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Response of some parameters of local orange seedling (*Citrus Sinensis L.*) budding on Sour Orange to organic waste addition and Zinc spraying

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Abstract

Objective

The goal of this study was to assess the effects of organic matter application and zinc foliar spraying on the vegetative growth of local orange seedlings (*Citrus sinensis* L.) grafted onto sour orange rootstock. The experiment was carried out at Al-Mahawil Horticultural Station, General Company of Horticulture and Forestry, Ministry of Agriculture, during the period from October 2024 to June 2025. Improving seedling growth and nutritional status under nursery conditions was the main aim of this research.

Materials and Methods

Cattle manure was used as a source of organic matter and applied at four levels: 0, 0.25, 0.50, and 0.75 kg per seedling. Zinc was applied as a foliar spray at three concentrations (0, 20, and 40 mg Zn L^{-1}) using hydrated zinc sulfate as the zinc source. The experiment was arranged in a factorial completely randomized design with three replications. We recorded several vegetative growth parameters. These parameters were: leaf nutrient content, seedling height, seedling dry weight, stem diameter, number of leaves, chlorophyll content (SPAD value), and leaf area. analysis of variance (ANOVA) was used to analyze data. Least Significant Difference (LSD) test at the 5% probability level was used to perform mean comparisons.

Results

The results of our study showed that if we increase the level of organic matter, all measured vegetative growth parameters can be significantly improved. For our study, the highest value was obtained at 0.75 kg per seedling. The values of the parameters also reached the following values: leaf nitrogen content of 1.88%, seedling height of 98.87 cm, seedling dry weight of 116.6 g, stem diameter of 1.23 cm, chlorophyll content of 45.37 SPAD units, number of leaves of 95.27 leaves per seedling, and leaf area of 21.27 dm2 per seedling. Zinc foliar spraying at 40 mg L^{-1} also caused a significant increase in all growth traits, including height (94.45 cm), stem diameter (1.20 cm), leaf number (91.9 leaves per seedling), leaf area (20.7 dm^2), chlorophyll content (45.48 SPAD units), dry weight (117.3 g), and improved leaf mineral content. The combined application of 0.75 kg organic matter with 40 mg Zn L^{-1} resulted in the highest values for all studied characteristics.

Conclusions

It can be concluded that the combined use of organic matter and zinc foliar application effectively enhances the vegetative growth and nutritional status of local orange seedlings. The treatment consisting of 0.75 kg organic matter per seedling combined with 40 mg Zn L^{-1} was the most effective, and can be recommended to improve seedling quality in citrus nurseries and support better orchard establishment.

Keywords: orange seedlings, organic residues, sour orange rootstock, zinc

Paper Type: Research Paper.

