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EFFECT OF FOLIAR SPRAYING WITH MELATONIN, POTASSIUM, AND ZINC ON SOME VEGETATIVE TRAITS AND SAPLING CONTENT OF SOME CHEMICALS IN KUMQUAT SAPLINGS

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ABSTRACT

The experiment was conducted in one of lath houses of Fruit Section belong to Department of Horticulture and Landscape Engineering, College of Agricultural Engineering Sciences, University of Baghdad, Research Station (B) for 2022 season to study effect of spraying with the growth regulator melatonin, potassium, and zinc on the growth of 3-year-old kumquat saplings Budded on lemon rootstock. A factorial experiment consisting of three factors with three replicates was conducted, using the Randomized Complete Block Design (RCBD) experimental design. The factors were foliar spraying with melatonin, potassium sulfate, and organic zinc. The addition was made at two times: spring and autumn. The results were as follows, where the main factor of the three factors, their interaction, had a significant effect on the traits under study. The results indicate that the concentration of 20 mg L^{-1} of melatonin outperformed in the following vegetative traits (plant height, stem diameter, number of branches, number of leaves, leaf area). The same factor also increased the plant content of the following chemicals (nitrogen, potassium, zinc, chlorophyll, carbohydrates). It is also observed that potassium sulfate at a concentration of 3000 mg L^{-1} and organic zinc at a concentration of 1000 mg L^{-1} gave the highest measurements for the same traits affected by melatonin.

Keywords: Plant height, Kumquat, Chlorophyll, Leaf area, Dry matter.

تأثير الرش الورقي بالميلاتونين والبوتاسيوم والزنك في بعض الصفات الخضرية ومحتوى الشتلات من بعض المواد الكيميائية لشتلات الكمكوات

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الخلاصة

نفذت هذه التجربة في احدى الظلل التابعة لشعبة الفاكهة- قسم البستنة وهندسة الحدائق- كلية علوم الهندسة الزراعية- جامعة بغداد، المحطة البحثية (B) للموسم 2022 لدراسة تأثير الرش بمنظم النمو الميلاتونين والبوتاسيوم والزنك في نمو شتلات الكمكوات بعمر 3 سنوات مطعمة على أصل الليمون، نفذت تجربة عاملية تتكون من ثلاث عوامل وبثلاث مكررات، التصميم التجريبي RCBD. العوامل هي الرش الورقي بالميلاتونين، كبريتات البوتاسيوم والزنك العضوي الاضافة كانت في موعدين ربيعي وخريفي. وكانت النتائج كما يلي حيث اعطت العوامل الثلاثة منفردة ومشتركة بالتداخل بينهما تأثيرا معنويا على الصفات المدروسة، تفوق التركيز 20ملغم.لتر$^{-1}$ من الميلاتونين في الصفات الخضرية الاتية (ارتفاع النبات ، قطر الساق، عدد الافرع، عدد الأوراق، المساحة الورقية) كما وادت نفس المعاملة بزيادة محتوى النبات من المواد الكيميائية الاتية (النتروجين، البوتاسيوم, الزنك، الكلوروفيل، الكربوهيدرات) كما نلاحظ بان كبريتات البوتاسيوم وبتركيز 3000 ملغم.لتر$^{-1}$ والزنك العضوي بتركيز 1000 ملغم.لتر$^{-1}$ قد اعطتا اعلى القياسات ولنفس الصفات التي اثر فيها الميلاتونين.

الكلمات المفتاحية: ارتفاع النبات، كمكوات، كلوروفيل، مساحة ورقية، مادة جافة.

