_2 : Nano potassium and calcium foliar application 200 gm / 100 L.

Traditional high-potassium foliar fertilizer (Green Leaf) produced by Italian Biochem company was applied at the recommended concentration of (2.5 g L^{-1}). The nano high-potassium foliar fertilizer manufactured by an Iranian company was applied at a concentration of (2.5 g L^{-1}) as per company recommendations. Applications were conducted four times throughout the growing season with 10-day intervals between successive applications. The first application was performed when plants reached 30 days of age, with spraying conducted in early morning hours.

Traditional calcium foliar fertilizer (Foliastim Calcium) liquid formulation produced by Van Iperen Netherlands was applied at a concentration of (2.5 mL L^{-1}) according to company recommendations. The nano calcium foliar fertilizer (G-Power-Calcium) liquid formulation produced by Turkish Agrisciences company was applied at a concentration of (2 mL L^{-1}) following company guidelines. These were applied four times with 10-day intervals, alternating with high-potassium fertilizer applications with a 3-day interval between different fertilizer types. Calcium application commenced when plants reached 33 days of age.

Results and Discussion

The experiment was implemented using a split-plot system (2×2×3) within a Randomized Complete Block Design (RCBD) with three replications for each experiment. Significant differences between means were

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compared at (0.05) probability level using Least Significant Difference (LSD) test [8]. Statistical analysis was performed using Genstat-2012 software.

Ten plants were selected from each experimental unit for measurement purposes. Vegetative growth parameters including plant height, leaf number, leaf area, and chlorophyll content (SPAD) were recorded as shown in Table (2). Yield components including fruit number, individual plant yield, fruit weight, and total yield were documented as presented in Table (3.(

Table 1. Physical and Chemical Properties of Greenhouse Soil Before Planting

Property	Unit	Value
Soil pH	---	7.78
Electrical Conductivity (EC)	dS m^{-1}	2.5
Organic Matter	%	1.67
Available Nitrogen	mg kg^{-1}	23
Available Phosphorus	mg kg^{-1}	1.98
Exchangeable Potassium	mg kg^{-1}	124.77
Sand Percentage	g kg^{-1} soil	597
Silt Percentage	g kg^{-1} soil	250
Clay Percentage	g kg^{-1} soil	153
Soil Texture	---	Silty Loam

Analysis conducted at You Science Private Laboratory - Al-Qadisiyah Governorate

Table 2. Effect of Nano and Traditional Potassium and Calcium Foliar Application on Growth Parameters of Pickling Cucumber Hybrids

Treatment	Plant Height (cm $plant^{-1}$)	Leaf Number	Leaf Area (cm^2 $plant^{-1}$)	Chlorophyll (SPAD)
Hybrids				
Russian	231.7	34.5	6665.5	45.1
BOBY	223.3	31.5	6581.7	40.3
LSD	0.311	1.045	22.43	0.89
Foliar Application				

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Control	225.0	30.8	5644.8	41.73
K+Ca Traditional	227.6	33.2	6684.7	42.83
K+Ca Nano	229.9	35.0	7241.2	43.54
LSD	0.376	0.360	18.76	2.31
A_1 B_0	228.5	32.5	5959.5	43.0
A_1 B_1	231.8	34.7	6779.3	46.87
A_1 B_2	234.8	36.4	7257.6	45.17
A_2 B_0	221.6	29.0	5930.1	40.46
A_2 B_1	223.5	31.7	6590.0	38.79
A_2 B_2	224.9	33.7	7224.9	41.92
LSD	0.458	0.788	24.36	2.69

Results in Table 2 indicate that foliar application of traditional and nano potassium and calcium significantly affected hybrid performance and vegetative growth characteristics. The Russian hybrid demonstrated superior performance, recording the highest mean plant height (231.7 cm plant^{-1}), leaf number (34.5 leaves plant^{-1}), leaf area (6665.5 cm^2 plant^{-1}), and chlorophyll content (45.11 SPAD). In contrast, the BOBY hybrid exhibited lower values for these parameters: plant height (223.3 cm plant^{-1}), leaf number (31.5 leaves plant^{-1}), leaf area (6581.7 cm^2 plant^{-1}), and chlorophyll content (40.39 SPAD.(

Regarding foliar application treatments, nano potassium and calcium application yielded the highest means for plant height (229.9 cm plant^{-1}), leaf number (35.0 leaves plant^{-1}), leaf area (7241.2 cm^2 plant^{-1}), and chlorophyll content (43.54 SPAD). Conversely, the control treatment recorded the lowest values for these parameters: plant height (225.0 cm), leaf number (30.8 leaves plant^{-1}), leaf area (5644.8 cm^2 plant^{-1}), and chlorophyll content (41.73 SPAD.(

For the interaction between hybrids and foliar application (A×B), the Russian hybrid with nano potassium and calcium application (A_1 B_2) significantly outperformed other combinations, recording the highest plant height (234.8 cm), leaf number (36.4 leaves plant^{-1}), and leaf area (7257.6 cm^2 plant^{-1}). The BOBY hybrid under control conditions (A_2 B_0) exhibited the lowest values for these parameters. For chlorophyll content, the Russian hybrid with traditional potassium and calcium application (A_1 B_1) recorded the highest value (46.87 SPAD), while the BOBY hybrid with traditional potassium and calcium application (A_2 B_1) showed the lowest value (38.79 SPAD). The table clearly demonstrates that foliar application of traditional and nano potassium and calcium had substantial effects on vegetative growth characteristics.

