Effect of two different application methods of vitamin b3 (niacin) on vegetative growth characteristics and mineral content of radish (*Raphanus sativus* L.)

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Abstract

This research study explores the impact of Niacin (Vitamin B3) application on the vegetative growth characteristics and mineral content of radish plant. The experiment was conducted using a Randomized Complete Block Design with four replicates per treatment. Compared the effects of foliar spray and soil irrigation with Niacin on radish growth. Results indicate that Niacin application, especially treatment SN2 with foliar spray at 80 mg/L, led to a significant enhancement of vegetative growth characteristics with radish plants showing leaf length of 21.95 cm, leaf width of 95.85 cm, 17.0 leaves per plant, and a root weight of 615.2 g. Also, treatment SN2 showed higher concentrations of nitrogen (0.19%), phosphorus (0.04%), potassium (1.61%), copper (13.66 mg/kg), and iron (10.91 mg/kg) in radish plants compared to control treatment. These findings highlight the effects of Niacin in promoting growth and enhancing nutrients, indicating its potential for optimizing nutrient management strategies in vegetable production systems.

Keywords: Radish, Niacin, Irrigating, Soil application, Foliar application.

Introduction

Vegetables are considered important in dietary guidance because of their high concentrations of dietary fiber, vitamins and minerals [1]. Radish (Raphanus sativus L.) is herbaceous annual root vegetable belonging to Brassicaceae family. It is one of the stored winter plants which is common in Iraq and the quickest growing root vegetables [2]. It is farmed and consumed globally for the leaves and roots which are eaten fresh providing crunchy texture and peppery flavor, and with the roots of some of its' varieties cooked [3]. Carbohydrate, protein, crude fiber, and vitamin C are the nutritious constituents of radish, making it a valuable component of a healthy diet [4]. The high nutritious value of radish isn't just for the fact that it possess plenty of nutritious factors alone, but due to its medicinal benefits as well, since medical reports have shown that radish is amongst vegetables that help in lowering cholesterol percentages and blood sugar, in addition to providing protection from cancer [5], as well as being of benefit in curing headaches, liver diseases, gallbladder, and getting rid of urine stones.[6]

Vitamins have important effects on plant growth; they provide plants with essential nutrients and improve their immunity against plant diseases [7]. Nicotinamide (vitamin B3) is a water-soluble vitamin; it is a part of vitamin B group. For the purpose of not mixing between nicotinic acid and nicotine tobacco, this vitamin was also called niacin [8]. It is a well- characterized constituent of the pyridine dinucleotide coenzymes NADH and NADPH. It plays a vital role in energy metabolism, cell division, and stress response mechanisms as they work with a large number of enzymes dehydrogenases, which are found in the cytoplasm, as shown by [9]. secondary metabolite accumulation as well as manifestation of defense metabolism in plants can be induced and regulated by Niacin [10,11] has confirmed that the application of niacin caused an increase in vegetative growth and flowering of geranium *Pelargonium hortorum* L. as well as [12] on hoary stock Mathiola incana L. and [13] on *Dahlia variabilis* L. [9] have also found that niacin spraying affects plant height and the number of leaves positively in celery *Apium graveolens* L. Therefore, supplementing this vitamin through external application can potentially enhance plant growth and development.

The method of niacin application can significantly impact its effectiveness in promoting plant growth and influencing nutrient uptake in plant, the choice between irrigating with niacin and applying niacin foliarly presents advantages and considerations for radish cultivation [14]. Where irrigating with niacin provides sustained exposure of the root system to the nutrient, facilitating gradual uptake and distribution within the plant. This method ensures that niacin is readily available in the root zone, promoting root development and overall plant enhancement. However, the effectiveness of soil applied with niacin may be influenced by soil characteristics, such as pH and nutrient interactions, which can affect nutrient availability to the plant.[15]

While foliar spraying of niacin offers a more targeted and immediate approach to nutrient supplementation. As the direct application of niacin onto leaves allows rapid absorption. This method is particularly effective under conditions where root uptake is obstructed, such as in soils with nutrient deficiencies or environmental stress. However, foliar applied niacin may require frequent applications to maintain desired nutrient levels in plants and may be likely to be washed off due to rainfall or irrigation.[16]

Different application methods may influence niacin uptake, plant performance, and nutrient composition in radish. Therefore, this study aims to:

1.Study the effect of niacin on vegetative growth and mineral content of radish plants.