INTRODUCTION

Citrus trees are evergreen trees that belong to the Rutaceae family, which is characterized by the presence of oily glands with a distinctive aromatic odor in most parts of the plant. This family includes many genera that are distributed in tropical and subtropical regions between latitudes 40 north and south of the equator. This family includes three important commercial genera, namely (Ponirus and Fortunella, and Citrus). The genus Fortunella is one of these genera and four main species are attributed to it (*F. japonica*, *F. margarita*. *F. crassifolia* and *F. hindsii*). **(Zhang & Mabberley, 2008; Ortiz, 2002).** This genus adapts to a wide range of environmental conditions ranging from tropical humid hot climates to warm subtropical regions to even cold coastal areas **(Ahmed & Salih, 2023).** Phytomelatonin was discovered in plants and is also found in bacteria, algae, protozoa, invertebrates, and mammals. It also appears that bone marrow, the digestive system, the retina, and immune cells participate in the biosynthesis of melatonin. Melatonin acts as a biological protective molecule that can cope with physical, chemical, and biological effects. Melatonin has been studied for its role in plant stress tolerance. It has been shown to protect plants from a variety of stress factors, both physical (heat, cold, ultraviolet radiation) and chemical (salinity, drought, waterlogging, heavy metals, mineral deficiency, and pesticide damage). Melatonin works to improve membrane stability and also induces the expression of genes for antioxidant enzymes. It also enhances resistance to biological stress factors, such as extreme temperatures, radiation, and osmotic regulatory responses of stomata **(Rehaman *et al.*, 2021; Negi *et al.*, 2022).** In an experiment conducted by **Hu *et al*., (2022)** on trifoliate orange saplings, using four melatonin concentrations, the melatonin-treated saplings showed better growth performance, especially at the concentration of 100 $\mu M.l^{-1}$. It gave a significant increase in plant height, stem diameter, and total dry weight of the plant and root. In an experiment conducted by **Manafi *et al.*, (2022**) on strawberry plants, they found that treatment with melatonin at a concentration of 100 $\mu M.l^{-1}$ led to an increase in the plant's chlorophyll content, inhibition of pigment degradation, and improved water exchange with reduced oxidative damage by free radicals by activating antioxidant enzymes. In an experiment conducted on different varieties of citrus, it was found that the use of melatonin increased the leaf membrane permeability, resulting in a decrease in the relative water content of the leaves. It was observed that both of these traits improved when melatonin was used, in terms of leaf water content and membrane permeability. Spraying melatonin externally improves the growth of citrus because it increases the physiological processes that raise the plant's content of important chemical elements **(Saadoun & Al-Juthery, 2018; Korkmaz *et al.*, 2022).** The main reason for the increase in growth in plants is due to the addition of chemical fertilizers, especially the macro-nutrients, where it was observed that potassium fertilization leads to an increase in vegetative growth and a high accumulation of nutrients in the plant. A study found that potassium fertilizer treatment can effectively reduce the cracking of citrus fruits. It also increases their size, as it enhances the metabolism of amino acids in the citrus peel and works to accelerate the consumption of gibberellins **(Jiao *et al.*, 2022).**

Potassium also played a critical role in photosynthesis. If potassium is not present in sufficient quantities, the complex reactions in the plant lead to a reduction in photosynthetic carbon. The focus was the structure of chloroplasts, light-dependent reactions and photosynthesis and the diffusion of carbon dioxide, which is considered the main substrate for photosynthesis in chloroplasts. It also contributed to the loading of the phloem and the transport of photosynthesis products over long distances and in the photoprotection of the photosynthetic system **(Al-Dulaimi & Al-Jumaili, 2017;Osama, 2022).** A study conducted by **Moura *et al*., (2023)** aimed to evaluate the effects of irrigation depth and potassium doses on fig quality under semi-arid conditions. It was carried out with four levels of irrigation, and four concentrations of potassium (K_2O). The results showed that water deficit reduced fig productivity, and that irrigation levels equal to or greater than 100% of Et_c. lead to a cumulative increase in growth during growth cycles. Moreover, potassium fertilization alleviated water stress in fig plants, allowing for a reduction in irrigation levels, especially in the second year.

