Research Article

Evaluation of the Effectiveness of Spraying Nano-Silica and Aqueous Rice Extract to Alleviate the Phenomenon of Redness to Barhi Cultivar Date Palm Fruits under Basrah Conditions, Iraq

Hassan A. Faisal[1], Ahmad Y.L. Hzaa[2]* and Yahya N. Kalaf[1]

[1]Date Palm Research Centre, University of Basrah, Iraq; [2]Department of Marine Biology, Marine Science Centre, University of Basrah, Iraq.

Abstract | Severe changes in climate over the past three years have caused various problems for palm orchards in Basrah, Iraq. One of the main challenges has been the phenomenon of redness and immaturity of the fruits. Therefore, this study was conducted to determine the effect of spraying nano-silicone (0, 250, and 500) mg. L-1, and rice water extract (0, 50 and 100%) help alleviate and reduce this phenomenon. The results showed that using aqueous rice extract at a concentration of 100% was the most effective treatment, improving most physical and chemical characteristics of the fruit compared with the comparison treatment. However, the comparison treatment had a higher sucrose percentage and water content. The results of the anatomical analysis showed that the nano-silicone (Nsi) 250 mg.L^{-1} spray treatment was significantly better than other treatments in terms of the thickness of the outer layer of the fruit and the number of vascular bundles. On the other hand, treatment with 100% aqueous rice extract was significantly better in terms of the number of tannin layers and pulp cells. The Nsi-500 mg.L^{-1} spray treatment performed well in increasing the thickness of the inner pulp layer. There were no significant differences between the spray and control treatments in the other anatomical characteristics of the fruits. The above results demonstrated the significant role of nanosilica and rice water extract in improving fruit characteristics and quality by alleviating the side effects of climate change in Basrah Governorate.

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***Correspondence** | Ahmad Y.L. Hzaa, Date Palm Research Center, University of Basrah, Iraq; **Email:** ahmed.lafta@uobasrah.edu.iq
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Introduction

Phoenix dactylifera L. palm is a crucial evergreen fruit that grows in subtropical regions. It is widely cultivated in Iraq and some parts of the Middle East, because it holds significant economic value (Barreveld, 1993). This blessed tree has played a vital role in Mesopotamian civilization because of its importance. The cultivation of palm trees is a crucial aspect of Iraq's agricultural environment. In Iraq, the Barhi date is a significant and well-known variety. It ripens early and produces a fruit with a sweet and

sugary taste. Its sweetness is due to its high sucrose content, which is present from the yellow Khalal (busr) stage to the date stage. This makes it unique among other cultivars, because it can be enjoyed at all three stages: Khalal, rutab, and dates. This exceptional feature distinguishes it from other varieties, making it highly sought after worldwide (Zabar and Borowy, 2012). The Barhi date is widely cultivated in many regions of Iraq due to its popularity, but it has faced setbacks due to the country's circumstances, similar to other commercial varieties. According to current statistics, the Barhi cultivar represents only 11.5% of Iraq's total date production, along with other commercial varieties (Yahia and Kader, 2011). The concept of climate change is centered on fluctuations in temperature. The impact of climate change is directly proportional to the extent of these fluctuations in the climatic elements. Whether there is a rise or fall from the prevailing rate, the greater the change, the more significant is the impact on living organisms and their systems. This has become increasingly clear over time (Al-Amoud, 2017). Iraq will face its second driest season in 40 years in 2021, as rainfall will reach record lows. The Euphrates and Tigris rivers, which provide nearly all of Iraq's surface water, have experienced a 30%–40% decrease in water flows over the past four decades. The southern marshes, a natural heritage wonder, have also dried up. Additionally, temperatures are on the rise in Iraq, with the highest recorded temperature in Basra reaching approximately 54 °C (Ishaqzai, 2022). The cultivation of date palms is influenced by various environmental factors such as temperature, humidity, rainfall, wind, light, and sunlight. Each of these factors has a minimum, maximum, and optimum level. When the environmental factor is at its optimum level, the physiological, metabolic, and growth processes reach their maximum rate of development. However, if the intensity or level of the environmental factor exceeds the optimal limit, it can affect the rate of operations (Ibrahim, 2014). For palm cultivation and date production to be successful, sunlight is an essential climate element. The palm tree naturally grows by elongating its fronds on top, typically between sunrise and sunset. If planted in shaded areas, palm tree growth will not be normal, even in hot regions. This is because the green fronds are unable to perform their function unless they are exposed to direct sunlight, making areas with frequent sun obstruction unsuitable for growing palm trees (Mahmoud, 1988). Exposure to direct sunlight can be harmful, especially when the temperature rises to 50°C and the degree of solar radiation increases in June and July. The ultraviolet ray index is high during this time, reaching its peak between 10:00 AM and 4:00 PM. This means that on average, fruits are exposed to sunlight for at least 5h a day. Sun-scaldcan occur, leaving dry, leathery brown spots with a rough texture on the surface of the fruit facing the sun's rays. These spots are dry, dead areas of tissue that can affect the size and taste of the fruit. Additionally, the flesh of the fruit located under these spots may become dark in colour. Fruits exposed to sunlight are more likely to be infected than shaded fruits (Ibrahim, 2019). Applying silicon to plant leaves is more effective in helping plants cope with stressful conditions, including salinity, drought, floods, heat, cold, and biotic stress (Artyszak, 2018). Silicon can mitigate the harmful effects of oxidative stress and provide resistance against various abiotic and biotic stresses. In fact, when plants experience stress, many genes are activated, and silicon-producing proteins involved in biochemical pathways can enhance stress tolerance (Balakhnina and Borkowska, 2013).