2.Compare the impacts of soil-applied versus foliar-applied niacin on vegetative growth and mineral content of radish plants.

Materials and Methods

The experiment was conducted in Scientific Departments of Educational College for Women, Tikrit university, during the agricultural season of 2024. It was done by planting radish seeds in 30 cm high pots filled with transported soil, the physical and chemical properties of the soil are shown in Table 1. Planting took place on 3 Febru-

ary, 2024, and the pots were arranged according to a Randomized Complete Block Design (RCBD) with 4 replicates per treatment [17]. totalling 20 pots including a control treatment.

Table (1): The chemical and physical characteristics of the soil used in the experiment.

Traits	Value	Unit of Measurement
Clay Silt Sand	18 20 62	% % %
Soil texture	Sandy loam	----
pH	7.6	----
EC	2.7	Ds/m
Nitrogen Phosphorus Potassium Iron	73.00 2.71 54.00 1.20	mg/kg mg/kg mg/kg mg/kg
Organic material	1.7	%
Calcium carbonates	25.5	%

The treatments applied to the plants were as follows:
N0: Control treatment (no niacin spray or irrigation).
SN1: Niacin spray at concentration of 40 mg/L.
SN2: Niacin spray at concentration of 80 mg/L.
IN1: Niacin irrigation by adding quantity of 40 mg/L.
IN2: Niacin irrigation by adding quantity of 80 mg/L.

Thus, there were 5 treatments randomized. The first spray and irrigating were applied when the seedlings reached a height of 6 cm with 3-4 leaves on 28 February, 2024. The second spray and irrigating were applied 10 days after the first ones. Samples were collected 20 days after the second spray and watering for plant element analysis and study of the following traits: plant height (cm), leaf width (cm), leaf number per plant, and root weight (g).

Statistical analysis of the research results was conducted using Duncan's Multiple Range Test and data analysis was done using the statistical software Minitab on a computer.

Estimation of Nitrogen Content (% N)

During the vegetative stage of the plants, the samples were collected. Nitrogen concentration (N%) was estimated using the Kjeldahl method with modifications by [18] depending on the procedure described by [19]. A known weight of the sample (approximately 0.5 g) was placed in a flask, and sulfuric acid was added along with appropriate amounts of copper sulphate and potassium sulphate. The digestion process was carried out by heating the contents until pale blue liquid was obtained. The liquid then was transferred quantitatively to a Kjeldahl flask containing 40% sodium hydroxide solution and connected to a condenser ending in a receiving flask with bo-

ric acid and methyl red indicator. The estimation flask was heated until approximately 25 ml of distilled liquid was collected, then the collected liquid was titrated with 0.1N hydrochloric acid and a blank solution prepared as mentioned above, excluding the sample, was used for calibration. The nitrogen percentage was calculated using the following equation:

$$\%N = \frac{Volume\ of\ HCl\ consumed\ (mL) \times Normality\ of\ HCl \times 0.014}{Sample\ weight} \times 100\%$$

Estimation of Phosphorus Content (% P)

Phosphorus was determined colorimetrically using a Spectrophotometer based on the method described by [20]. Approximately 0.5 g of dried ground sample was dissolved in 5 mL sulfuric acid and 2 mL perchloric acid. Ascorbic acid and Aluminum molybdate (colorimetric method) were used, and the absorbance was measured using a Spectrophotometer at a wavelength of 700 nm.

