H

EGYPTIAN ACADEMIC JOURNAL OF
BIOLOGICAL SCIENCES
BOTANY

ISSN 2090-3812

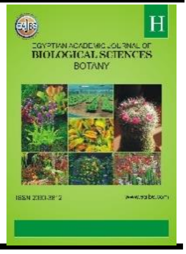
www.eajbs.com

Vol. 13 No.2 (2022)

Citation: Egypt. *Acad. J. Biolog. Sci.* (H. Botany) *Vol.13(2) pp171-178(2022)*
DOI: 10.21608/EAJBSH.2022.275939

Egypt. Acad. Journal Biology. Sci., 13(2):171-178(2022)

Egyptian Academic Journal of Biological Sciences
H. Botany
ISSN 2090-3812
www.eajbsh.journals.ekb.eg.



Response of "Kalllmata" Olive Cultivar to The Foliar Application of Moringa Extract, Boron, and Zinc

Harhash, M.M., W.M. E. Nasr Alla and Walid F. A. Mosa
Plant Production Department (Horticulture-Pomology), Faculty of Agriculture, Saba Basha, Alexandria University, Alexandria 21531, Egypt
*****E-mail: walidmosa@alexu.edu.eg

ARTICLE INFO
Article History
Received:9/10/2022
Accepted:5/12/2022
Available:12/12/2022

***Keywords*:**
Olive; Boron: fruit set: zinc

ABSTRACT

This study was conducted at Wady El Natron, Beheira Governorate, Egypt through three successive seasons from 2019 to 2021, to examine the role of the foliar spraying of Moringa leaf extract (MLE) at 2000, 4000, 6000 ppm, Boric acid (H_3BO_3) at 250, 500, 1000 ppm, Zinc (Zn SO_4) at 250, 500, 1000 ppm, Combination 1: 2000 ppm MLA + 250 ppm H_3BO_3 + 250 $ZnSO_4$, Combination 2: 4000 ppm MLA + 500 ppm H_3BO_3 + 500 $ZnSO_4$, Combination 3: 6000 ppm MLA + 1000 ppm H_3BO_3 + 1000 $ZnSO_4$ on vegetative growth, fruit yield, oil yield and fruit quality of ten-year-old olive (*Olea europaea*) cv. Kalamata. The trees were planted at a distance of 6 × 5 m in sandy soil under a drip irrigation system. Sixty-five uniform trees of the same growth and size were randomly chosen, arranged in a randomized complete block design (RCBD), and subjected to the same applied agricultural practices in the field during the three seasons. The trees were sprayed three times i.e., at the start of the season (April), at full bloom (mid of May) and three weeks later by the following treatments Control, Moringa Leaf Aqueous (MLAE) at 2000, 4000, and 6000 ppm. The results showed that the foliar application of moringa, zinc and boron solely or in combination improved greatly the leaf chlorophyll content, the number of flowers per m^2, fruit set % and the leaf content from nitrogen, phosphorous, potassium, zinc and boron and the most obvious effect was noticed with the spraying of combination 3 or combination 2 over control or the rest applied treatments in both experimental seasons. Additionally, it was clear from the shown data that moringa at 6000 or 4000 ppm, and zinc sulfate at 1000 were more effective in improving the same measured parameters over the rest applied treatments in both experimental seasons. The influence of 1000 ppm from zinc or born in olive trees was higher than the effect of 500 or 250 ppm from these elements during study seasons.

INTRODUCTION

Moringa oleifera Lam is a great plant, which is grown in a lot of regions in the tropics and subtropics zones. It contains a large number of compounds with great uses and of good nutritional value, and it also contains a lot of minerals and is a proper source of vitamins, proteins, carotene, amino acids and different phenols. Besides, it can purify water (Anwar *et al.*, 2007). Moreover, Phiri (2010) stated that moringa has a great impact on the growth and productivity of crops and thus it could be used as an alternative to chemical

Citation: Egypt. *Acad. J. Biolog. Sci.* (H. Botany) *Vol.13(2) pp171-178(2022)*
DOI: 10.21608/EAJBSH.2022.275939

fertilizers. documented that leaf-dried moringa has amino acids, and minerals such as Ca, Mg, P, K, Na, S, Zn, Cu, Fe, and Se. Besides, it and Vitamin E. (Howladar, 2014; Rady *et al.*, 2015; Nisar, *et al.*, 2021).

