ISSN NO: 2771-8840
Date of Publication: 28-04-2023

The effect of some soil Improvers and irrigation water quality on the anatomical characteristics of the date palm *Phoenix dactylifera* L. Barhi cultivar under salt stress conditions

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Abstract
The study was applied to offshoots of date palms Barhi cv. tissue culture growing in one of the private orchards, The experiment included a study of the effect of two factors, the first factor as a soil improver (without adding improvers, an organic improver in which decomposing sheep waste was used by adding it to the soil, an industrial improver that treats salinity, Super soil). As for the second factor, the quality of irrigation water, which included (irrigation water with low salinity, which is river water (4-5 dsm^{-1}, Control treatment), irrigation water with salinity (8 dsm^{-1}), and irrigation water with salinity (15 ds m^{-1}). The results of the study showed the effect of soil improvers and the quality of irrigation water on the anatomical characteristics of the roots of date palm offshoots of the Barhi cv,, as the Super soil treatment was significantly superior to the organic fertilizer treatment and the Control treatment, and the highest mean thickness of the epidermis, cortex, endodermis, pericycle, diameter of vascular bundle, diameter of phloem and xylem reached (32.86, 860.14, 27.67, 24.33, 1356.67, 46.33 and 127.52µm) respectively, while the treatment without the addition of improvers (Contol) recorded the lowest mean for the same characteristics .The quality of irrigation water also had a significant effect on the anatomical characteristics of the roots, as it excelled with It low salinity irrigation water, which is the river water (5-4 dsm^{-1}) significant and recorded the highest mean of the thickness of the epidermis, cortex, endodermis, pericycle, diameter vascular bundles, and diameter of phloem and xylem were (33.81, 863.57, 28.00, 23.67, 1360.00, 46.67 and 127.17 µm), respectively. While the treatment of irrigation water with salinity (15 dsm^{-1}) recorded the lowest mean for the same characteristics. The interaction between the factor of improvers (Super soil) and the factor of quality of irrigation water (4-5 dsm^{-1}) recorded the highest mean for all characteristics, while the interaction between treatment without adding improvers (Control treatment) and the salinity of irrigation water (15 dsm^{-1}) was recorded the lowest means for all studied anatomical features

Keywords: improvers - irrigation water quality - anatomical characteristics - date palm - tissue culture - salt stress.

1- Introduction

Date palm is one of the most important types of palms in the palm family Arecaceae, which includes more than 200 genus and more than 2500 species, and it is one of the most beneficial plant families for humans after the Poaceae family, as it is of great nutritional and economic importance, which makes it contribute to the economic income (EL-Hadrami and EL-Hadrami, 2009 ; Jain *et al*., 2011). Cultivation of date palm trees is concentrated in southern Iraq in the muddy areas along the Shatt al-Arab. Iraq was one of the most important date-producing countries in the world, but its date palm productivity has become low due to inappropriate environmental conditions, foremost of which is the problem of salinity and scarcity of irrigation water, which is one of the problems facing agriculture on a global scale, especially in arid and semi-arid regions, and affects more than 20% of the world's irrigated land (Munns and Tester, 2008). Iraq is the forefront of the Arab and Asian countries in terms of the total area affected by salinity, and the problem of salinity has worsened in Iraq in recent years, as a result of the scarcity of water and water resources in addition to the deterioration of its quality and mismanagement and the rise in groundwater levels, which led to soil salinization in the irrigated areas in central and southern Iraq. Salt stress is one of the most effective types of stress on the growth and development of the plant, as this type of stress leads to the entry of the plant into the second type of stress, which is water stress, where salinity leads to a decrease in the ability of the plant to absorb water, and in general, most of the stresses that plants are exposed to them cause protein transformations And the lack of nucleic acid synthesis in plant tissues (Popp,1990 and Al-Najjar, 2017). Challa and Van (2004) explained the mechanism of the direct effect of salinity on the plant by causing some morphological and anatomical changes in the plant. Plants growing in desert areas suffer from different environmental factors, which are determinants of plant growth and development. Despite the harsh conditions in desert areas, plants developed some morphological and anatomical characteristics that enabled them to survive under inappropriate conditions (Abdul-Wahid, 2003 and Al-Masoudi, 2021).Therefore, it was necessary to take some preventive measures to treat these soils, such the use of natural conditioners of organic and industrial materials such as polymers, antioxidants and the amino acid proline, because of its ability to improve the physical and chemical properties of the soil, in addition to the role of these conditioners in increasing the tolerance of offshoots to unfavorable environmental conditions. The suitability and improvement of most of the physical, biochemical, physiological and anatomical characteristics associated with the conditions of salt stress and water stress of date palms (Al-najjar and Al-presem, 2018 ; ALnajjar *et al*., 2020).