The deficiency of zinc inhibits the cell division process, resulting in stunting and weakened growth of the plant in general, and the leaves in particular. This is one of the most important signs of zinc deficiency in plants **(Al-Ahmad *et al.*, 2023)**. It also prevents glucose from being converted into sugar, starch, or cellulose, increases the plant's content of organic acids, and stops protein synthesis **(Al-Atrushy, 2021; Al-Azzawi & Al-Ibadi, 2017).** Zinc plays a key role in the biosynthesis of chlorophyll, but it does not play a direct role in photosynthesis. Therefore, yellowing of the leaves is a symptom of zinc deficiency due to a lack of chlorophyll formation. Zinc also plays a major role in the plant's utilization of phosphorus by helping to convert it from inorganic phosphate to organic compounds **(Ibrahim & Tayib, 2019).** A study was conducted to investigate the effect of foliar application of micronutrients on flowering and fruit formation in mandarin (*Citrus reticulata* Blanco). The foliar treatments consisted of zinc and boron sprays at concentrations of (0.15% zinc, 0.04% boron), (0.1% zinc + 0.02% boron), and (0.05% zinc + 0.04% boron). Twenty trees of the same age and height were selected. Foliar application of micronutrients was done twice, the first spray 45 days before flowering and the second spray two days after full bloom. The results revealed that different combinations of micronutrients significantly affected flowering, fruit set, fruit growth rate, and fruit drop rate. The use of boron, zinc, or a combination of the two was effective in promoting flowering and fruit set as well as reducing fruit drop in mandarin **(Ruchal *et al.*, 2020).** A study was conducted on local orange trees (*Citrus sinensis* L.) to investigate the effect of spraying gibberellin at a concentration of 20 $mg.L^{-1}$, urea 0.05 %, and zinc (zinc sulfate 0.5 %) on tree growth and yield characteristics. The results showed that the effect of spraying gibberellin, urea, and zinc on the trees, either individually or in combination was positive in increasing the percentage of fruit set, the percentage of the number of fruits remaining on the trees, and reducing the percentage of fruit drop compared to the control treatment. The interaction treatments between gibberellin, urea, and zinc were distinguished with the best results, as they led to a significant increase in the total chlorophyll content in the leaves and leaf area. The treated trees also outperformed the control treatment in terms of increased quantitative yield, fruit length, diameter, weight, size, peel thickness, and percentage of total sugars. **(Al-Hamadani & Al-Bayaty, 2015).**

This study aimed to evaluate the influence of melatonin, potassium, and zinc, applied as foliar sprays, on the vegetative growth and development of kumquat plants, along with their capacity to accumulate nutrients in vegetative tissues.

MATERIALS AND METHODS

The experiment was conducted in one of the lath house (covered with saran) belonging to the Department of Horticulture and Landscape Engineering, College of Agricultural Engineering Sciences, University of Baghdad, Research Station (B) for the season of 2022 to study the effect of spraying with the growth regulator melatonin, potassium, and zinc on the growth and yield of kumquat saplings aged 3 years grafted on lemon rootstock. A factorial experiment consisting of three factors and three replications was conducted, using the RCBD experimental design **(Al-Rawi & Khalafallah, 2000).**

Saplings were prepared and transferred to pots 32 cm in diameter and 30 cm in height, in a loamy soil, peat, and perlite in a ratio of 2:1:2. NPK fertilizer (15:15:15) was added to the soil of the pots from the beginning of the experiment, then every 30 days until the end of the experiment, at a rate of 1.5 g pot^{-1}. The experiment include three factors: melatonin, which was added to the leaves by spraying, at three concentrations (0, 10, and 20) mg L^{-1} **(Jafari & Shahsavar, 2021)**. The spraying was done six times, starting on April 10, 2022, and the remaining sprays were done every 30 days until September 1, 2022. The second factor was foliar application of potassium sulfate, at three concentrations (0, 1500, 3000) mg L^{-1}. The spraying was done three times, starting on April 6, 2022, at a 30-day interval between sprays. The spraying was repeated in the fall, also three times, starting on September 3, 2022, with a 20-day interval between sprays, ending in early November. The third factor was foliar application of zinc, at two concentrations (0, 1000) mg L^{-1}. The addition was made three times, starting on April 3, 2022, with a 30-day interval between additions. The addition was repeated in the fall, also three times, starting on September 1, 2022, with a 20-day interval between additions. There were 18 treatments in the experiment, with three replicates, with two saplings per experimental unit. The total number of saplings was 108.

The results were analyzed using the Genstat program, and the means were compared using the least significant difference (LSD) test at a significance level of 5%.

Characters studied

The following experimental measurements were taken:

Rate of increase in plant height (cm), Rate of increase in stem diameter (mm), Rate of increase in the number of main branches in the plant (branches/sapling), Rate of increase in the number of leaves (leaves/sapling), Rate of leaf area of the plant (cm^2), Percentage of leaf dry weight (%).

