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Impact of Varieties and Spraying with Nano Calcium Fertilizer on the Anatomical Traits of Potato Tubers

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Abstract
The experiment was conducted in the vegetable field of the Department of Horticulture and Landscape design, College of Agriculture and Forestry, University of Mosul, during the spring growing season of 2022. The aim was to study the effect of spraying with nano calcium fertilizer at three concentrations (0, 1.5, and 2.5 g/L) on some anatomical characteristics of two imported potato varieties (EL-Beida and Montreal).The nano calcium fertilizer was sprayed at three stages of plant growth: the first spray after field emergence, second and third sprays with a 20-day interval between each spray. The experiment involved 6 treatments which conducted in a split-plot system arranged within Randomized Complete Block Design, where the main plots were considered as varieties, and the sub-plot were the concentrations of nano calcium. The data were analyzed using the computer software SAS (2017), and the Duncan's multiple range test was used to test the means at a significance level of 0.05.

Keywords- Nano calcium, Potato, Fertilizer varieties.

1. Introduction

Potato, scientifically known as Solanum tuberosum L., belongs to the Solanaceae family, which includes more than 2,000 species and 90 genera. It is one of the most important and widely cultivated vegetable crops, especially known for its tuberous edible part. Potatoes are rich in nutrients, easily digestible, and constitute a significant portion of the world's tuber crops. The dry matter content in potatoes ranges from 15-29%, with starch content ranging from 10-24%, proteins at 1-2%, and carbohydrates at 17.5%. They also contain minerals such as potassium, phosphorus, magnesium, calcium, sodium, and iron, along with vitamins A, B, and C [1,2],.Potatoes are considered one of the most important food crops globally, following grains such as wheat, corn, and rice. They play a vital role in the global sustainable food system and in addressing food crises in developing countries [3]. Potatoes are a staple food in many regions, providing significant energy compared to other crops [4]. According to the Central Statistical Organization, the cultivated area for potatoes in Iraq reached 76,673 dunums in 2021, with an average production rate of 466,127 tons per cultivated area. The yield per dunum was 6,079.4 kg. When comparing the cultivated areas and production with global figures, it is evident that local production is relatively low, necessitating a study of the causes and the implementation of various methods and techniques to increase productivity. One of these methods is the introduction of new varieties and the use of nano calcium fertilizer for fertilization.

The importance of nano calcium in improving plant growth is evident as it plays a crucial role in plant development. It participates in metabolic processes, enhances cell elongation, contributes to cell wall construction, and increases cell rigidity. Nano calcium is involved in the formation of calcium pectates, which promote cell wall stability and cell adhesion, thereby contributing to the structural integrity of plant tissues. Additionally, calcium is involved in hormonal and enzymatic functions that protect plants against heat stress. It regulates the opening and closing of stomata and enhances plant resistance to diseases. Furthermore, nano calcium supplementation results in higher-quality fruits [5,6,7].

2. Literature Review

Each nutrient element plays a significant role in different stages of plant growth. Carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur are essential elements in the formation of organic matter and participate in complex biological processes at the cellular and plant levels. Other elements like potassium, magnesium, sodium, and chlorine serve as non-specialized ion functions, such as maintaining ion balance and facilitating cellular osmotic pressure. Cationic elements in this group, such as potassium, activate enzymatic systems. Certain elements are primarily involved in plant structure, such as magnesium in chlorophyll formation, calcium in cell wall and membrane construction, and iron and copper in cytochrome synthesis. Consequently, nutrient elements have multiple physiological functions in plant life, and their concentrations vary between plants, growth stages, and plant organs, affecting plant growth, appearance, and anatomical composition based on their concentrations in plant tissues [8,9].Potassium deficiency can lead to degradation of plastids and mitochondria in plants [10]. Calcium contributes to the formation of the middle lamella in the cell wall as calcium pectates, and it forms salts with phosphatic acid, which is essential for cell membrane integrity and various cellular activities [11]. A significant portion of calcium is associated with the carboxyl group of polygalacturonans and the hydroxyl group of polysaccharides, providing strength and flexibility to the cell wall [12,13].Calcium's utmost importance lies in cell wall construction, and it is also involved in cell division, elongation, membrane permeability, and enzymatic [14,15,16]. An investigation by [17] observed that foliar spraying of calcium, specifically calcium sulfate, on potato crops resulted in an increase in the expansion of wood and bark tissues in stolons and a significant increase in the thickness of surrounding cortex cells.[18] reported that the application of calcium chloride to potato crops led to an increase in the size and thickness of cortex and cortex cells in tubers, resulting in noticeable improvements in quantitative and qualitative traits of the yield. Similarly, [19] found that spraying calcium at concentrations of 500 and 1000 mg/L resulted in an increase in the thickness of the cortex layer, leading to a significant increase in tuber yield.