The importance of using natural plant bio stimulants has increased in recent years. These bio stimulants can be highly beneficial in fruit crops, because they improve various aspects of the fruit's anatomy, morphology, and physiology. This ultimately leads to better yields and higher quality fruit. In addition, biostimulants can help enhance physiological actions such as photosynthesis, nutrient metabolism, enzymatic activities, and levels of chlorophyll, protein, and carbohydrates. They can also help reduce the negative effects of abiotic stresses such as water stress, salinity, temperature changes, redox-related changes, detoxify reactive oxygen species, and regulate stress signals and hormonal pathways (Rana *et al.*, 2022). Rice water, a by-product of food production, contains essential minerals and vitamins that can be used to fertilize plants and improve their health. It is an efficient source of nutrients and minerals that help foster a healthy bacterial population, making it an ideal choice for watering plants. By using rice water, plants grow healthier and more robustly. White aqueous rice extract also contains Vitamin B1 (thiamine), and other nutrients such as N, P, K, Ca, Mg, and S. (Febriyanti *et al.*, 2021; Nabayi *et al.*, 2021). The primary objective of this research is to assess the efficacy of employing nano silica and rice water extract in enhancing the quality and attributes of fruits, particularly considering the obstacles posed by the impacts of climate change in Basrah Governorate. The agricultural industry

in Basra, specifically the cultivation of date palms, encounters significant challenges due to severe weather conditions and unpredictable variations.

Materials and Methods

During the 2022 growing season, a study was conducted in a private orchard located in the Kataiban Shatt al-Arab region of Basra Governorate in Iraq (30°42'44.8"N 47°46'59.0"E). The study involved selecting fifteen Barhi histological cultivar date palms that were almost identical in age, height, and vegetative growth, and were free of any disease infection. These trees were 11 years old (The fruits of the trees were damaged by the phenomenon of redness in the previous year). The trees were irrigated with water from the Katiban River (Tigris River), and horticultural services, such as irrigation and fertilization were performed on the palm trees under study. This study investigated the effectiveness of two materials in reducing the impact of sunburn: The experiment involved spraying nanosilica (Nsi) at three different concentrations (0, 250, and 500 mg/L^{-1}) provided by Sikma Company. Another factor was the application of aqueous rice extract (Rwe) at three concentrations (0, 50 and 100) %. The aqueous extract of rice was prepared by mixing rice and distilled water in a ratio of 1:2 w/v. The mixture was left for 24 hours with continuous stirring, then filtered using Whatman No.1 filter paper. Subsequently, the necessary concentrations were then prepared.