Boron is one of the important elements in the transport of sugar and carbohydrates within the plant. Also, the lack of boron reduces the production of pollen and affects the development of fruits in the olive plant and the reproductive organs. (Khayyat *et al.*, 2007). Moreover, boron plays an active role in a variety of plant life processes, including the transfer of hormones, active absorption of salts, flowering and fruiting, and pollen germination. Several studies indicate the importance of boron in improving the fertility of flowers and the rate of fruit formation in olives. It was found during an experiment that treating plants with boron led to an improvement in the percentage of knots and yield in olive fruits. (Stellaci *et al.*, 2008).

Swietlik (2002) reported that zinc could be implicated in the activation of enzymes which are important for the synthesis of protein and improving the index of maturity in plants. Besides, the same authors also added that zinc deficiency is common all over the world resulting in an economic loss in many crops. Zinc could be involved in the metabolism of DNA, RNA and nitrogen, the division of the cell, and the synthesis of protein and the shortage of zinc in plants decreases the synthesis and consequently the levels of protein while amino acids usually accumulate (Dickinson *et al.*, 2003). Moreover, the same author added that zinc has a clear role in the metabolisms of starch and nucleic acid in plants, and influences photosynthesis reactions likewise protein and carbohydrate biosynthesis.

Amiri *et al.* (2008) stated that zinc is a crucial nutrient because it can be involved in a lot of reactions but as its movement in the soil and in the plant is slow, it is difficult to be absorbed easily, so the foliar application is more efficient than the soil application. Adding Zn boosted the biosynthesis of chlorophyll and carotenoid synthesis which is essential for the performance of the photosynthesis process (Mousavi, 2011). Zinc shortage inhibits the growth of plants and lessens the final obtained yield and it is one of the fundamental elements for plants, and its shortage is widespread in numerous crops (Ojeda-Barrios (2014). Therefore, this study was performed to examine the role of the foliar spraying of different concentrations from Moringa leaf extract (MLE), boron acid (H_3BO_3) and zinc sulfate ($ZnSO_4$) on vegetative growth, fruit yield, oil yield and fruit quality of "Kalamata" olive trees.

MATERIALS AND METHODS

This study was conducted at Wady El Natron, Beheira Governorate, Egypt through three successive seasons from 2019 to 2021, on ten-year-old olive (*Olea europaea*) cv. Kalamata. The trees were planted at a distance of 6 × 6 m in sandy soil under a drip irrigation system. The physicochemical characteristics of the experimental soil and water are presented in Table 1 and 2 according to (Sparks *et al.,* 2020). A total of 65 trees, of the same growth and size, were randomly chosen, arranged in a randomized complete block design (RCBD), and subjected to the same applied agricultural practices in the field during the three seasons. The following treatments were sprayed from 2019 to 2021. During the study, it was reported that 2019 and 2021 were fruiting seasons (on years) but the 2020 season was a non-fruiting season (off-season), where in it there was no flowering, and consequently no yield.

Sixty-five uniform trees were randomly chosen for this study and all of them were subjected to the same cultural practices in the three seasons. The trees were sprayed three times i.e., at the start of the season (April), at full bloom (mid of May) and three weeks later by the following treatments: Control (not treated); Moringa Leaf Aqueous (MLA) at 2000 ppm, 4000 ppm and 6000 ppm; Boric acid (H_3BO_3) at 250 ppm, 500 ppm and 1000 ppm; Zinc sulphate ($ZnSO_4$) at 250 ppm, 500 ppm and 1000 ppm; Combination 1: 2000 ppm MLA

+ 250 ppm H_3BO_3 + 250 $ZnSO_4$; Combination 2: 4000 ppm MLA + 500 ppm H_3BO_3 + 500 $ZnSO_4$ and Combination 3: 6000 ppm MLA + 1000 ppm H_3BO_3 + 1000 $ZnSO_4$.