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Introduction

Orange (*Citrus sinensis* L.) belongs to the family Rutaceae and is one of the most important citrus crops worldwide. Because it has a pleasant taste and is not bitter, it has been widely accepted by consumers. This has led to it accounting for almost two-thirds of the world's total citrus production (Hilgeman & Reuther, 1967). Oranges are purchased and consumed by people both fresh and processed. This has made the crop economically valuable in many countries. Commercial orange production usually depends on grafting onto seed-derived rootstocks. This is done to improve adaptability, vigor, and resistance to environmental stresses. One of the most widely used rootstocks for citrus trees, particularly in arid and semi-arid regions is sour orange (*Citrus aurantium* L.). This plant has adapted well to the environmental conditions of Iraq, as studies have shown that it can tolerate several soil-borne diseases such as gummosis and root rot. Orange has a deep and branched root system. This improves water and nutrient uptake and makes the plant more resilient. In addition, it has a high compatibility with many citrus cultivars, including sweet orange, making it suitable for local citrus production systems (Debnath & Jain, 2025). Organic fertilizers can be used to improve soil quality and maintain plant growth in the long term (Al-Meekh et al., 2021; Abd Hamidi & Arak, 2024). These fertilizers are derived from decomposed plant and animal remains. They are commonly known as compost or animal manure. They provide essential nutrients in a slow and balanced manner, improve soil structure, enhance microbial activity, and increase water holding capacity. The combined use of organic and biological fertilizers can significantly increase soil nutrient availability and seedling growth. This is most effective when combined with foliar application of micronutrients (Al-Shahbani & Almekh, 2022; Ajeel & Al-Hakeim, 2024; Almekh, 2025; Assi et al., 2021; Hussein et al., 2025). Fikry et al. (2022) showed that using decomposed organic residues in the growth medium can increase chlorophyll content of apple seedlings, leaf area, and shoot dry weight. Franzluebbers (2002) also reported that organic fertilization can improve antioxidant compounds and phenolic content in olive fruits. Also, the culture media containing organic residues showed better performance than the culture media without organic residues. In addition, similar positive effects were reported with foliar application of humic acid in their study. Their results showed that olive seedlings had a significant increase in leaf carbohydrate, leaf number, and nitrogen, phosphorus, potassium content and stem length compared to untreated plants (Miri Nargesi et al., 2022). Using poultry manure enhances potassium concentration, leaf area, and yield of apple trees cv. Anna (Li et al., 2024). It was also shown that the use of organic residue extracts improved the chlorophyll content in soursop seedlings, increased the number of leaves, increased the fresh and dry weight of the plant, and increased the height of the seedling (Hoque et al., 2022). Zinc is an essential micronutrient required for normal plant growth and development. Zinc deficiency leads to reduced growth and poor physiological performance. This element plays a very important role in enzyme activation, protein synthesis, and gene expression. In addition, zinc plays a key role in the synthesis of tryptophan, a precursor of indole-3-acetic acid (IAA), which regulates cell elongation (Broadley et al., 2007; Al-Mamouri & Hussien, 2023). Swietlik and Zhang (1994) showed that foliar usage of zinc on sour orange seedlings significantly increases leaf area and dry weight. In a study by Chakmak (2008), it was reported that foliar application of zinc sulfate to citrus seedlings grafted onto orange rootstock improved leaf nitrogen and phosphorus content, growth rate, leaf area, and branching. In addition, it was found that foliar application of zinc chelate improved vegetative growth and leaf nutrient status in olive cultivars, including increasing leaf area, stem length and diameter, and leaf dry weight (Başar & Gürel, 2016). Moreover, studies by Cakmak (2008) and Hasanuzzaman et al. (2020) confirmed that zinc spraying enhances chlorophyll content, leaf number, total yield, and fruit size in orange trees. These important issues led us to conduct this study with the aim of evaluating the response of local orange seedlings grafted on orange rootstock to different levels of organic matter added to the growing medium and zinc foliar application, so that we can provide practical recommendations for improving the quality of citrus seedlings under greenhouse conditions.

Materials and methods

The experiment was done from October 2024 to June 2025 under greenhouse conditions at the Al-Hindiyah Horticultural Station, Karbala Governorate, Iraq. The station is under the supervision of the General Horticulture and Forestry Company, Ministry of Agriculture. The aim of this study was to evaluate the effects of adding organic matter to the growing medium and foliar application of zinc on the vegetative growth characteristics of local orange (*Citrus sinensis* L.) seedlings grafted onto orange (*Citrus aurantium* L.) rootstock.

Experimental design and treatments: Used design was a factorial experiment in a completely randomized design (CRD) with three replications with two factors. The first factor had four levels of organic matter of 0, 0.25, 0.50, and 0.75 kg per seedling. The second factor had three zinc foliar spray concentrations of 0, 20, and 40 mg Zn L^{-1}. Hydrated zinc sulfate was used as the zinc source. Each experimental unit had five seedlings. A total of 180 uniform, one-year-old seedlings were used to perform this study.

Plant material and growth conditions: 10 kg plastic bags were filled with uniform nursery soil to prepare for planting seedlings. To ensure uniform distribution of organic fertilizers, they were mixed with the soil and thoroughly mixed before planting. Diammonium phosphate (DAP) was used as mineral fertilizer at the rate of 25 g per seedling (50% of the recommended rate). This prevents overfeeding of minerals and accentuates the effects of organic matter and zinc treatments. Regular irrigation was used along with leaching of excess salts.

Zinc foliar application: Zinc foliar sprays were applied four times at 30-day intervals starting on 15 November 2024. A 2-litre hand spray was used in the early morning hours until the crown of the seedlings was completely wetted. A wetting agent (1 cm3 of detergent per spray solution) was used to improve spray persistence and leaf surface coverage (Fernández & Eichert, 2009). The seedlings were watered one day before each foliar spray. This was done to increase cell turgor, stomatal opening and nutrient uptake through the leaf surface (Hernández et al., 2024). Distilled water was used to spray the control plants.