Chlorophyll content of the leaves (mg/100 g fresh weight) was estimated according to the method of **Goodwin (1976)** by taking leaf samples from the saplings, digesting them, and placing the solution in a dark bottle. Then, the total chlorophyll measurement was read at the wavelengths of 645 and 663 in a UV-VIS spectrophotometer.

After digesting the dried samples by wet digestion, the nitrogen content of the leaves (%) was estimated by the Kjeldahl method **(Chapman *et al.*, 1961).** Then, the phosphorus content of the leaves (%) was estimated by wet digestion using ammonium molybdate and ascorbic acid. When the blue color of the sample developed, it was read by a spectrophotometer (LKB Biochrom Ultrospec II) at a wavelength of 620 nm **(Olsen *et al.*, 1982).** The potassium content of the leaves (%) was estimated by reading the extract with a flame photometer and extracting the potassium concentration from the standard curve **(Al-Sahaf, 1989).** The zinc content of the leaves (mg L^{-1}) was also estimated by an atomic absorption device using standard solutions with different concentrations of zinc salts. Then, we read the prepared standard solutions. After that, we read the samples to be measured **(Walsh, 1970).** The percentage of carbohydrates in the vegetative system of the plant was estimated according to the method of **Joslyn (1970).**

RESULTS AND DISCUSSION

The results showed that spraying melatonin has an effect on the measured traits of kumquat plants (Table 1). The 20 mg L^{-1} treatment outperformed the other treatments in terms of plant height, stem diameter, number of branches, number of leaves, and leaf area. The plants treated with 20 mg L^{-1} had an average height of 25.44 cm, a stem diameter of 0.588 mm, 7.16 branches $plant^{-1}$, 298.78 leaves $plant^{-1}$, and a leaf area of 55.11 cm^2. The results also showed that spraying potassium has a highly significant effect on kumquat plants. The 3000 mg L^{-1} potassium treatment outperformed the other treatments, resulting in superior plant growth parameters, including plant height (24.66 cm), stem diameter (0.55 mm), number of branches per plant (6.88), number of leaves per plant (282.33), and leaf area (53.74 cm^2). In addition, the results indicate that spraying organic zinc on kumquat plants at a concentration of 1000 mg L^{-1} is superior to the control treatment of 0 mg L^{-1} in all vegetative traits under study. These traits are: plant height (23.11 cm), stem diameter (0.52 mm), number of branches (6.88 branches $plant^{-1}$), number of leaves (268.07 leaves $plant^{-1}$), and leaf area (52.19 cm^2).

The effect of melatonin, potassium sulfate, and organic zinc on the vegetative traits of kumquat

The experiment showed that melatonin had a significant effect on plant height, the experiment demonstrated a clear relationship between melatonin concentration and plant height, with the maximum height achieved at the highest concentration. This is because the mechanism of biological synthesis of auxin is the same as the mechanism of biological synthesis of phytomelatonin **(Hernàndez-Ruiz *et al.,* 2021)**, with a change in the rate of synthesis caused by one of the environmental conditions of the plant **(Arnao, 2014).** Considering that the addition of external melatonin has increased the melatonin levels in treated plants, this has consequently reflected in an increase in the plant's auxin content, leading to an increase in plant elongation.. With the noticeable increase in plant height, there was a corresponding increase in the diameter of the main stem, as melatonin influenced the increase in the plant's carbohydrate content stored in the stem due to the enhanced photosynthetic process resulting from an increase in the plant's chlorophyll content. This is because melatonin has an effect on delaying chlorophyll breakdown in the leaves **(Arnao & Hernàndez-Ruiz, 2009).** In addition to an increase in the biosynthesis of chlorophyll in cooperation with potassium, which naturally affects the process of gas exchange between the plant and its surroundings by controlling the opening and closing of stomata. It also stimulates a number of enzymes that control the electron transport chain and the molecular binding of chemical substances inside the plant **(Ashok *et al*., 2006).** Zinc also plays a role in the process of biosynthesizing chlorophyll **(Rodriguez *et al*., 2000**). This means that it will help to maintain the presence of chlorophyll for a longer period of time, allowing it to function and produce carbohydrates in the plant. In addition, the increase in the height of the main stem of the plant was not due to the elongation of the internodes, but rather it gave a larger number of nodes that contributed to the increase in the number of lateral branches and leaves of the plants. In addition, it was observed that the increase in leaf area was due to the effect of zinc on the plant, where it doubled the work of melatonin due to its direct intervention in the biosynthesis of melatonin, as the increase in the number of leaves led to an increase in leaf area.