The previously applied treatments were arranged in a randomized complete block design where each treatment was composed of five replicates/trees. The influence of the above-mentioned treatments was investigated on the following parameters:

- **Total chlorophyll:** In the fresh leaves, it was determined as SPAD units by using Minolta chlorophyll meter (SPAD, 501).
- **Flower number** per m^2.
- **Fruit set %:** To estimate the percentages of fruit set, and drop as well as fruit yield, four branches were selected from each side of each replicate (tree) and labeled carefully. No. of flowers on each branch was counted and the percentage of fruit was set.
- **Leaf Chemical Composition:** Samples of thirty leaves from the middle part of the shoots according to Arrobas *et al.* (2018) were randomly selected from each replicate after harvesting time in June to determine their content from N, P and K percentages. The leaf samples were washed with tap water, then with distilled water and dried at 70ºC until constant weight, finally, ground and acid were digested using H_2SO_4 and H_2O_2 till the solution became clear. The digested solution was used for the determination of each nitrogen using the micro Kjeldhal method (Wang *et al.*, 2016), phosphorus by the vanadomolybdo method Weiwei *et al.* (2017) and potassium was determined by flame photometer according to the method described by (Mutalik *and* Mutalik., 2011).

RESULTS AND DISCUSSION

Leaf Chlorophyll Content, Flower Number And Fruit Set Percentage:

The results listed in Table (1) showed that the foliar application of moringa, zinc and boron solely or in combinations improved greatly the leaf chlorophyll content as compared to the control. Moreover, the most obvious effect on leaf chlorophyll was noticed with the spraying of combination 3 or combination 2 with respect to the control or the rest applied treatments in both experimental seasons. Additionally, it was clear from the shown data that MLAE at 6000 and 4000 ppm was more effective in improving the leaf chlorophyll than the application of boron or zinc individually in both experimental seasons. The number of flowers per m^2 was clearly improved by foliar spraying of combination 3 and MLAE at 6000 ppm over the control in the two seasons. MLAE at 6000 ppm and zinc sulfate at 1000 ppm showed an improvement over the other applied treatments and control in both experimental seasons. The best results were obtained by using 6000 ppm MLAE + 1000 ppm boric acid + 1000 ppm zinc sulfate compared with the other treatments applied in the two seasons. Boric or zinc sulfate at a concentration of 1000 ppm was better than 250 or 500 ppm. Fruit set % was increased by spraying the combinations of 6000 ppm MLAE + 1000 ppm boric acid + 1000 ppm zinc sulfate, and also by 4000 ppm MLAE + 500 ppm boric acid + 500 ppm zinc sulfate and boric acid at 1000 ppm as compared to control in the two seasons. MLAE 6000 ppm was better than MLAE at 4000 or 2000 ppm in improving the fruit set % in both experimental seasons. The impact of zinc sulfate and boric acid was lower than the impact of MLAE.

These results are previously confirmed by the findings of (Foidl *et al.*, 2001; Nagar *et al.*, 2006). They reported that moringa contains proteins, vitamins; A, B1, B2, and B3, ascorbic acid and E, β carotene, amino acids phenolic compounds, and sugars, as well as calcium, magnesium, sodium, iron, phosphorus and potassium and several flavonoid pigments. The foliar spraying of zinc improved the gas exchange and kept the integrity of the cell membrane (Khan *et al.*, 2004). Mousavi (2011) reported that adding Zn boosted the biosynthesis of chlorophyll and carotenoid synthesis which are essential for the performance of the photosynthesis process. Treating 'Balady' Mandarin (Sarrwy *et al.*, 2012) and