Estimation of Other Elements (K, Cu, Fe) in the Plant:

The potassium, copper and iron in the plant samples (collected, dried, and ground) were determined by acid digestion according to the American Public Health Association method [21]. Approximately 3 g of plant sample was digested using wet digestion with sulfuric acid as per the method described. The solution was adjusted to the expected concentration, and absorbance was measured using an Atomic Absorption Spectrophotometer (Shimadzu AA 7000).

Results and Discussion

Effect of Niacin Spray and Irrigation on the Vegetative Growth of Radish Plants

Table 2 and Figures 1-4 illustrate the effect of niacin spray and irrigation on the vegetative growth characteristics of radish plants. The treatments excelled in all studied vegetative growth characteristics, including leaf length, leaf width, leaf number, and root weight compared to the control plants. Plants treated with niacin spray exhibited higher growth rates compared to those treated with irrigation. Treatment SN2 (niacin spray at 80 mg/L) recorded the highest values, reaching 21.95 cm for leaf length, 95.85 cm for leaf width, 17.00 leaves per plant, and 615.2 g for root weight. While treatment IN2 (niacin irrigation at 80 mg/L) recorded values of 15.8 cm for leaf length, 84.25 cm for leaf width, 14.00 leaves per plant, and 449.40 g for root weight. The control plant recorded the lowest values for these characteristics (12.25 cm, 9.6 cm, 4.50 leaves per plant, 92.2 g) respectively compared to other treatments.

Table (2): The effect of foliar spray and irrigation with niacin on vegetative growth traits of radish.

Treatments	Leaf length (cm)	Leaf width (cm)	Number of leaves per plant	Root weight (g)
N_0	12.250 c	9.60 e	4.50 d	92.2 d
SN_1	20.885 a	87.65 b	14.50 b	455.9 b

SN_2	21.950 a	95.85 a	17.00 a	615.2 a
IN_1	13.900 c	72.25 d	12.50 c	262.6 c
IN_2	15.800 b	84.25 c	14.00 b	449.4 b

*Numbers with the same letters in the same column have no significant differences according to the Dunkin' polynomial test at the probability level of 5%.

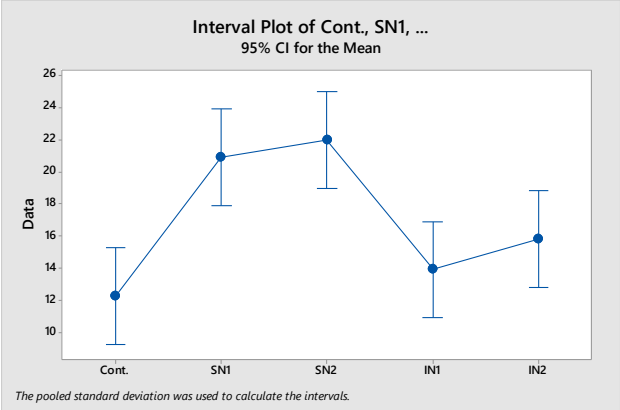

Figure (1): The effect of foliar spray and irrigation with niacin on leaf length of radish plant.

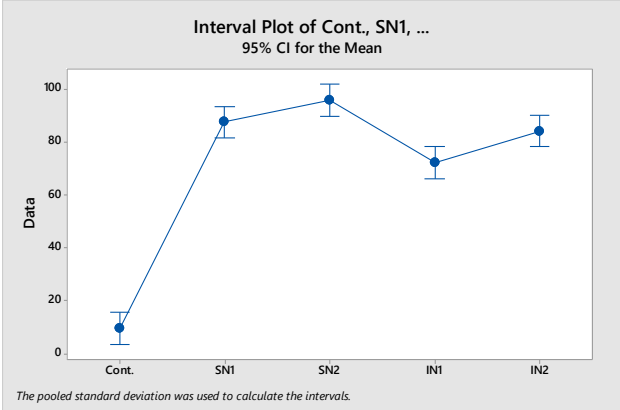

Figure (2): The effect of foliar spray and irrigation with niacin on leaf width of radish plant