Soil and organic fertilizer analysis: A random sampling method was used to collect soil samples from the growing medium before planting to analyze selected physical and chemical properties. Standard procedures described by Jackson (1958) and Page (1982) were used for the analyses. The physical and chemical characteristics of the nursery soil are presented in Table 1. The chemical composition of the decomposed organic residues used in the experiment was also analyzed, and the results are shown in Table 2.

Table 1. Physical and chemical characteristics of the nursery soil used in the experiment

Property	Value	Unit
pH	7.5	-
Electrical conductivity (EC)	2.47	dS m^{-1}
Bulk density	1.38	Mg m^{-3}
Cation exchange capacity (CEC)	19.4	cmolc kg^{-1}
Organic matter	8.7	g kg^{-1}
Calcium carbonate ($CaCO_3$)	186.6	g kg^{-1}
Available nitrogen (N)	27.7	mg kg^{-1}
Available phosphorus (P)	8.2	mg kg^{-1}
Available potassium (K)	136.2	mg kg^{-1}
Clay	336.3	g kg^{-1}
Silt	368.4	g kg^{-1}
Sand	295.3	g kg^{-1}
Soil texture	Clay loam	-

Measured growth parameters: At the end of the experiment, three seedlings were randomly selected from each experimental unit for growth measurements. Seedling height (cm) was measured using a measuring tape as the distance from the soil surface to the apical bud. Stem diameter (cm) was measured at the position of the fifth true leaf on the main stem using a digital caliper. The total number of leaves per seedling was counted, and the mean value was calculated for each experimental unit. Leaf area was determined using a planimeter on three fully expanded leaves per seedling, collected from the upper, middle, and lower canopy positions. Leaves were photocopied, and leaf area was expressed in square decimeters (dm^2) by multiplying the average leaf area by the total number of leaves per seedling. The number of lateral shoots per seedling was also recorded.

Table 2. Chemical composition of the organic residues used as organic fertilizer

Parameter	Value	Unit
pH	6.32	-
Electrical conductivity (EC)	5.82	dS m^{-1}
Organic matter	479.6	g kg^{-1}
Organic carbon	330.2	g kg^{-1}
C:N ratio	20.8	-
Total nitrogen (N)	14.6	g kg^{-1}
Total phosphorus (P)	0.23	g kg^{-1}
Total potassium (K)	2.4	g kg^{-1}

Chlorophyll and dry matter determination: Leaf chlorophyll content was measured in situ using a SPAD chlorophyll meter, with three readings taken per leaf and averaged. Leaf dry matter percentage was determined by drying five fresh leaves of known weight in a forced-air oven at 65–70°C until a constant weight was achieved, followed by weighing using a sensitive balance.

Leaf nutrient analysis: To measure the nutrient content of leaves, random sampling was done from all parts of the seedlings in each replicate. To remove dust and impurities, the samples were washed with distilled water. Then they were placed in perforated paper bags. The samples were dried in an oven at 70°C until constant weight was reached. After grinding the samples, 0.2 g of each was digested using 4 ml of sulfuric acid and 2 ml of perchloric acid, according to the method described by Jones and Case (1990). The modified Kjeldahl method with a micro Kjeldahl apparatus (Heins, 1980) was used to measure the nitrogen content. The ammonium molybdate-ascorbic acid method with a spectrophotometer (John, 1970) was used to determine the phosphorus concentration. The flame photometer as described by Hesse (1971) was used to measure the potassium content. An atomic absorption spectrophotometer was used to obtain leaf zinc concentration (mg/kg dry matter) according to the method described by Page (1982).

Statistical analysis: SAS statistical software (SAS, 2023) was used for analysis of variance (ANOVA) of the data and information of this study. The least significant difference (LSD) test at the 5% probability level was used to compare the means of the treatments.