'Pistachio' trees (Soliemanzadeh *et al.*, 2013; El-Sayed and Habasy, 2015) with Zn raised the fruit set percentage as compared to the control. Moreover, these results are previously confirmed by the findings of Mohamed and El-Tanany (2016). They mentioned that the foliar spraying of zinc sulfate at 0.02% on 'Balady' Mandarins raised the fruit set and fruit retention percentages. Ahmad *et al.* (2018) mentioned spraying mango cv. Chaunsa white with zinc sulphate at 0.5 % increased flowers number per panicle, the percentages fruit-set. Hassan *et al.* (2019) stated treating olive trees cv. picual with moringa extract at 0, 2 and 4% increased leaf total chlorophyll content, and fruit set percentage. Besides Mosa *et al.* (2021) mentioned that the foliar application of moringa at 2%, 4% and 6% on seedless grapes. The authors noticed that the application increased leaf chlorophyll, yield and fruit quality rather than control. Additionally, these results are in the same trend as the findings of Sardar *et al.* (2021), they mentioned documented that moringa extract contains a high concentration of hormones, macro and micro minerals, as well as amino acids in the right amounts and many other good compounds. Besides, they reported that it also improved greatly plant growth and the concentration of chlorophyll pigment was also found in stevia leaves.

Table 1: the influence of the foliar spraying of MLAE, ZnSO4 and H_3BO_3 on the leaf chlorophyll content, flower number and fruit set percentages in olive during the 2019 and 2021 seasons.

Treatments	Total chlorophyll content (SPAD)		Flower number per m^2		Fruit set %	
	2019	2021	2019	2021	2019	2021
Control	55.76f	57.18h	575.6i	637.8i	3.09i	3.17j
2000 ppm MLAE	61.95de	61.99fg	723f	800.60f	4.12fg	4.30hi
4000 ppm MLAE	69.04bc	71.69bc	802d	889.80c	4.64de	4.83ef
6000 ppm MLAE	73.29b	78.78a	892b	990.60b	5.20c	4.39cd
250 ppm H_3BO_3	55.51f	59.96gh	649.60h	720.60h	4.47ef	4.63dfg
500 ppm H_3BO_3	62.93de	64.36ef	722.20f	802.00f	5.12c	5.31d
1000 ppm H_3BO_3	69.03bc	70.65cd	801.80d	868.00e	5.56b	5.93b
250 ppm $ZnSO_4$	59.24ef	60.59f-h	686g	761.00g	3.96h	4.10i
500 ppm $ZnSO_4$	65.39cd	67.32d e	762e	846.40e	4.31fg	4.46fg
1000 ppm $ZnSO_4$	72.87b	74.79b	847.20c	942.40c	4.79d	4.94e
Combination 1	64.81cd	67.34de	762e	845.80e	4.80d	4.99e
Combination 2	72.87b	74.79b	848c	942.80c	5.45b	5.64c
Combination 3	81.32a	81.96a	942.6a	1046a	6.14a	6.37a
$LSD_{0.05}$	4.58	3.63	14.85	21.21	0.20	0.27

The treatments have the same letters in the same column means that there are no significant differences between means at 0.05 level of probability.

Leaf Mineral Content From N, P, K, Zn and B:

The results listed in Table (2) showed that the spraying of MLAE, boron and zinc solely or in combination improved statistically the leaf content from nitrogen compared with untreated trees during the study season. Moreover, the obvious increment was noticed by the application of 6000 ppm MLAE + 1000 ppm boron+ 1000 zinc sulphate and also by the combination of 6000 ppm MLAE and 4000 ppm + 1000 ppm boron+ 1000 zinc sulphate, as well as by the single application of each one of MLAE at 4000 ppm, boron at 500 ppm or 500 ppm zinc over untreated trees. The foliar application of MLAE, zinc and boron alone or in combination led to an improvement in phosphorous content in Kalamata olive leaves compared to the control. Moreover, the effect on phosphorous content in olive tree leaves was more obvious when using a combination of 6000 ppm MLAE + 1000 ppm boric acid + 1000 ppm zinc sulfate and a combination of 4000 ppm MLAE + 500 boric acid + 500 zinc sulfate compared to the control treatment in both experimental seasons. In addition, it was found from the annotated data that zinc and boron at 1000 ppm were more effective in improving the phosphorous content of leaves in olive trees individually in both experimental seasons. It was also found that the use of MLAE at 6000 ppm and 4000 ppm was the best treatment for improving the phosphorous content of leaves in olive trees in both experimental seasons. It was found from the data in the table that the foliar use of moringa, zinc and boron alone or in combination led to an improvement in the potassium content in the leaves of Kalamata olives compared to the control. Moreover, the effect on potassium content in olive leaves was more pronounced when a combination of 6000 ppm MLAE + 1000 ppm boric acid + 1000 ppm zinc sulfate and 6000 ppm MLAE was used compared to the control treatment in both experimental seasons. Also, it was found that the use of MLAE at 6000 ppm and 4000 ppm was the best treatment for improving the potassium content of leaves in olive trees in both experimental seasons. It was also shown from the results listed in the table that the foliar application of MLAE, zinc and boron alone or in combination led to an improvement in the boron content in the leaves of Kalamata olives compared to the control. Moreover, the effect on boron content in olive tree leaves was more pronounced, when using a combination of 6000 ppm of MLAE + 1000 ppm of boric acid + 1000 ppm of zinc sulfate and 1000 ppm of boric acid. compared to the control treatment in the two experimental seasons. It was also found that using MLAE at 6000 ppm and 4000 ppm was the best treatment for improving the boron content in olive tree leaves in both experimental seasons. It was found from the data in the table that the foliar application of MLAE, zinc and boron alone or in combination improved the zinc content in the leaves of Kalamata olives compared to the control. Moreover, the effect on zinc content in olive leaves was more pronounced when using a combination of 6000 ppm of MLAE + 1000 ppm of boric acid + 1000 ppm of zinc sulfate and 1000 ppm of zinc sulfate compared to those treated in both experimental seasons. It was also found that using MLAE at 6000 ppm and 4000 ppm was the best treatment for improving zinc content in olive tree leaves in both experimental seasons.

These results are in agreement with the results of El-Moneim *et al.* (2007), who reported that the addition of Zn at 0.4% on “Washington” navel orange significantly increased leaf mineral composition from nitrogen, phosphorous, potassium and zinc in both experimental seasons. Ashraf *et al.* (2012) reported the addition of zinc to citrus increased leaf mineral composition from nitrogen, phosphorous, potassium, magnesium, zinc copper, iron and manganese, zinc and copper compared with the control. The exogenous spraying effect of zinc sulfate at 0.2, 0.4, 0.6 and 0.8% at the fruit set stage of mandarin boosted the chemical composition from nitrogen, calcium, and manganese, particularly at 2%. The usage of zinc sulphate at 0.6 % raised the leaf mineral composition from phosphorus and iron, while the spray of 0.8 % gave the highest increase in the leaf content from potassium and zinc over control in the two seasons (Razzaq *et al.*, 2013). Zinc is playing a fundamental role in the activation of different enzymes involves in elements uptake, metabolism and composition of phytohormones (Elanchezhian *et al.*, 2017).

Abd El–Hamied and El-Amary (2015), stated that the spraying of moringa leaf extract at 2 and 4% on pear trees cv. Le-Conte raised obvious leaf mineral content from nitrogen, phosphorous and potassium as compared to the control. Additionally, Abd Al Rhman *et al.* (2018) reported spraying of moringa leaves extract at 0.50 ml/L on "Washington" and "Murcott Tangor" orange cultivars significantly increased the leaf mineral composition from nitrogen, phosphorous, potassium, zinc, iron, and manganese as compared to control. Ahmad *et al.* (2018) stated that spraying mango cv. Chaunsa white with zinc sulphate at 0.5 % increased leaf mineral content from nitrogen, and potassium, boron and zinc compared with the control. Hassan *et al.* (2019) reported that treating olive trees cv. picual with moringa extract at 0, 2 and 4% increased leaf chemical composition from nitrogen, phosphorous and potassium as compared to control. In addition, Nikbakht *et al.* (2021) stated that the foliar spraying of apples with nano-chelated zinc at 1000 and 2000 mg

L^{-1} and zinc sulfate at 1000 and 2000 mg L^{-1} improved the leaf content from nitrogen, phosphorous and potassium elements and fruit yield per plants.