The fruits were sprayed twice- the first 70 days after the pollination process and the second 100 days after the pollination process. The spraying process was performed early in the morning before the temperatures rose, and Tween 20 (diffuser) was used at all concentrations. All measurements were taken during the Khalal stage, which is the phase where redness and delayed ripening occur, measurements were taken to determine physical characteristics such as length, diameter, weight, and fruit size as well as the weight of the pulp and seed. For each replicate in each treatment, fruits were randomly selected, and their length and diameter were measured using a Vernier digital measuring foot. The average length and diameter of the fruit were calculated by dividing the sum of their length and diameter by the number of fruits, with the unit of measurement being centimeters. The fresh weight of ten fruits, selected randomly from each replicate and treatment, was measured using a sensitive digital balance.

The chemical properties analyzed were the total, reducing sugars, and sucrose. To estimate total and reducing sugars and sucrose in the fleshy layer of fruits, the method of Lane and Eynon, as in Abbas and Abbas (1992), was used based on dry weight. During the khalal stage, we studied the anatomical characteristics of the fruits. We collected samples from their locations and brought them to the laboratory. The fruits were cut crosswise and placed in plastic bottles for further analysis. To prepare the samples for examination, we fixed the samples in a 70% concentration of formalin acetic alcohol (F.A.A) solution for 24 h. Then, we gradually passed the cut parts through increasing concentrations of ethyl alcohol. Next, we embedded the samples in paraffin wax at 58°C. Next, we used a Rotary Microtome to cut the samples into thin 10-micrometre slices. We then dyed the samples with safranin and fast green dyes. Finally, we loaded the samples with drops of PDX and placed them on a slide cover. These methods were based on the work of (Willey, 1971). The anatomical sections were studied after measurement using an Optika-B-350 optical microscope (the average thickness of the outer shell, the average thickness of the cuticle layer, the average thickness of the epidermis layer, the average thickness of the sclerotic cells) microns (average thickness of the middle outer shell, average thickness of the inner pulp layer,) mm (number of pulp cells, number of vascular bundles) mm^2. Rate of number of tannin layers. The experiment was conducted with a Randomized Complete Block Design (RCBD). It was a simple experiment with five treatments and three replications. The results were analyzed using GenStat version 7. Means were compared using the Least Significant Difference Test (L.S.D) at probability level of 0.05 (Al-Raw and Khalafallah, 2000).

Results and Discussion

The results presented in Table 1 indicate that the use of natural organic fertilizers in spraying treatments has a significant advantage over chemical fertilizers. Specifically, the spraying treatment using aqueous rice extract at a concentration of 100% showed outstanding performance in various physical attributes of the fruit, such as length, diameter, size, weight of the fruit, pulp, and seed weight. This treatment produced the highest values for all these characteristics, with measurements

Table 1: *The impact of study variables on various physical characteristics of fruits.*

Transactions	Lengthfruit (cm)	Diameterfruit (cm)	Weightfruit (g)	Sizefruit cm^3	Weightpulp (g)	Weightseed (g)
control	2.600	1.870	6.00	6.04	4.53	1.47
Nsi-250 $mg.L^{-1}$	3.177	2.210	8.78	8.81	7.04	1.74
Nsi-500 $mg.L^{-1}$	3.110	2.083	8.16	8.20	6.51	1.65
Rwe 50%	3.097	2.157	8.88	8.93	6.96	1.92
Rwe 100%	3.353	2.467	10.37	10.43	8.33	2.04
L.S.D.	0.358	0.252	2.00	1.98	2.06	0.20

Table 2: *The impact of study variables on some different chemical properties of fruits.*