Table (1): Effect of the foliar application of Melatonin, potassium sulfate, and organic Zinc on vegetative traits in kumquat saplings.

Treatments	**Plant's height (cm)**	**Stem diameter (mm)**	**Shoots number (shoot.plant^{-1})**	**Leaves number leave.plant^{-1}**	**Leaves area (dm^2 plant^{-1})**	**Vegetative dry matter (gm)**
M0	15.27	0.26	4.77	213.44	40.54	23.49
M1	21.61	0.46	6.27	266.06	47.66	26.77
M2	25.44	0.58	7.16	298.78	55.11	29.30
L.S.D	**0.42**	**0.03**	**0.41**	**2.58**	**056**	**0.14**
K0	16.61	0.28	5.11	230.72	41.89	21.98
K1	21.05	0.47	6.22	265.22	47.59	27.69
K2	24.66	0.55	6.88	282.33	53.74	29.89
L.S.D	**0.42**	**0.03**	**0.41**	**2.58**	**0.56**	**0.14**
Z0	18.44	0.34	5.25	250.78	43.29	23.10
Z1	23.11	0.52	6.88	268.07	52.19	29.94
L.S.D	**0.34**	**0.03**	**0.34**	**2.11**	**0.46**	**0.11**
M0K0Z0	11.33	0.13	3.33	177.33	30.87	12.04
M0K0Z1	13.66	0.26	4.00	208.33	37.49	22.84
M0K1Z0	12.66	0.16	4.00	198.00	36.39	21.17
M0K1Z1	16.66	0.43	6.00	230.00	45.66	29.63
M0K2Z0	15.66	0.20	4.66	224.00	43.38	24.24
M0K2Z1	21.60	0.36	6.66	243.00	48.90	31.04
M1K0Z0	15.66	0.16	4.66	207.00	38.97	19.64
M1K0Z1	18.33	0.40	6.33	235.00	44.09	25.66
M1K1Z0	19.66	0.36	5.33	283.33	41.50	24.09
M1K1Z1	25.00	0.63	7.33	278.67	52.24	31.32
M1K2Z0	22.33	0.53	6.33	281.67	49.54	27.26
M1K2Z1	28.66	0.66	7.66	310.67	59.64	32.66
M2K0Z0	18.33	0.30	5.33	276.67	44.85	23.18
M2K0Z1	22.33	0.43	7.00	280.00	55.05	28.52
M2K1Z0	23.66	0.56	6.66	296.67	50.30	26.69
M2K1Z1	28.66	0.70	8.00	304.67	59.47	33.27
M2K2Z0	26.66	0.66	7.00	312.33	53.84	29.63
M2K2Z1	33.00	0.86	9.00	322.33	67.16	34.51
L.S.D	**1.03**	**0.09**	**1.02**	**6.33**	**1.39**	**0.35**

The results indicated a significant impact of melatonin at a concentration of 20 mg L^{-1} on the treatments in the content of leaves and plants regarding chemical compounds (Table 2), such as nitrogen, (2.42%), phosphorus (0.33%), potassium (1.74%), zinc (74 mg kg^{-1}), chlorophyll (11.39 mg/100 g fresh weight, and carbohydrates (9.74%,). Additionally, it was observed that spraying the saplings with potassium sulfate at the same concentration increased the plant and leaf content of elements and chemical compounds nitrogen, (2.4%), phosphorus (0.30%), potassium (1.83%), zinc (73.7 mg kg^{-1}), chlorophyll (10.49 mg/100 g fresh weight, and carbohydrates (9.36%,). As for Zinc the plant and leaf content of elements and chemical substances, the treatment with 1000 mg L^{-1} also outperformed the control treatment, with measurements of 2.38%, 0.29%, 1.73%, 82.9 mg/kg, 10.43 mg/100 g fresh weight, and 9.34%, respectively.