Table 2: the influence of the foliar spraying of MLAE, $ZnSO_4$ and H_3BO_3 on leaf mineral content from N, P, K, B, and Zn in olive during 2019 and 2021 seasons.

Treatments	N%		P%		K %		B ppm		Zn ppm	
	2019	2021	2019	2021	2019	2021	2019	2021	2019	2021
Control	1.15h	1.16i	0.40e	0.38f	0.78i	0.77i	37.81h	37.43g	23.96h	23.49h
2000 ppm MLAE	1.37f	1.38g	0.46cd	o.44cde	0.95f	0.94f	40.52g	40.19g	28.60g	27.99g
4000ppm MLAE	1.51d	1.53e	0.48bc	0.46bcd	1.06d	1.05d	45.04ef	44.60f	31.54f	30.91f
6000 ppm MLAE	1.67b	1.71b	0.51ab	0.48b	1.18b	1.17b	50.05d	49.65de	34.72de	34.03de
250 ppm H_3BO_3	1.32f	1.35g	0.40d	0.41e	0.84h	0.84h	47.56de	47.08ef	24.43h	24.99h
500 ppm H_3BO_3	1.44e	1.45f	0.44d	0.42e	0.95f	0.94f	52.88c	52.35cd	28.33g	27.77g
1000 ppm H_3BO_3	1.58c	1.60d	0.46cd	0.44cde	1.06d	1.05d	58.86b	58.27b	30.95fg	30.33fg
250 ppm $ZnSO_4$	1.24g	1.26h	0.44d	0.43de	0.91g	1.05d	40.25gh	39.85g	33.56ef	32.89ef
500 ppm $ZnSO_4$	1.36f	1.38g	0.46cd	0.44cde	1.01e	1e	44.71f	44.26f	36.57cd	35.84cd
1000 ppm $ZnSO_4$	1.51d	1.53e	0.48bc	0.46bc	1.12c	1.11c	49.71d	49.21e	39.91ab	39.11ab
Combination 1	1.47de	1.48f	0.51ab	0.49ab	1.07d	1.06d	50.26d	49.76de	34.45de	33.77de
Combination 2	1.69b	1.65b	0.52a	0.49ab	1.15b	1.15b	55.31c	54.76c	37.61bc	36.86bc
Combination 3	1.76a	1.78a	0.53a	0.51a	1.22a	1.24a	62.63a	62.00a	42.05a	41.24a
$LSD_{0.05}$	0.04	0.04	0.03	0.03	0.03	0.03	2.55	2.78	2.56	2.52

The treatments have the same letters in the same column means that there are no significant differences between means at 0.05 level of probability.

REFERENCES

Abd Al Rhman, A., H. S. Ahmed, and S. A. Mohamed (2018). Effect of moringa extracts and diatoms foliar applications on Washington Navel Orange and Murcott Tangor Transplant Performance. *Horticulture Science,* 10(1): 28-40.

Abd EL–Hamied, S.A. and E. I. EL-Amary (2015). Improving growth and productivity of "pear" trees using some natural plants extracts under north sinai conditions. *Journal of Agricultural Science and Technology*, 8: 1-9.

Ahmad, I., F. Bibi, H. Ullah, and T. M. Munir (2018). Mango fruit yield and critical quality parameters respond to foliar and soil applications of zinc and boron. *Plants,* 7(97): 1-11.

Amiri, M. E., E. Fallahi, and A. Golchin (2008). Influence of foliar and ground fertilization on yield, fruit quality, and soil, leaf, and fruit mineral nutrients in apple. *Journal of Plant Nutrition,* 31(3): 515-525.

Anwar, F., S. Latif, M. Ashraf, and A.H. Gilani (2007). Moringa oleifera: a food plant with multiple medicinal uses. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 21*(1): 17-25.