Results and discussion

Seedling height (cm) and stem diameter (cm): The results showed that the application of organic matter had a significant effect on seedling height and stem diameter of local orange seedlings grafted onto orange rootstock (Table 3). Both growth parameters improved under the treatment. When the treatment of 0.75 kg seedlings per liter was used, the highest mean values for seedling height (98.87 cm) and stem diameter (1.23 cm) were obtained. The lowest mean values for seedling height of 78.43 cm and stem diameter of 0.80 cm were recorded, which were related to the control treatment (0 kg seedlings per liter). The improvement in vegetative growth could be due to the positive role of organic matter in improving soil physical properties, such as aeration, water holding capacity and soil structure. In addition, organic matter acts as a slow-release source of essential nutrients. They stimulate microbial activity in the rhizosphere. This improves root growth and nutrient uptake. When root activity increases, cell division and root elongation increase, ultimately leading to increased stem thickness and seedling height. These results were consistent with the results reported by other researchers (Visconti et al., 2023; Ajeel et al., 2025). Foliar application of zinc also significantly affected seedling height and stem diameter. This element plays an important role in plant growth by interfering with the synthesis of tryptophan, which is a precursor of indole-3-acetic acid (IAA). This hormone is responsible for cell division and elongation. Zinc is an important element involved in many enzymes. It plays a role in nucleic acid synthesis and protein metabolism. All of these are effective in stem growth and overall plant growth (Broadley et al., 2007; Cakmak, 2008). In this study, the interaction between organic matter and foliar application of zinc was very significant. The combined treatment of 0.75 kg of organic matter per seedling and 40 mg of zinc per liter produced the highest values (seedling height reached 107.6 cm and stem diameter reached 1.40 cm). In contrast, the lowest values were in the control group (treatment without the application of organic matter and zinc). This interaction may indicate that adequate soil nutrition by organic amendments increases the effectiveness of zinc foliar application. Therefore, this interaction improves vegetative growth and produces stronger seedlings.

Total number of leaves per seedling and leaf area (dm^2): The application of organic matter had a significant effect on the total number of leaves per seedling and leaf area (Table 4). The increase in leaf number and leaf area with the addition of organic matter can be attributed to the improvement in the availability of nutrients, especially nitrogen and phosphorus. These nutrients are essential for leaf initiation and expansion. Organic matter improves chlorophyll content and nutrient balance. They also increase photosynthetic activity, leading to the production of new leaves and larger leaf areas. These parameters were also significantly increased by foliar application of zinc. The 40 mg/L zinc treatment resulted in the highest mean values (91.90 leaves and 20.70 dm2 leaf area). The lowest values were in the control group. Zinc is involved in carbohydrate metabolism, chlorophyll synthesis and enzyme activation. All of these together promote leaf growth and expansion (Hasanuzzaman et al., 2020). The interaction between organic matter and zinc foliar application showed a significant synergistic effect. This suggests that organic amendments can enhance the efficiency of zinc foliar application, thereby improving canopy development and photosynthetic capacity.

Table 3. Effects of organic residue addition, zinc foliar spray, and their interaction on seedling height and stem diameter of local orange seedlings

Organic residue (kg seedling^{-1})	Zinc (mg L^{-1})	Seedling height (cm)	Stem diameter (cm)
0.00	0	72.3	0.60
	20	80.7	0.80
	40	82.3	1.00
Mean		**78.43**	**0.80**
0.25	0	77.6	0.70
	20	80.9	0.90
	40	85.5	1.20
Mean		**81.33**	**0.93**
0.50	0	83.9	0.90
	20	89.7	1.10
	40	102.4	1.20
Mean		**92.00**	**1.07**
0.75	0	88.4	1.00
	20	100.6	1.30
	40	107.6	1.40
Mean		**98.87**	**1.23**

LSD (0.05): Organic residue: 4.86 (height), 0.14 (diameter); Zinc: 3.94 (height), 0.09 (diameter); and Interaction: 7.93 (height), 0.21 (diameter)

Leaf chlorophyll content (spad) and seedling dry weight (g): The results showed that the application of organic matter had significant effects on leaf chlorophyll content and seedling dry weight (Table 5). For the 0.75 kg treatment, the highest seedling values (45.37 SPAD units and 116.60 g) were observed. However, the lowest seedling values (39.43 SPAD units and 100.80 g) were obtained for the control group. Foliar application of zinc also significantly increased both parameters. For the 40 mg/L zinc treatment, the highest values (45.48 SPAD units and 117.30 g) were observed. However, the lowest values were obtained for the control group. This increase in chlorophyll content indicates that zinc plays an important role in chlorophyll biosynthesis and activation of photosynthetic enzymes and is likely to lead to greater biomass accumulation and dry matter production (Downton et al., 1987). The combined use of organic matter and zinc (0.75

kg organic matter per seedling + 40 mg zinc/liter) further enhanced these traits and resulted in the highest chlorophyll content (48.4 SPAD) and dry weight (126.2 g). This indicates that organic soil amendments and foliar application of micronutrients have a synergistic effect and affect seedling vigor and biomass production.