Table (2): Effect of the foliar application of Melatonin, potassium sulfate, and organic Zinc on chemical content in vegetative system kumquat saplings.

Treatments	Nitrogen (%)	Potassium (%)	Zinc (ml.l^{-1})	Carbohydrate (%)
M0	2.25	1.64	65.0	8.40
M1	2.33	1.70	69.4	9.15
M2	2.42	1.74	74.0	9.79
L.S.D	**0.008**	**0.009**	**0.7**	**0.03**
K0	2.27	1.50	66.0	8.88
K1	2.34	1.74	66.6	9.13
K2	2.40	1.83	73.7	9.36
L.S.D	**0.008**	**0.009**	**0.7**	**0.03**
Z0	2.29	1.65	56.0	8.91
Z1	2.38	1.73	82.9	9.34
L.S.D	**0.007**	**0.007**	**0.5**	**0.02**
M0K0Z0	2.18	1.38	46.3	8.11
M0K0Z1	2.22	1.54	76.6	8.27
M0K1Z0	2.22	1.67	51.3	8.24
M0K1Z1	2.31	1.69	78.3	8.73
M0K2Z0	2.25	1.78	58.6	8.29
M0K2Z1	2.36	1.76	78.6	8.96
M1K0Z0	2.23	1.43	54.0	8.85
M1K0Z1	2.30	1.59	80.3	8.94
M1K1Z0	2.29	1.72	53.6	8.92
M1K1Z1	2.36	1.78	81.6	9.40
M1K2Z0	2.36	1.80	63.3	9.10
M1K2Z1	2.48	1.87	83.6	9.72
M2K0Z0	2.36	1.46	54.0	9.51
M2K0Z1	2.37	1.62	84.6	9.63
M2K1Z0	2.34	1.76	57.3	9.56
M2K1Z1	2.50	1.81	89.6	9.91
M2K2Z0	2.42	1.87	65.3	9.67
M2K2Z1	2.56	1.98	93.0	10.46
L.S.D	**0.021**	**0.023**	**1.7**	**0.08**

The effect of melatonin, potassium sulfate, and organic zinc on the chemical content of the vegetative part of kumquat

Spraying melatonin on the kumquat plant affected the total vegetative content of elements and chemical substances Melatonin is considered a plant growth regulator **(Arnao & Hernàndez-Ruiz, 2018)** that works to increase the synthesis of certain chemical compounds, such as chlorophyll. Moreover, it prolongs its presence for a longer period than natural. Additionally, melatonin, in conjunction with zinc, participates in the biological synthesis process of the chlorophyll molecule. Together, they elevate the chlorophyll content in the leaves. This was observed in plants treated with melatonin compared to control plants. It was observed that melatonin improves water and gas exchange between the plant and its surrounding environment, whether in soil or air, enhancing the absorption of the necessary nutrients by the plant. The structural composition of melatonin was noted to be similar to that of auxin, leading to a similar impact on growth and nutrient absorption. While, it was observed that potassium and zinc have a shared effect on the quantitative yield of PSII in the photosynthetic process, resulting in an increase in carbohydrate production for the plant. This, in turn, is reflected in an increased plant uptake to provide sufficient energy, leading to the accumulation of nitrogen, a crucial element in the chlorophyll molecule **(Kadhom & Salih, 2019; Jifon *et al.*, 2005).** Furthermore, the addition of potassium to these plants led to an increase nutrients absorption, such as phosphorus, due to its impact on the opening and closing of stomata. On the other hand, the increase in the plant's zinc content in the vegetative system was attributed to its foliar application, thereby enhancing the absorption properties at the plant roots. This increased the plant's ability to maximize the biological synthesis of carbohydrates and proteins due to the enhanced metabolic processes in these plants **(Noulas *et al.*, 2018).**

CONCLUSION

Melatonin is showed an effect such as plant growth regulator especially when it take Cytokinin path, its effect on vegetative growth by increasing chlorophyll concentration, because it inhibit senescence of chlorophyll, and enhance some elements accumulation and increase carbohydrate synthesis, while Potassium and Zinc paths as assistant for melatonin behavior.