Arrobas, M., S. Afonso and M.Â. Rodrigues, (2018). Diagnosing the nutritional condition of chestnut groves by soil and leaf analyses. Science. *Horticulture,* 228, 113-121

Ashraf, M. Y., M. Yaqub, J. Akhtar, M. A. Khan, M. Ali-Khan, and G. Ebert (2012). Control of excessive fruit drop and improvement in yield and juice quality of Kinnow (*Citrus deliciosa* x *Citrus nobilis*) through nutrient management. *Pakistan Journal of Botany*, 44: 259-265.

Dickinson, J. R., L. E. J. Salgado and M. J. Hewlins (2003). The catabolism of amino acids to long chain and complex alcohols in Saccharomyces cerevisiae. *Journal of Biological Chemistry,* 278(10), 8028-8034.

Efe, L., and E. Yarpuz, (2011). The effect of zinc application methods on seed cotton yield, lint and seed quality of cotton (*Gossypium hirsutum* L.) in east Mediterranean region of Turkey. *African Journal of Biotechnology*, 10: 8782-8789.

Elanchezhian, R., D. Kumar, K. Ramesh, A. K. Biswas, A. Guhey, and A. K. Patra (2017). Morpho-physiological and biochemical response of maize (*Zea mays* L.) plants fertilized with nano-iron (Fe3O4) micronutrient. *Journal of Plant Nutrition,* 40(14):1969-1977.

El-Moneim, E., M. El-Migeed, A. Omayma, and M. Ismail (2007). GA3 and zinc sprays for improving yield and fruit quality of Washington Navel orange trees grown under sandy soil conditions. *Research Journal of Agriculture and Biological Sciences,* 3(5): 498-503.

El-Sayed, R., and Y. Habasy (2015). Effect of spraying salicylic acid on fruiting of Valencia orange trees. *Alexandria Journal of Agricultural Sciences,* 60(3): 119-126.

Foidle, N., H. P. S. Makkar and K. Becker (2001). The potential of moringa oleifera for agricultural and industrial uses. p. 45-76. In L. Fuglie (ed.) The miracle tree: The multipurpose attributes of moringa. CTA publications. Wageningen, the Netherlands.

Hassan, A., N. Abd-ALHamid, R.B. ALY, and H. Hassan (2019). Effect of foliar application with algae and moringa leaves extracts on vegetative growth, leaf mineral contents, yield and chemical fruit quality of picual olive trees. *Arab Universities Journal of Agricultural Sciences,* 27: 659-671.

Howladar, S.M., (2014). A novel Moringa oleifera leaf extract can mitigate the stress effects of salinity and cadmium in bean (*Phaseolus vulgaris* L.) plants," *Ecotoxicology and Environmental Safety*, 100: 69-75.

Khan, H., G. McDonald, and Z. Rengel (2004). Zinc fertilization and water stress affects plant water relations, stomatal conductance and osmotic adjustment in chickpea (*Cicer arientinum* L.). *Plant Soil*, 267(1): 271-284.

Khayyat, M., E. Tafazoli, S. Eshghi, and S. Rajaee (2007). Effect of nitrogen, boron, potassium and zinc sprays on yield and fruit quality of date palm. *American-Eurasian Journal* of *Agricultural* and *Environmental Sciences,* 2 (3): 289-296.

Mohamed, S. A., and M. El-Tanany (2016). Efficacy of foliar applications of salicylic acid, zinc and potassium on reducing fruit drop, yield improvement and quality of Balady mandarins. *Egyptian Journal of Horticulture,* 43(20): 371-388.

Mosa, W. F., M. Z. Salem, A. A. Al-Huqail, and H. M. Ali (2021). Application of glycine, folic acid, and moringa extract as bio-stimulants for enhancing the production of 'Flame Seedless' Grape Cultivar. *Bioresources,* 16(2): 3391-3410.

Mousavi SR., M. Galavi and v. G. Ahmad (2007). Effect of zinc and manganese foliar application on yield, quality and enrichment on potato (*Solanum tuberosum* L.). *Asian journal of plant sciences,* 6: 1256-1260.

Mousavi, S. R., (2011). Zinc in crop production and interaction with phosphorus. *Australian Journal of Basic and Applied Sciences,* 5(9): 1503-1509.