Transactions	Total sugars %	Reducingsugars %	Sucrose %	Water content %	Dry matter %	Total soluble solids %
Control	39.49	18.29	21.2	36.63	63.37	43.73
Nsi-250 $mg.L^{-1}$	40.09	19.00	21.08	34.90	65.10	47.90
Nsi-500 $mg.L^{-1}$	42.28	22.32	19.95	32.58	67.42	50.23
Rwe 50%	41.25	21.00	20.26	32.49	67.51	49.07
Rwe 100%	43.20	24.25	18.95	30.27	69.73	61.40
L.S.D.	1.07	1.32	1.15	1.25	1.14	2.69

of (3.353), (2.467), (10.43), (10.37), (8.33), and (2.04). However, the comparison treatment resulted in the lowest values for these physical characteristics. The findings presented above demonstrate a significant impact on enhancing the physical attributes of fruits when they are subjected to rice extract spraying, particularly during the interstitial stage of complete growth, among fluctuating sun temperatures and high levels of incident rays. This positive effect can be attributed to the presence of essential elements such as phosphorus and potassium, which contribute to the improvement of the physical characteristics of fruits treated with rice extract. These elements are crucial in facilitating the transfer of materials resulting from photosynthesis and stored materials, as well as stimulating the function of plant hormones that enhance the strength of fruit consumption centers, thereby increasing its weight and size (Taiz *et al*., 2015). The increase in fruit length, diameter, and overall size observed when utilizing organic fertilizer can be attributed to the role of mineral nutrients, particularly nitrogen. Nitrogen stimulates cell division and enhances meristematic activity by participating in the synthesis of various plant hormones, including auxins (Leghari *et al*., 2016). In addition, nitrogen (N) plays a significant role in how plants respond to both abiotic and biotic stresses. The reactivity of nitrogen in plants is closely linked to nitrogen metabolism, carbon (C) fixation, and secondary metabolic pathways.

Glutamate, a crucial nitrogen-containing molecule, is responsible for the synthesis of proline (Pro), arginine (Arg), and ornithine (Orn). It serves as a major common pathway for polyamides (PAs) and the assimilation/incorporation of carbon and nitrogen, both of which are involved in various stress responses. PAs and their derivatives are essential signaling molecules that primarily function by safeguarding and preserving cell function and structure in response to stressors (Paschalidis *et al*., 2019). The findings from the analysis of the chemical properties of the fruits (Table 2) demonstrate that the application of aqueous rice extract through spraying, at a concentration of 100%, had a significant impact on the examined properties (total and reducing sugars, dry matter, and total dissolved solids). This treatment yielded the highest percentages of 43.2, 24.25, 69.73, and 61.40, respectively. In contrast, the comparison treatment exhibited superiority in terms of sucrose percentage and water content, recording the highest percentages of 21.2 and 36.63, respectively.

The sugar content of fruits can vary depending on the nutrients present in natural and nano-fertilizers. These fertilizers play a crucial role in stimulating the activity of plant hormones such as auxins. Auxins work to attract the products of photosynthesis, including sugars, into fruits. In addition, they promote the conversion of organic acids into sugars through the activity of specific enzymes responsible for ripening, such as invertase. This enzymatic activity affects the solute content of cells, ultimately resulting in a higher sugar content in the fruits (Mosa *et al*., 2014; Shareef *et al*., 2020). The increase in the proportion of overall and decreasing sugars after exposure to aqueous rice extract could be ascribed to the existence

of significant and minor mineral components. These elements, including N, P, and K, function as catalysts that enhance enzyme efficiency in biological processes (Singh *et al.*, 2020). The rise in total sugar concentrations can be attributed to the incorporation of nitrogen, which facilitates the synthesis of amino acids, DNA, RNA, and ATP. These essential molecules are utilized by the plant to generate proteins, enzymes, chlorophyll, and a range of other organic substances, thereby contributing to an enhancement in the sugar levels found in the fruits (Cooper and Adams, 2022).