Table 4. Influence of organic residue addition, zinc foliar spray, and their interaction on total leaf number and leaf area of local orange seedlings

Organic residue (kg seedling^{-1})	Zinc (mg L^{-1})	Total leaves (no./seedling)	Leaf area (dm^2/seedling)
0.00	0	77.2	17.5
	20	81.1	18.8
	40	82.5	19.1
Mean		**80.27**	**18.47**
0.25	0	79.6	18.1
	20	84.8	19.4
	40	86.5	19.8
Mean		**83.63**	**19.10**
0.50	0	82.3	18.9
	20	93.4	20.6
	40	95.2	21.1
Mean		**90.30**	**20.20**
0.75	0	84.8	19.3
	20	97.6	21.7
	40	103.4	22.8
Mean		**95.27**	**21.27**

LSD (0.05): Organic residue: 2.22 (leaves), 0.92 (leaf area); Zinc: 2.82 (leaves), 0.52 (leaf area); and Interaction: 5.68 (leaves), 1.38 (leaf area)

Leaf nitrogen (n) and phosphorus (p) content (%): In this study, increasing the level of organic matter significantly increased the leaf nitrogen and phosphorus content (Table 6). For the 0.75 kg seedlings/liter treatment, the highest values of leaf nitrogen and phosphorus content (1.88% nitrogen and 0.34% phosphorus) were obtained. For the control treatment, these values were 1.61% and 0.27%, respectively. Foliar application of zinc significantly increased the leaf nutrient content in the 40 mg zinc/liter treatment group (1.87% nitrogen and 0.32% phosphorus) compared to the control. This could be because zinc plays a key role in protein synthesis and enzyme activation and increases nitrogen uptake and phosphorus uptake (Cakmak, 2008). The interaction between organic matter and zinc was also significant. The combined treatment resulted in the highest nutrient content (2.03% nitrogen and 0.36% phosphorus). This indicates that organic soil amendments and zinc foliar application have a synergistic effect on nutrient accumulation in citrus seedlings.

Table 5. Effects of organic residue addition, zinc foliar spray, and their interaction on leaf chlorophyll content and seedling dry weight of local orange seedlings

Organic residue (kg seedling^{-1})	Zinc (mg L^{-1})	Chlorophyll content (SPAD)	Seedling dry weight (g)
0.00	0	33.9	90.6
	20	41.3	103.7
	40	43.1	108.1
Mean		**39.43**	**100.80**
0.25	0	36.2	93.9
	20	42.8	110.6
	40	44.3	113.4
Mean		**41.10**	**105.97**
0.50	0	40.2	97.4
	20	44.7	117.7
	40	46.1	121.5
Mean		**43.67**	**112.20**
0.75	0	41.8	100.2
	20	45.9	123.4
	40	48.4	126.2
Mean		**45.37**	**116.60**

Leaf potassium (K) and zinc (Zn) content: The use of organic matter in this experiment significantly increased the leaf potassium and zinc content (Table 7). The highest values (1.81% potassium and 50.77 mg zinc/kg) were observed for the concentration of 0.75 kg seedlings. The control treatment recorded the lowest values. Foliar application of zinc also significantly increased the potassium and zinc content. The highest mean values (1.69% potassium and 43.63 mg zinc/kg) were observed for the concentration of 40 mg zinc/L. Zinc increases enzymatic activity and nutrient transport. This facilitates the accumulation of potassium and the uptake of zinc in plant tissues (Wen et al., 2021). The interaction between organic matter and zinc resulted in the highest nutrient concentrations. This increase was particularly achieved at the concentration of 0.75 kg seedlings/kg organic matter combined with 40 mg zinc/L. These results confirm the benefits of integrated nutrient management in citrus nurseries. The results of our study showed that the use of organic matter and foliar application of zinc increased the vegetative growth and nutrient status of local orange seedlings grafted on orange rootstock (Tables 3-7).