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Table 3. Effect of Foliar Application on Fruit Number, Individual Plant Yield, Fruit Weight, and Total Yield

Treatment	Fruit Number	Individual Plant Yield (g)	Fruit Weight (g)	Total Yield (kg)
Hybrids				
Russian	30.66	282.2	12.49	477.8
BOBY	30.83	282.7	12.44	478.4
LSD	0.20	4.29	0.11	5.36
Foliar Application				
Control	27.38	346.4	12.68	433.0
K+Ca Traditional	32.22	391.5	12.17	489.4
K+Ca Nano	32.64	409.5	12.55	511.8
LSD	0.67	5.51	0.246	6.89
Interaction (A×B)				
A_1 B_0	27.48	348.5	12.72	435.6
A_1 B_1	32.00	388.8	12.14	486.0
A_1 B_2	32.50	409.3	12.61	511.6
A_2 B_0	27.28	344.3	12.64	430.4
A_2 B_1	32.43	394.2	12.21	492.8
A_2 B_2	32.76	409.6	12.48	512.1
LSD	0.78	6.67	0.288	8.34

Results in Table 3 indicate that foliar application of traditional and nano potassium and calcium significantly influenced hybrid performance and yield parameters. The BOBY hybrid demonstrated superior performance, recording the highest mean fruit number (30.83 fruits plant^{-1}), individual plant yield (282.7 g), and total yield (478.4 kg per greenhouse), compared to the Russian hybrid which exhibited slightly lower values for these parameters: fruit number (30.66 fruits plant^{-1}), individual plant yield (282.2 g), and total yield (477.8 kg per greenhouse). However, the Russian hybrid significantly

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outperformed the BOBY hybrid in fruit weight when treated with traditional and nano potassium and calcium foliar application, recording a mean of 12.49 g compared to 12.44 g for BOBY.

Regarding foliar application treatments, nano potassium and calcium application significantly enhanced fruit number, yielding the highest mean (32.64 fruits plant^{-1}) compared to the control treatment which recorded the lowest (27.38 fruits plant^{-1}). For fruit weight, the control treatment exhibited the highest mean (12.68 g), while traditional potassium and calcium application recorded the lowest (12.17 g), though not significantly different from nano application. Nano potassium and calcium application significantly increased individual plant yield (409.5 g) and total yield (511.8 kg) compared to the control treatment which recorded the lowest values (346.4 g and 433.0 kg, respectively.(

For the interaction between hybrids and foliar application (A×B), the BOBY hybrid with nano potassium and calcium application (A_2 B_2) significantly outperformed other combinations in fruit number (32.76 fruits plant^{-1}), individual plant yield (409.6 g), and total yield (512.1 kg per greenhouse). The Russian hybrid under control conditions (A_1 B_0) recorded the highest fruit weight (12.72 g), while the same hybrid with traditional potassium and calcium application (A_1 B_1) exhibited the lowest fruit weight (12.14 g). The table clearly demonstrates that foliar application of traditional and nano potassium and calcium had substantial effects on hybrid performance and yield parameters.

Discussion

The enhancement of vegetative growth parameters and quantitative characteristics of pickling cucumber hybrids following foliar application of traditional and nano potassium and calcium played a crucial role in improving nutrient absorption efficiency. Nano fertilizers contribute significantly to plant growth promotion and yield enhancement. Calcium (Ca) and potassium (K) are essential nutrients that perform vital functions in plant growth and development, with calcium supporting cell wall formation and reducing environmental stress effects. Additionally, calcium is essential for internal nutrient translocation, contributing to improved crop quality. Potassium, conversely, is vital for regulating cell turgor pressure, enhancing plant resistance to drought and harsh environmental conditions while improving photosynthesis efficiency, which aligns with findings by [4.[

Potassium supplementation is important for cell division, photosynthesis, enzyme activation, nitrate reduction, and protein synthesis. When present in sufficient quantities, potassium prevents the formation of toxic amines and increases plant disease resistance, consistent with [9]. The observed increases in vegetative parameters (plant height, leaf number, leaf area, and chlorophyll content) and yield components (fruit number, individual plant yield, and total yield) can be attributed to potassium's role in nutrient translocation. Potassium facilitates the transport of nutrients such as sugars and amino acids through plant tissues, enabling the movement of these compounds from leaves, where they are synthesized, to other plant parts like roots and fruits. This translocation is essential for supporting growth and plant

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productivity. Furthermore, potassium is crucial for producing vital energy molecules like adenosine triphosphate (ATP), which are utilized in transporting photosynthesis products through the phloem, as reported by [10.[

Similarly, calcium contributes to enhancing vegetative and quantitative traits by regulating nutrient transport and metabolism within the plant. It plays a key role in translocating nutrients such as magnesium (Mg) and phosphorus (P) within plant tissues and regulates the activity of enzymes responsible for protein synthesis and other organic compounds. Additionally, calcium assists in carbohydrate translocation from leaves, where they are produced through photosynthesis, to other tissues like roots and fruits. This translocation is essential for supporting overall plant growth and increasing productivity, consistent with findings by [11.[

Conclusion

The study demonstrated that foliar application of traditional and nano potassium and calcium to pickling cucumber hybrids contributed to achieving optimal vegetative characteristics and maximum values in quantitative traits. Results indicated the superiority of treatment (A_2 B_2)—BOBY hybrid with nano potassium and calcium foliar application—in achieving the highest productivity with an increase of 15.9% when compared to the control treatment.

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