The increase in dry substance and the decline in water content percentage after aqueous rice extract treatment could be attributed to the presence of nitrogen, a crucial element that facilitates the production of amino acids. These amino acids play a significant role in enhancing protein synthesis, ultimately leading to an increase in dry matter within the fruit cells and a subsequent reduction in moisture content. This inverse correlation between the two factors has been highlighted by (Rütting *et al.*, 2018). The addition of natural extract may contribute to the reduction in moisture content and increase in dry matter and soluble solids in the fruits. This effect could be attributed to the role of macro- and microelements in mitigating the impact of heat stress. These elements activate antioxidant enzymes, regulate the osmotic potential within cells, enhance the process of photosynthesis, and facilitate the formation of diverse proteins, nucleic acids, amino acids, and sugars (Babaei *et al.*, 2017). The role of amino acids in enhancing the levels of sugars and soluble solids in date palm fruits has been investigated by (Abdullah *et al.*, 2023).

Table 3 shows that employing various spraying concentrations resulted in notable variances in the anatomical traits of the fruits. The spraying treatment of Nsi-250 mg.L^{-1} exhibited remarkable superiority in terms of exocarp layer thickness and the number of vascular bundles, with the highest values recorded at 127.9 µm and 220.33 mm, respectively. In comparison, the control treatment recorded values of 90.1 µm and 212.67 mm. Furthermore, the results showed that the use of 100% rice water by spraying showed significant superiority in terms of the number of tannin layers and pulp cells. Specifically, it resulted in 3.33 tannin layers and 3273 pulp cells, whereas the control treatment resulted in 2.00 and 2233 cells, respectively. The Nsi-500 mg.L^{-1} spray treatment demonstrated superior performance in terms of the average thickness of the inner pulp layer, achieving a remarkable value of 2833 mm, compared to the control treatment, which only reached 2397 mm (Figure 1). The spray treatments resulted in a noticeable decrease in the average thickness of the outer layer, whereas the control treatment had the highest value of 506.7 mm. However, no significant variations were observed between the spray treatments and the comparison treatment in terms of the remaining anatomical characteristics of the fruits. The treated fruits exhibit notable variations in their anatomical features, which can be attributed to the palm trees' remarkable adaptability to environmental stress conditions (Swaed, 2012). The application of either a nano-fertilizer or natural fertilizer may enhance cell division and elongation in the underlying layer of the exocarp, resulting in a favorable increase in the thickness of the outer layer.

The thickening of the outer and inner middle layers of the fruit's flesh may be attributed to the presence of silicon, which helps alleviate both abiotic and biotic stresses in plants. This is achieved by enhancing the process of photosynthesis at multiple levels, including safeguarding the photosynthetic structure, improving water use efficiency, enhancing photosynthetic electron transfer, and protecting the photosynthetic machinery. In addition, silicon influences various

Table 3: *The impact of study variables on the anatomical attributes of fruits.*

Transactions	Thickness of exocarp layer (µm)	Thickness of cuticle layer (µm)	Thickness of epidermal layer (µm)	Thickness the stone cell layer (µm)	Thickness outer mesocap layer (mm)	Thickness inner mesocap (mm)	number of tannin layeres	Number of vascular bundles per mm^2	Number of pulp cells per mm^2
Control	90.1	7.80	12.13	50.3	506.7	2397	2.00	12.67	2233
Nsi-250 (mg.L^{-1})	127.9	9.53	12.13	61.5	246.7	2657	2.00	20.33	2640
Nsi-500 (mg.L^{-1})	84.1	9.53	11.27	46.8	373.3	2833	2.00	15.00	2237
Rwe (50%)	110.1	9.53	11.26	60.7	193.3	2500	2.00	17.67	3211
Rwe (100%)	87.5	8.67	11.27	39.0	216.7	2317	3.33	14.33	3273
L.S.D.	**34.14**	**2.443**	**2.731**	**27.74**	**59.04**	**338.8**	**0.469**	**6.320**	**553.7**