Table 6. Influence of organic residue addition, zinc foliar spray, and their interaction on leaf nitrogen and phosphorus content of local orange seedlings

Organic residue (kg seedling⁻¹)	Zinc (mg L⁻¹)	Leaf N (%)	Leaf P (%)
0.00	0	1.42	0.23
	20	1.68	0.28
	40	1.73	0.29
Mean		**1.61**	**0.27**
0.25	0	1.48	0.24
	20	1.79	0.31
	40	1.85	0.30
Mean		**1.71**	**0.28**
0.50	0	1.62	0.29
	20	1.83	0.32
	40	1.88	0.34
Mean		**1.78**	**0.32**
0.75	0	1.69	0.31
	20	1.91	0.34
	40	2.03	0.36
Mean		**1.88**	**0.34**

Table 7. Effects of organic residue addition, zinc foliar spray, and their interaction on leaf potassium and zinc content of local orange seedlings

Organic residue (kg seedling⁻¹)	Zinc (mg L⁻¹)	Leaf K (%)	Leaf Zn (mg kg⁻¹)
0.00	0	1.36	27.4
	20	1.49	29.2
	40	1.55	31.8
Mean		**1.47**	**29.47**
0.25	0	1.41	31.1
	20	1.53	34.9
	40	1.62	38.4
Mean		**1.52**	**34.80**
0.50	0	1.68	37.7
	20	1.71	41.2
	40	1.73	45.6
Mean		**1.71**	**40.50**
0.75	0	1.72	44.1
	20	1.83	49.5
	40	1.87	58.7
Mean		**1.81**	**50.77**

The best growth responses were observed for the treatment of the excellent material at a concentration of 0.75 kg per seedling in terms of seedling height, stem diameter, leaf number, leaf area, chlorophyll content, dry weight and leaf nutrient concentration. These positive responses can be attributed to the presence of humic and fulvic acids in the organic matter. These increase nutrient availability, membrane permeability and cation exchange capacity of the soil. Humic substances also inhibit the activity of IAA oxidase. Therefore, they increase auxin activity and stimulate root and shoot growth (Canellas & Olivares, 2014). Improved nutrient uptake, especially N, P, K and Zn, explains the enhanced vegetative performance observed in this study (Tattini et al., 1991; Aswad et al., 2026). Foliar application of 40 mg/L zinc also increased growth and nutrient accumulation. This element improved photosynthetic efficiency and improved chlorophyll formation and enzyme activity. Together, these increased biomass production and seedling vigor (Al-Bamarny & Abdulrhman, 2018). The combined application of organic matter and zinc showed a strong synergistic effect. These results indicate that integrated nutrient management can be an effective strategy to improve citrus seedling quality under greenhouse conditions.

Conclusion: The results of the present study showed that the use of organic fertilizer can play an important role in improving the vegetative growth of local orange seedlings. Foliar application of zinc also increased the growth of seedlings. Although the effectiveness of foliar application of zinc depended on the level of organic matter applied. The combined use of organic fertilizer and foliar application of zinc showed an obvious synergistic effect. This can lead to better growth performance and greater accumulation of nutrients in seedlings. Therefore, the integrated application of organic amendments and zinc nutrition can be recommended as an effective approach for producing healthy and vigorous orange seedlings.

Author contributions

Conceptualization: M.T.A.A., B.H.K., Methodology: M.T.A.A., M.R.M., Investigation: M.T.A.A., B.H.K., M.R.M., Data curation: M.T.A.A., Formal analysis: B.H.K., Writing – original draft: M.T.A.A.

Writing – review and editing: B.H.K., M.R.M., and Supervision: M.T.A.A. All authors have read and agreed to the published version of the manuscript.

Data availability statement

The corresponding author can provide data supporting this study's conclusions upon reasonable request.

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Ethical approval

The authors avoided data fabrication, falsification, plagiarism, and any form of scientific misconduct.

Conflict of Interest

The authors declare no conflict of interest.