REFERENCES

1. Ahmed, T.S., & Salih, A.Y. (2023). Effect of foliar application of salicylic acid, magnesium, and iron on the seedlings of *Citrus medica* L. *Iraqi Journal of Agricultural and Sciences, 54*(2): 388-398.
2. Al-Ahmad, A.A., Batha. M. & Muzher. B. (2023). Impact of thinning and foliar-Boron-Zinc spray on some morphological and physiological indicators in apple tree (*Malus domestica* CV. Golden Delicious)-"Tartous Governorate". *Iraqi Journal of Agricultural Sciences*.54(3): 874-883.
3. Al-Atrushy, Sh. M. M. (2021). Effect of foliar application of zinc and salicylic acid on vegetative growth and yield characteristic of halawani grape cultivar (*Vitis vinifera* L.). *Iraqi Journal of Agricultural Science, 52*(4): 989-998.
4. Al-Azzawi, O.S. & Al-Ibadi. I.M. (2017). Effect organic nutrient Humic and compound chemical fertilizer in leaves content from elements and total yield cucumber. *Iraqi Journal of Agricultural Sciences.* 48(3): 720-728.
5. Al-Dulaimi, N.H & Al-Jumaili. M.A. (2017). Response of green beans to spray some micronutrients and addition organic fertilizer. *Iraqi Journal of Agricultural Sciences*. 48(2): 447-455.
6. Al-Hamadani, K. A., & Al_Bayaty, I. A. A. (2015). The Effect of Spraying Gibberellin, Urea, and Zinc on The Growth and Yield of Orange Trees (*Citrus sinensis* L) Grown in Salah Adin Governorate. *Tikrit Journal for Agricultural Sciences, 15*(3). 50-63
7. Al-Rawi, K. M., & Khalafallah, A. A. H. (2000). *Design and analysis of agricultural experiments*. Second Edition – University of Mosul, Iraq.
8. Al-Sahaf, F. H. (1989). *Practical plant nutrition*. Bait Al-Hikma for Publishing, Translation, and Distribution, University of Baghdad, Iraq.
9. Arnao, M.B., & Hernàndez-Ruiz, J. (2018). Melatonin and its relationship to plant hormones. *Annals of Botany*, *122*, 195-207.

10. Arnao, M.B. (2014). Phytomelatonin: discovery, content, and role in plants. *Advances in Botany*, 2014,1-11.
11. Arnao, M.B., & Hernàndez-Ruiz, J. (2009). Protective effect of melatonin against chlorophyll degradation during the senescence of barley leaves. *Journal of Pineal Research, 46*, 58-63.
12. Ashok, K.A., Jr., Mattos, D., Paramasivam, S., Patil, B., Dou, H., & Sajwan, K.S. (2006). Potassium management for optimizing Citrus production and quality, *International Journal of Fruit Science,* 6(1): 3-43.
13. Chapman, H.D., Pratt, P.E., & Parker, F. (1961). *Methods of analysis for soils, plants, and waters.* University of California Division of Agricultural Sciences, Riverside.
14. Goodwin, T.W. (1976). *Chemistry & Biochemistry of plant pigmen*ts (2nd edition). Academic Press, Cambridge, Massachusetts, United states.
15. Hernàndez-Ruiz, J., Cano, A., & Arnao, M.B. (2021). A phytomelatonin-rich extract obtained from selected herbs with application as plant growth regulators. *Plants,* 10(2): 2-12.
16. Hu, C.H., Zheng, Y., Tong, C.L., & Zhang, D.J. (2022). Effects of exogenous melatonin on plant growth, root hormones, and photosynthetic characteristics of trifoliate orange subjected to salt stress. *Plant Growth Regulation, 97*(3): 551-558.
17. Ibrahim, Z.R., & Tayib, A.A. (2019). Effect of foliar application of Aminoplasma, boron, zinc and their interactions on fruit set and yield characteristics of pistachio (*Pistacia vera* L.) cv. Halaby. *Iraqi Journal of Agricultural Science*, *50*(5): 1281-1289.
18. Jafari, M., & Shahsavar, A. (2021). The effect of foliar application of melatonin on changes in secondary metabolite contents in two citrus species under drought stress conditions. *Frontiers in Plant Science*, 12,1-20.
19. Jiao, Y., Sha, C., & Shu, Q. (2022). Integrated physiological and metabolomic analyses of the effect of potassium fertilizer on Citrus fruit splitting. *Plants,* 11(4):1-15.
20. Jifon, L.J., Syvertsen, J.P., & Whaley, E. (2005). Growth environment and leaf anatomy affect nondestructive estimates of chlorophyll and nitrogen in Citrus sp. leaves. *Journal of the American Society for Horticultural Science, 130*(2): 152-158.
21. Joslyn, M.A. (1970). *Methods in food analysis: Physical, chemical and instrumental methods of analysis* (2nd Edition). Academic Press, Cambridge, Massachusetts, United states.
22. Kadhom, A. & Salih. A.Y. (2019). The effect of foliar fertilization and root stimulate at growth of Olive's (*Olea europaea* L.) saplings (Nabali and Ashraci). *Plant archives*. (19): 169-175.
23. Korkmaz, N., Aşkın, M.A., Altunlu, H., Polat, M., Okatan, V., & Kahramanoğlu, İ. (2022). The effects of melatonin application on the drought stress of different citrus rootstocks. *Turkish Journal of Agriculture and Forestry*, *46*(4): 585-600.
24. Manafi, H., Baninasab, B., Gholami, M., Talebi, M., & Khanizadeh, S. (2022). Exogenous melatonin alleviates heat-induced oxidative damage in strawberry (*Fragaria× ananassa* Duch. cv. Ventana). *Journal of Plant Growth Regulation*, 41,52-64.
25. Moura, E.A., Mendonça, V., Figueirêdo, V.B., Oliveira, L.M., Melo, M.F., Irineu, T.H.S., & Figueiredo, F.R.A. (2023). Irrigation Depth and Potassium Doses Affect Fruit Yield and Quality of Figs (*Ficus carica* L.). *Agriculture,* 13(3):1-16.