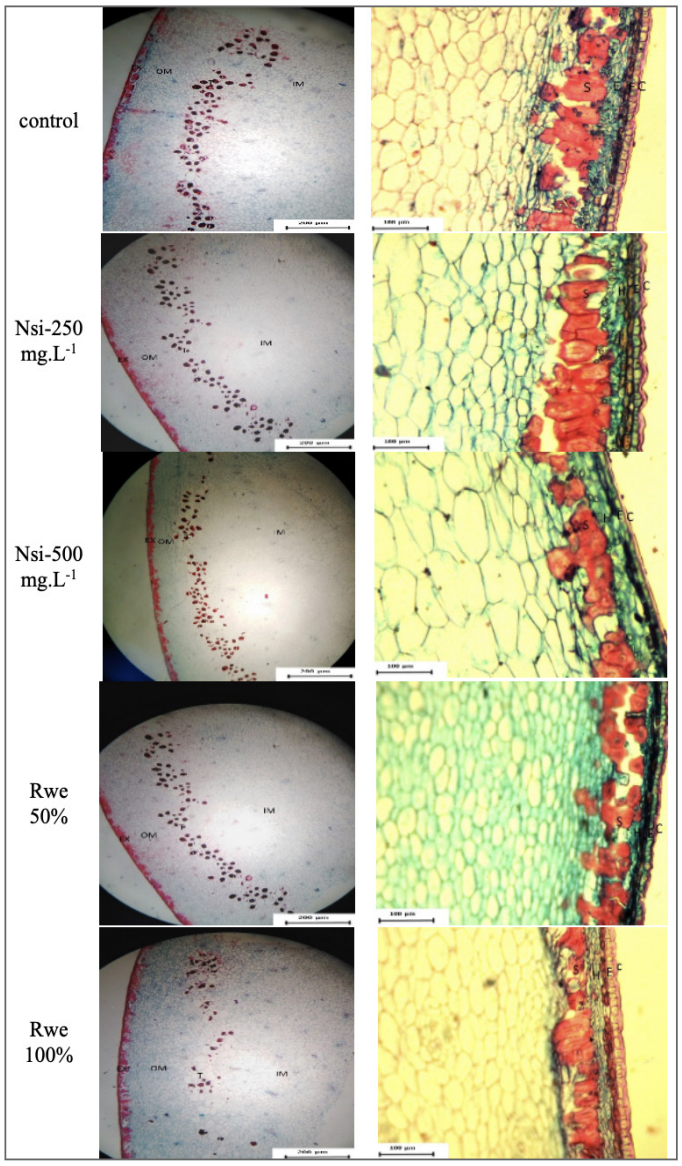

Figure 1: *The influence of study treatments on specific anatomical traits of Barhi variety date palm fruits during the khalal stage, using a magnification of 100X.*

physiological processes such as the absorption of macro- and micronutrients, gene regulation, and interaction with plant hormones, all of which impact photosynthesis activity. Consequently, metabolic processes are enhanced, leading to increased production and efficient transfer of nutrients from the manufacturing sites to the aerenchyma cells comprising the mesocarp layer in fruits. These cells are responsible for nutrient storage (Chaffey, 2008; Debona *et al*., 2017; Hussain *et al*., 2021).

Si, or silicon, is an important element in the regulation of phytohormones, which are vital metabolites in plants. These phytohormones play a crucial role in maintaining the biochemical and physiological health of plants, especially during abiotic stress conditions. Si not only has a positive impact on phytohormone metabolism but also helps maintain the overall physiological balance of plants. Furthermore, Si assists in improving the tolerance of crop plants to abiotic stress by assisting in the transformation of processes at the metabolic and molecular levels (Mir *et al*., 2022).

The concentration of natural fertilizer (rice water) directly affects the increase in tannin layers, which in turn affects the number of pulp cells. This increase is likely due to the mineral elements present in the fertiliser, which play a crucial role in enhancing the tannin content. Tannins act as natural antioxidants produced by plants to combat stressful conditions. They can inhibit various enzymes, particularly proteolytic enzymes, either by directly impeding hydrolytic enzymes or by forming hydrogen bonds with proteins. As a result, this inhibitory action hinders the degradation of these enzymes (Al-Hassanin, 2009).