Mutalik, M., and M. Mutalik (2011). Tinospora cordifolia: Role in depression, cognition and memory. *Australian Journal of Medical Herbalism,* 23(4): 168-173.

Nikbakht, M., M. Solouki, and M. Aran (2021). Effects of foliar application of zinc nano-chelate and zinc sulfate fertilizers on some quantitative and qualitative properties of bitter apple (*Citrullus colocynthis* L.). *Iranian Journal of Medicinal and Aromatic Plants Research*, 36(6): 898-911.

Nisar,M., M. Nasir, S. Saleem, M.U. Iqbal and T. Athar (2021) "Effect of foliar application of moringa leaf extract (mle) on growth and yield of gossypium hirsutum. *Acta Scientific Agriculture,* 5(2): 33-36

Ojeda-Barrios, D. L., E. Perea-Portillo, O.A. Hernández-Rodríguez, G. Avila-Quezada, J. Abadía and L. Lombardini (2014). Foliar fertilization with zinc in pecan trees. *Horticultural Science,* 49(5): 562-566.

Phiri, C., (2010). Influence of Moringa oleifera leaf extracts on germination and early seedling development of major cereals. *Agriculture and Biology Journal of North America,* 1(5):774-777.

Rady, M.M., F. Gamal, A.M. Mohamed and H.M. Yas-min (2015). Integrated application of sali-cylic acid and Moringa oleifera leaf extract alle-viates the salt-induced adverse effects in com-mon bean plants. *Journal of Agricultural Technology,* 11(7): 1595-1614.

Razzaq, K., A. Khan, A. Malik, M. Shahid and S. Ullah (2013). Foliar application of zinc influences the leaf mineral status, vegetative and reproductive growth, yield and fruit quality of 'Kinnow'mandarin. *Journal of Plant Nutrition,* 36(10): 1479-1495.

Sardar, H., A. Nisar, M. A. Anjum, S. Naz, S. Ejaz, S. Ali, and R. Ahmad, (2021). Foliar spray of moringa leaf extract improves growth and concentration of pigment, minerals and stevioside in stevia (*Stevia rebaudiana* Bertoni). *Industrial Crops and Products,* 166: 113485.

Sarrwy, S., M.H. El-Sheikh, S.S. Kabeil, and A. Shamseldin (2012). Effect of foliar application of different potassium forms supported by zinc on leaf mineral contents, yield and fruit quality of "Balady" mandarin trees. *Middle East Journal Scientific Research,* 12(4): 490-498.

Soliemanzadeh, A., V. Mozafari, A. T. Pour, and A. Akhgar (2013). Effect of Zn, Cu and Fe foliar application on fruit set and some quality and quantity characteristics of pistachio trees. *South-Western Journal of Horticulture, Biology and Environment,* 4(1):19-34.

Sparks, D. L., A. L. Page, P. A. Helmke, and R. H. Loeppert (Eds.). (2020). Methods of soil analysis, part 3: *Chemical methods,* (Vol. 14). John Wiley & Sons.

Stellacci, A. M., A. Caliandro, M. A. Mastro, and D. Guarini (2008). Effect of foliar boron application on olive (*Olea europaea* L.) fruit set and yield. *In VI International Symposium on Mineral Nutrition of Fruit Crops,* 868: 267-272).

Swietlik, D. (2002). Zinc nutrition of fruit crops. *HortTechnology,* 12(1): 45-50.

Usenik, V., and F. Stampar (2001). Effect of foliar application of zinc plus boron on sweet cherry fruit set and yield. *In International Symposium on Foliar Nutrition of Perennial Fruit Plants, 594*: 245-249.

Wang, H., N. Pampati, W.M. McCormick and L. Bhattacharyya (2016). Protein nitrogen determination by kjeldahl digestion and ion chromatography. *Journal of Pharmaceutical Sciences,* 105(6): 1851-1857.

Wei, W., Y. Zhang, Q. Xu, H. Wei, Y. Fang, Q. Wang, and J. Huang (2017). Monolithic integration of hybrid perovskite single crystals with heterogenous substrate for highly sensitive X-ray imaging. *Nature Photonics,* 11(5), 315-321.