26. Noulas, C., Tziouvalekas, M., & Karyotis, T. (2018). Zinc in soils, water and food crops. *Journal of Trace Elements in Medicine and Biology, 49*, 252-260.
27. Negi, N., Sharma, S., Bansal, N., Saini, A., Bose, R., Bhandari, M. S.,& Pandey, S. (2022). Effect of abiotic stresses on plant systems and their mitigation. *Plant Protection: From Chemicals to Biologicals*, 59-74.
28. Olsen, S.R., Sommers, L.E., & Page, A.L. (1982). *Methods of soil analysis*. Wisconsin Madison ,America, Part, 2, 403-430.
29. Ortiz, J. M. (2002). *Botany: taxonomy, morphology and physiology of fruits, leaves and flowers*. Citrus, CRC Press, England, 30-49.
30. Osama, S.S. (2022). Micropropagation of grapevine (*Vitis vinifera* L.) CVS. Red Globe and superior. *Iraqi Journal of Agricultural Science, 53*(4): 833-849.
31. Rodriguez, V.A., Mazza, S.M., Martinez, G.C., & Ferrero, A.R. (2000). Zn and K incidence in fruit sizes of 'Valencia' orange with CVC symptoms. *The 9th International Citriculture Conference,* Orlando, Florida, 3-7
32. Ruchal, O.K., Pandeya, S.R., Regmia, R., & Magrati, B.B. (2020). Effect of foliar application of micronutrient (Zinc and Boron) in flowering and fruit setting of mandarin (*Citrus reticulata* Blanco) in Dailekh, Nepal. *Malaysian Journal of Sustainable Agricultur* ,4(2): 94-98.
33. Rehaman, A., Mishra, A. K., erdose, A., Per, T. S., Hanief, M., Jan, A. T., & Asgher, M. (2021). Melatonin in plant defense against abiotic stress. *Forests*, 12(10): 1-23.
34. Saadoun, S.F. and Al-Juthery. H.W.A. (2018). Impact pf foliar application of some micronutrients nanoofertilizer on growth and yield of Jerusalem. *Iraqi Journal of Agricultural Sciences.* 49(4): 577-585.
35. Walsh, A. (1970). The application of new techniques to simultaneous multi-element analysis. *Atomic Absorption Spectroscopy*, Elsevier ,1,1-10.
36. Zhang, D.-X., & Mabberley, D.J. (2008). Citrus. In Z. Y., P. H., & D. Y. (Eds.), *Flora of China*, 11, 51-97.