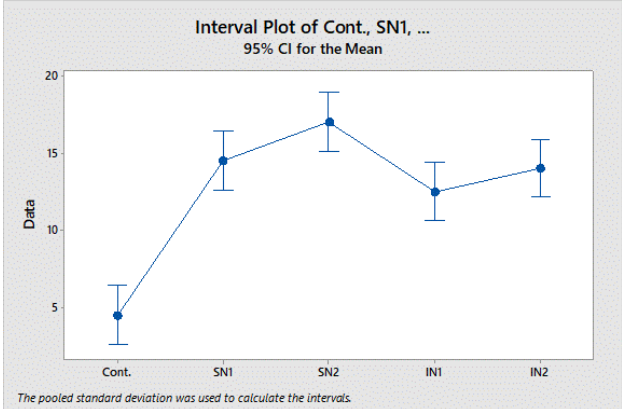

Figure (3): Tthe effect of foliar spray and irrigation with niacin on leaves number of radish plant.

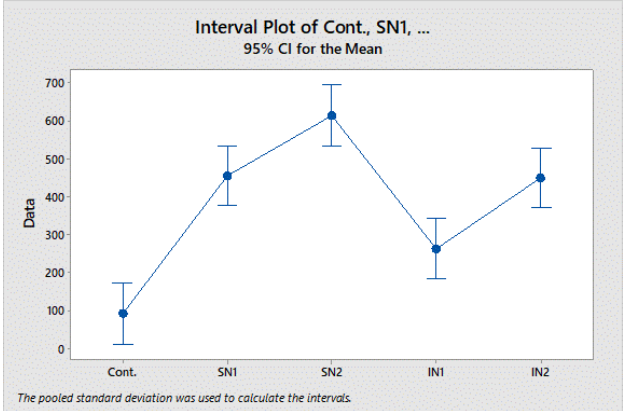

Figure (4): The effect of foliar spray and irrigation with niacin on root weight of radish plant.

These significant improvements on radish plants are due to the fact that niacin supplementation enhances the rate of photosynthesis and encourages plant elongation, promoting increased plant height [22]. Niacin also activates hormones within the plant and balances nutrient concentrations. The increase in vegetative biomass can be attributed to niacin's role in improving growth characteristics through the formation of indole acetaldehyde, an important compound in auxin (IAA) synthesis, crucial for cell elongation and proliferation. Moreover, niacin acts as a coenzyme in carbohydrate metabolism, releasing energy essential for various vital cellular processes [8]. The positive impact of niacin aligns with [22] findings on Cladodes plants, demonstrating a significant positive effect of niacin spray on vegetative growth. These results agree with [9] study on celery plants.

As indicated in table 2 and figures 1-4, the highest rates of vegetative growth were recorded in treatments SN1 and SN2 (foliar spray), while the rates observed in treatments IN1 and IN2 (soil irrigation) were lower. The delayed effects of soil irrigation

on plant appearance are due to the plant's reliance on soil microorganisms to convert fertilizers into usable nutrients [23]. Foliar spray is essential for enhancing growth rates; therefore, it is imperative to apply necessary nutrients directly to the foliage to ensure direct plant absorption and prevent leaching or fixation upon soil addition [24].

Effect of Niacin Spray and Irrigation on the Mineral Content of Radish Plants

Table 3 and Figures 5-9 indicate that niacin spray and irrigation resulted in significantly higher concentrations of nitrogen, phosphorus, potassium, copper, and iron. The highest values (0.19%, 0.04%, 1.61%, 13.66 mg/kg, 10.91 mg/kg) were observed in treatment SN2 (niacin spray at 80 mg/L) compared to the control treatment, which recorded concentrations of 0.12%, 0.03%, 1.05%, 6.14 mg/kg, 4.13 mg/kg, respectively. The same table and figures demonstrate that nutrient concentrations were higher in treatment SN2 compared to the treatment IN2 (niacin irrigation at 80 mg/L) that recorded (0.17%, 0.03%, 1.46%, 11.55 mg/kg, 9.53 mg/kg) respectively.