Conclusions and Recommendations

The presence of Silicon element plays a crucial role in enhancing the fruit's flesh thickness and overall quality. Additionally, Silicon element positive impact on phytohormone metabolism and abiotic stress tolerance cannot be overstated. Furthermore, the role of natural fertilizers, such as rice water, cannot be understated, as their influence on increasing tannin layers and pulp cell count is evident. The mineral elements in these fertilizers enhance the tannin content, providing natural antioxidants that help the plant cope with stressful conditions. The combination of silicon and natural fertilizers creates a synergistic effect, improving the fruit's overall health, nutrient content, and resistance to various stresses.

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Novelty Statement

This research shows that using aqueous rice extract (ARE) is a new and eco-friendly way to help improve the quality of date palm fruits in Basra, Iraq, especially

with the challenges of climate change. Although nanosilicone had some positive effects, like making the outer layer of the fruit thicker and increasing the number of vascular bundles, ARE provided a better overall im-provement in fruit quality. This makes it a hopeful option for farming that can withstand climate issues.

Author's Contribution

Hassan A. Faisal: Co-supervision, investigation, visualization, review and editing.
Ahmad Y.L. Hzaa: Resources, formal analysis and review.
Yahya N. Kalaf: Investigation, write-up and proofreading

Conflict of interest
The authors have declared no conflict of interest.

References

Abbas, M.F. and J.A. Mushin. 1992. Care and storage of practical fruits and vegetables. Dar Al-Hickman Press, Basra University, Iraq.

Abdullah, A.S.A., H.A. Faisal and A.Y. Hzaa. 2023. Response of date palm *Phoenix dactylifera* L. Hillawi cultivar to some amino acids. J. Glob. Innov. Agric. Sci., 11(3): 341-346.

Al-Amoud, F.A.F., 2017. Suiting the climatic requirements for growing palm trees according to climate change data in Iraq. J. Educ. College Wasit Univ., 1(26): 345-402.

Al-Hassanin, Y.A.A., 2009. Economic plant, academic library. Egyptian Shareholding Company. pp. 346.

Al-Rawi, K.M. and A.M. Khalafallah. 2000. Design and analysis of agricultural experiments. Dar Al-Kutub for printing and publishing, Mosul, Iraq. pp. 448.

Artyszak, A., 2018. Effect of silicon fertilization on crop yield quantity and quality. A literature review in Europe. Plants, 7(3): 54.

Babaei, K., R.S. Sharifi, A. Pirzad and R. Khalilzadeh. 2017. Effects of bio fertilizer and nano Zn-Fe oxide on physiological traits, antioxidant enzymes activity and yield of wheat (*Triticum aestivum* L.) under salinity stress. J. Plant Interact., 12(1): 381-389.

Balakhnina, T. and A. Borkowska. 2013. Effects of silicon on plant resistance to environmental stresses. Int. Agrophys., 27(2).

Barreveld, W.H., 1993. Date palm products. FAO Agricultural Services Bulletin, No. 101. http://www.fao.org/docrep/t0681e/t0681e00.htm

Chaffey, N., 2008. Plant anatomy: An applied approach.

Cooper, G.M. and K. Adams. 2022. The cell: A molecular approach. Oxford University Press. https://books.google.iq/books?id=GNebEAAAQBAJandprintsec=frontcover#v=onepageandqandf=false

Debona, D., F.A. Rodrigues and L.E. Datnoff. 2017. Silicon's role in abiotic and biotic plant stresses. Ann. Rev. Phytopathol., 55(1): 85-107.

Febriyanti, F., L.P. Taib, D. Kurniadi and A. Ainina. 2021. Descriptive results of vegetative growth of rawit chili malita FM after giving liquid organic fertilizer rice water. J. NX Multidiscip. Peer Rev. J., 7(02): 282-287.

Hussain, S., L. Shuxian, M. Mumtaz, I. Shafiq, N. Iqbal, M. Brestic, M. Shoaib, Q. Sisi, W. Li, X. Mei and C. Bing. 2021. Foliar application of silicon improves stem strength under low light stress by regulating lignin biosynthesis genes in soybean (*Glycine max* (L.) Merr.). J. Hazard. Mater., 401: 123256.

Ibrahim, A.O., 2014. Environment and physiology of the date palm, Al-Ghadeer Printing and Publishing Company Limited, pp. 256.