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واکنش برخی صفات نهال پرتقال محلی (*Citrus sinensis* L.) پیوندشده روی پایه نارنج به افزودن پسماند آلی و محلول‌پاشی با روی

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چکیده

هدف: هدف از این پژوهش، بررسی اثر کاربرد ماده آلی و محلول‌پاشی روی بر رشد رویشی نهال‌های پرتقال محلی (*Citrus sinensis* L.) پیوندشده روی پایه نارنج بود. این آزمایش در ایستگاه باغبانی المحاویل وابسته به شرکت عمومی باغبانی و جنگلداری، وزارت کشاورزی عراق، طی دوره زمانی اکتبر ۲۰۲۴ تا ژوئن ۲۰۲۵ انجام شد. هدف اصلی تحقیق، بهبود رشد نهال و وضعیت تغذیه‌ای آن‌ها در شرایط نهالستانی بود.

مواد و روش‌ها: کود دامی به‌عنوان منبع ماده آلی در چهار سطح ۰، ۰/۲۵، ۰/۵۰ و ۰/۷۵ کیلوگرم برای هر نهال به کار رفت. عنصر روی به‌صورت محلول‌پاشی برگی در سه غلظت ۰، ۲۰ و ۴۰ میلی‌گرم روی در لیتر، با استفاده از سولفات روی آبدار اعمال شد. آزمایش به‌صورت فاکتوریل در قالب طرح کاملاً تصادفی با سه تکرار اجرا گردید. صفات رویشی شامل ارتفاع نهال، قطر ساقه، تعداد برگ، سطح برگ، میزان کلروفیل (عدد SPAD) ، وزن خشک نهال و محتوای عناصر غذایی برگ اندازه‌گیری شد. تجزیه و تحلیل داده‌ها با استفاده از آنالیز واریانس (ANOVA) و مقایسه میانگین‌ها با آزمون حداقل اختلاف معنی‌دار (LSD) در سطح احتمال ۵٪ انجام گرفت.

نتایج: نتایج نشان داد که افزایش سطح ماده آلی موجب بهبود معنی‌دار تمامی صفات رویشی اندازه‌گیری‌شده شد. بیشترین مقادیر در سطح ۰/۷۵ کیلوگرم ماده آلی برای هر نهال به دست آمد؛ به‌طوری‌که ارتفاع نهال به ۹۸/۸۷ سانتی‌متر، قطر ساقه به ۱/۲۳ سانتی‌متر، تعداد برگ به ۹۵/۲۷ برگ در هر نهال، سطح برگ به ۲۱/۲۷ دسی‌متر مربع، میزان کلروفیل به ۴۵/۳۷ واحد SPAD، وزن خشک نهال به ۱۱۶/۶ گرم و محتوای نیتروژن برگ به ۱/۸۸٪ رسید. محلول‌پاشی روی با غلظت ۴۰ میلی‌گرم در لیتر نیز باعث افزایش معنی‌دار تمامی صفات رشد شد، از جمله ارتفاع (۹۴/۴۵ سانتی‌متر)، قطر ساقه (۱/۲۰ سانتی‌متر)، تعداد برگ (۹۱/۹ برگ در هر نهال)، سطح برگ (۲۰/۷ دسی‌متر مربع)، میزان کلروفیل (۴۵/۴۸ واحد SPAD)) و وزن خشک (۱۱۷/۳ گرم)، همراه با بهبود محتوای عناصر معدنی برگ. بیشترین مقادیر تمامی صفات مورد مطالعه در تیمار ترکیبی ۰/۷۵ کیلوگرم ماده آلی به همراه ۴۰ میلی‌گرم روی در لیتر مشاهده شد.

نتیجه‌گیری: می‌توان نتیجه گرفت که کاربرد توأم ماده آلی و محلول‌پاشی روی به‌طور مؤثری رشد رویشی و وضعیت تغذیه‌ای نهال‌های پرتقال محلی را بهبود می‌بخشد. تیمار ۰/۷۵ کیلوگرم ماده آلی برای هر نهال همراه با ۴۰ میلی‌گرم روی در لیتر مؤثرترین تیمار بود و می‌تواند برای ارتقای کیفیت نهال در نهالستان‌های مرکبات و استقرار بهتر باغ توصیه شود.

کلمات کلیدی: بقایای آلی، پایه نارنج، روی، نهال پرتقال

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