3. Methodology

Preparation of plant models for anatomical study

Preparation of tubers: After completing the preventive treatment process, three homogeneous-sized tubers were taken from each treatment. They were longitudinally sliced into finger-shaped sections, ensuring uniformity in the site of the harvested parts. The sections were washed with distilled water, and the anatomical study was conducted using

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direct microscopy with an Optika microscope. A Optika B5 Digital Camera attached to the microscope and OptikalSview version 3.9.0.605 operating system were used for imaging. The thickness of the cortex was estimated at a magnification of 100x, and images of these sections were captured.

4. Results and Discussion

The results from Table (1) indicate that the thickness of the cortex layer at harvest was not significantly affected by the two potato varieties under study (EL-Beida and Montreal). However, spraying with nano calcium fertilizer at both concentrations of 1.5 and 2.5 g/L resulted in a significant increase in this trait, reaching 179.99 and 185.73 µm, respectively, compared to the control treatment, where this trait decreased to 150.90 µm.

The results of the interaction between varieties and spraying with nano calcium fertilizer indicate the significant superiority of the interaction treatment between the EL-Beida variety and spraying with 2.5 g/L concentration of nano calcium fertilizer. It recorded the highest significant value in this trait, reaching 206.29 µm. It differed significantly only from the interaction treatment for the Montreal variety in the absence of spraying with nano calcium fertilizer, where the latter interaction treatment yielded the lowest value in this trait, measuring 131.83 µm.

Table (1): The effect of varieties, spraying with nano calcium fertilizer, and their interaction on the thickness of the cortex layer at harvest (µm).

Varieties	Concentration of Nano Calcium Fertilizer $g.L^{-1}$			Average effect of Variety
	0	1.5	2.5	
EL-Beida	169.97 ab	179.81 a	206.29 a	185.36 a
Montreal	131.83 b	180.17 a	165.17 ab	159.05 a
Average effect of spraying calcium nano fertilizer	150.90 b	179.99 a	185.73 a	

The averages that share the same alphabetical letter for each factor and each interaction do not differ significantly according to the Duncan's multiple range test at a significance level of 0.05 ($P \leq 0.05$).

Table (2) shows that the thickness of the cortex layer significantly increased after five months of storage in EL-Beida plants, reaching 168.61 µm compared to Montreal plants, which had the lowest value in this trait at 140.60 µm. The foliar application of nano calcium fertilizer at concentrations of 1.5 and 2.5 g/L resulted in a significant increase in the thickness of the cortex layer compared to the control treatment, which had a value of 141.97 µm for this trait. Additionally, the treatment with a concentration of 1.5 g/L of nano calcium fertilizer showed a significant superiority over the treatment with a concentration of 2.5 g/L in this trait.

The interaction between EL-Beida plants and the foliar application with a concentration of 2.5 g/L of nano calcium fertilizer provided the best significant value in this trait, reaching 180.55 µm, which was significantly superior to all other treatments of this interaction except for the interaction treatment of the same variety with a foliar application at a concentration of 1.5 g/L of nano calcium fertilizer. The lowest value in this trait, 128.55 µm, was obtained in the interaction treatment between the Montreal variety and a foliar application at a concentration of 0 g/L of nano calcium fertilizer.

Varieties	**Concentration of Nano Calcium Fertilizer g.L^{-1}**			**Average effect of Variety**
	0	**1.5**	**2.5**	
EL-Beida	155.39 c	169.89 ab	180.55 a	168.61 a
Montreal	128.55 d	162.14 bc	131.11 d	140.60 b
Average effect of spraying calcium nano fertilizer	141.97 c	166.01 a	155.83 b	

Table (2): Effect of varieties, foliar application with nano calcium fertilizer, and their interaction on the thickness of the cortex layer (µm).

The averages that share the same alphabetical letter for each factor and each interaction do not differ significantly according to the Duncan's multiple range test at a significance level of 0.05 ($P \leq 0.05$).

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