Ibrahim, A.O., 2019. Palm cultivation and date quality between environmental factors and service and care programs. General Secretariat of the Khalifa International Award for Date Palm and Agricultural Innovation, pp. 436.

Ishaqzai, G., 2022. Climate change is the biggest threat Iraq has ever faced, but there is hope to turn things around. Article by the Deputy Special Representative for Iraq. https://news.un.org/ar/story/2022/11/1115457

Leghari, S.J., N.A. Wahocho, G.M. Laghari, A. HafeezLaghari, G. MustafaBhabhan, K.H. Talpur, T.A. Bhutto, S.A. Wahocho and A.A. Lashari. 2016. Role of nitrogen for plant growth and development: A review. Adv. Environ. Biol., 10(9): 209-219.

Mahmoud, J.H., 1988. The effect of climate on determining fruit production in the central region of Iraq, Master's thesis, College of Education, University of Baghdad, pp. 140.

Mir, R.A., B.A. Bhat, H. Yousuf, S.T. Islam, A. Raza, M.A. Rizvi, S. Charagh, M. Albaqami, P.A. Sofi

and S.M. Zargar. 2022. Multidimensional role of silicon to activate resilient plant growth and to mitigate abiotic stress. Front. Plant Sci., 13: 819658.

Mosa, W.F.A.E.G., L.S. Paszt and N.A. Abd El-Megeed. 2014. The role of bio-fertilization in improving fruits productivity. A review. Adv. Microbiol., 4(15):1057.

Nabayi, A., C.T.B. Sung, A.T.K. Zuan, T.N. Paing and N.I.M. Akhir. 2021. Chemical and microbial characterization of washed rice water waste to assess its potential as plant fertilizer and for increasing soil health. Agronomy, 11(12): 2391.

Paschalidis, K., G. Tsaniklidis, B.Q. Wang, C. Delis, E. Trantas, K. Loulakakis, M. Makky, P.F. Sarris, F. Ververidis and J.H. Liu. 2019. The interplay among polyamines and nitrogen in plant stress responses. Plants, 8(9): 315.

Rana, V.S., S. Sharma, N. Rana and U. Sharma. 2022. Sustainable production through biostimulants under fruit orchards. CABI Agric. Biosci., 3(1): 38.

Rütting, T., H. Aronsson and S. Delin. 2018. Efficient use of nitrogen in agriculture. Nutr. Cycl. Agroecosyst., 110: 1-5.

Shareef, H.J., R.A. Al-Yahyai, A.E.D.K. Omar and W.A. Barus. 2020. Foliar nano-fertilization enhances fruit growth, maturity, and biochemical responses of date palm. Can. J. Plant Sci., 101(3): 299-306.

Singh, T.B., A. Ali, M. Prasad, A. Yadav, P. Shrivastav, D. Goyal and P.K. Dantu. 2020. Role of organic fertilizers in improving soil fertility. Contaminants in agriculture: Sources, impacts and management., pp. 61-77.

Swaed, S.Y., 2012. Comparative anatomical study for some fruits of date palm *Phoenix dactylifera* L. cultivars in mature stage. Basrah J. Date Palm Res., 11(2): 58-74.

Taiz, L., E. Zeiger, I.M. Møller and A. Murphy., 2015. Plant physiology and development. (No. Ed. 6). Sinauer associates incorporated. https://www.cabidigitallibrary.org/doi/full/10.5555/20173165866

Willey, R.L., 1971. Microtechnique: Alaboratory guide. Memillan Publishing CO., Inc., N.Y. pp. 99.

Yahia, E.M. and A.A. Kader. 2011. Date (*Phoenix dactylifera* L.). In Postharvest biology and technology of tropical and subtropical fruits. Woodhead Publishing. pp. 41-81e.

Zabar, A.F. and A. Borowy. 2012. Cultivation of date palm in Iraq. Annales Universitatis Mariae Curie-Skłodowska. Sectio EEE: Horticultura, 22(1). https://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-d21d7bb7-2e83-4cfc-b716-ab69859953eb