Table (3): The effect of foliar spray and irrigation with niacin on mineral content of radish.

Treatments	N%	P%	K%	Cu mg/kg	Fe mg/kg
N_0	0.12400 e	0.026000 e	1.0500 e	6.1350 e	4.1250 e
SN_1	0.15550 c	0.035500 c	1.3900 c	10.2350 c	8.1500 c
SN_2	0.18700 a	0.042000 a	1.6100 a	13.6550 a	10.9150 a
IN_1	0.14300 d	0.031500 d	1.2150 d	8.1250 d	6.1450 d
IN_2	0.17400 b	0.037500 b	1.4600 b	11.5500 b	9.5250 b

***Numbers with the same letters in the same column have no significant differences according to the Dunkin' polynomial test at the probability level of 5%.**

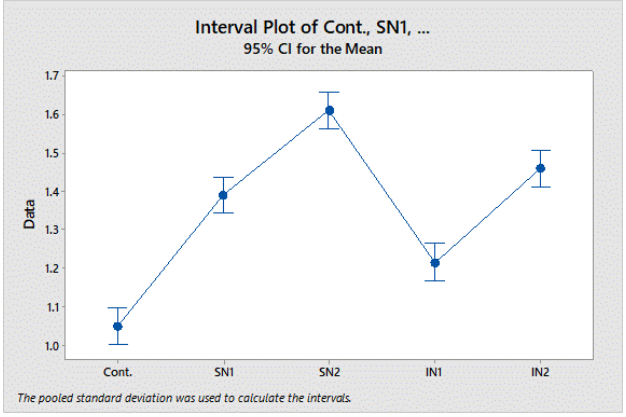

Figure (5): The effect of foliar spray and irrigation with niacin on N concentration in radish plant.

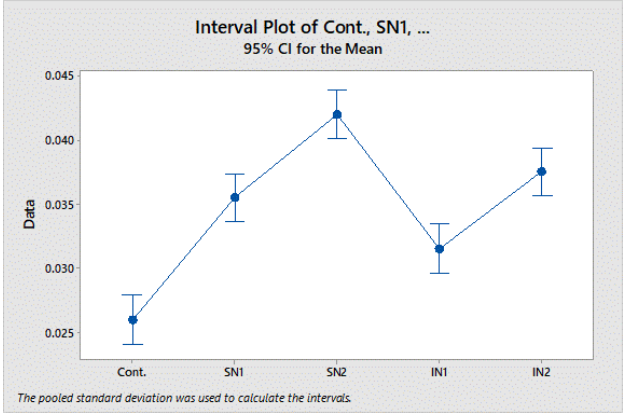

Figure (6): The effect of foliar spray and irrigation with niacin on P concentration in radish plant.

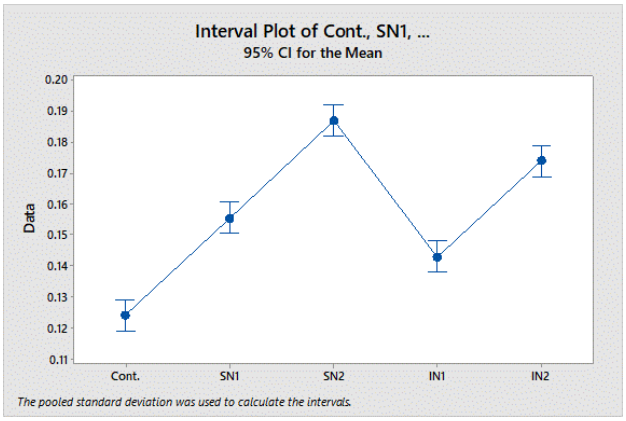

Figure (7): The effect of foliar spray and irrigation with niacin on K concentration in radish plant.

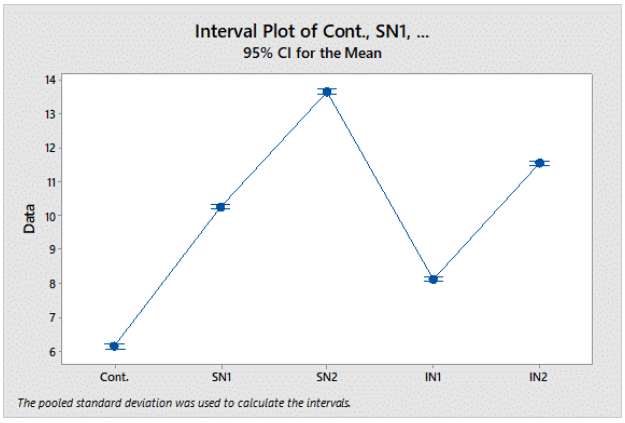

Figure (8): The effect of foliar spray and irrigation with niacin on Cu concentration in radish plant

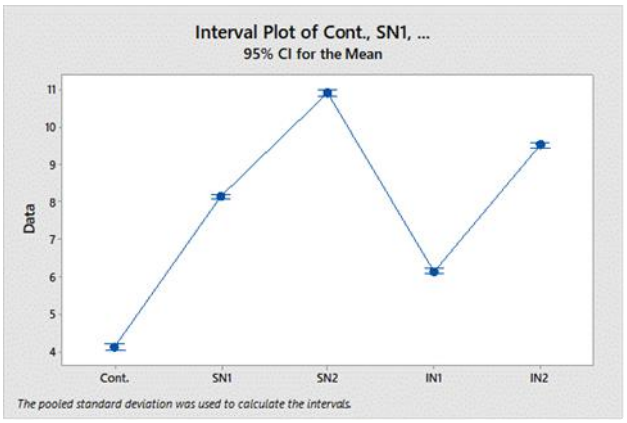

Figure (9): The effect of foliar spray and irrigation with niacin on Fe concentration in radish plant.

The significant positive effect on nutrient concentrations, including nitrogen, phosphorus, potassium, copper, and iron, since niacin enhances vegetative growth (Table 3) leading to increasing nutrient absorption from the soil and nutrient solutions to match the enhanced physiological plant activity [25].

The impact of niacin on increasing nutrient concentrations can be attributed to its vital role in numerous plant biological processes and its involvement in the enzymatic cofactors NADP and NAD, crucial in cytoplasmic metabolism for synthesizing essential biomolecules such as carbohydrates, lipids, and proteins [26]. Also, this increase in the nutrient concentrations may be attributed to niacin's role in stimulating nutrient absorption, influencing plant activity and growth processes, thereby enhancing the absorption of important nutrients necessary for these vital biological processes [22].

Generally, foliar and soil irrigation yielded contrasting results compared to control plants, with significant positive differences observed. This study revealed that foliar spray yielded higher mineral content levels, while soil irrigation yielded lower levels. This is due to the slow plant uptake of niacin due to the interference of soil elements. Foliar nutrition has been shown to be an effective method for better nutrient transport

within the plant, followed by its contribution to enhancing natural growth of plants [16].

Niacin application specially through foliar spray significantly enhances the vegetative growth characteristics and leads to increased concentrations of essential minerals in radish plants, indicating improved nutrient uptake compared to irrigation. The findings suggest that Niacin plays an important role in improving photosynthesis, plant elongation, and nutrient balance, contributing to overall plant health and productivity. Foliar application of Niacin demonstrates more immediate and targeted effects on plant growth compared to soil irrigation, highlighting the efficiency of this application method.

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