2-Materials and methods

This study was applied to offshoots of date palms Barhi tissue culture growing in one of the private orchards north of Basra, which were as homogeneous as possible in terms of the strength of vegetative growth, height and age, which was 5 years. palm tree . A compound soil sample distributed randomly was taken to represent the orchard soil at a depth of (0 - 60 cm) to study the soil characteristics before starting the study (Table 1) according to what was described in Al-Serafi (2003). The experience included the following factors: 1- Soil improver: A: without adding improvers (Control treatment) B: adding an organic improver, The decomposed sheep waste was used by adding it to the soil in the amount of 30 kg tree^{-1}, after making a basin surrounding each tree with a depth of 40 cm and a diameter of 3m. Organic manure was added to the treatments by mixing it with the soil, then covering it with a light layer of soil. C: Adding an artificial Improver The industrial improver used salinity treatment (Super soil), which is (a commercial product that binds with salts and keeps them away from the absorption area) at a concentration of 3 liters.100 L^{-1}, according to the recommendation of the producing company, by adding the quantity to each treatment after mixing it with water, then the trees are irrigated in all specified treatments in a homogeneous manner. 2- Irrigation water quality factor: This factor is included A: Low salinity irrigation water, which is the river water (4-5 dsm^{-1}) (Control treatment) B: Irrigation water with salinity (8 dsm^{-1}). C: Irrigation water with salinity (15 dsm^{-1}).

Anatomical features of the roots :

Anatomical sections of the roots were prepared using paraffin technology according to the method presented in Al-najjar *et al*. (2021), in which molten and solid paraffin wax is used.

Statistical analysis:

The experiment was designed using Randomized Complete Block Design (R.C.B.D). As a factorial experiment with two factors, the first factor is soil improvers and the second factor is irrigation water salinity. The number of experimental units was 27 trees, to which the factorial treatments were distributed randomly. Then the results were analyzed using analysis of variance to ensure that there are significant differences between the traits studied by the statistical program SPSS. The differences between the means were compared using the LSD Significant Difference Test at the probability level of 0.05 (Bashir, 2003).

Table (1) some characteristics of the soil and irrigation water in the orchard

1	Soil characteristics	Values

ISSN NO: 2771-8840
Date of Publication: 28-04-2023

2	EC dsm^{-1}	4.1
3	pH	7.33
4	OM $gmkg^{-1}$	0.55
5	Soil texture	
	Irrigation water characteristics	
6	EC dsm^{-1}	2.93
	pH	8.19

3-Result and Discussion

The effect of soil Improvers and irrigation water quality on the anatomical characteristics of the roots.

1- Thickness of epidermis:

The results of the study shown in table (2) and panel (b-a1) show the effect of soil Improvers and irrigation water quality on thickness of epidermis of the roots of date palm offshoots of Barhi cv. The highest mean was 32.86µm, while the Control treatment recorded the lowest mean of 18.79 µm. As for the effect of irrigation water quality, the Control treatment (4-5 dsm^{-1}) was significantly superior to the rest of the treatments and recorded the highest mean of root thickness of epidermis at 33.81µm, while the salinity treatment (15 dsm^{-1}) recorded the lowest mean of thickness of epidermis in the roots, which amounted to 20.87 µm. The interaction between the artificial Improver (Super soil) and river water (5 -4 dsm^{-1}) was recorded the highest mean of thickness of epidermis in roots was 43.21 µm, with a significant difference from the rest of the interactions, while the interaction between without the addition of Improvers(Control treatment) and salinity of irrigation water (15 dsm^{-1}) recorded the lowest means of thickness of epidermis in The roots reached 17.11 µm.

Table (2) Effect of soil Improvers and irrigation water quality on thickness of epidermis of roots of date palm offshoots of Barhi cultivar (µm).

Thickness of epidermis	**Irrigation water salinity**			**The effect rate of the enhancers**
Improvers	**4-5 dsm^{-1}**	**8 dsm^{-1}**	**15 dsm^{-1}**	
Control	**20.10**	**19.15**	**17.11**	**18.79**
Organic improver	**38.11**	**28.21**	**22.24**	**29.52**
Super soil	**43.21**	**32.11**	**23.25**	**32.86**
Effect mean of Irrigation water salinity	**33.81**	**26.49**	**20.87**	
L.S.D.	**Improvers = 1.234**	**Salinity = 1.234**	**Interaction=2.754**	

2- Thickness of cortex:

The results shown in table (3) and panel (b-a1) indicate the effect of soil Improvers and irrigation water quality on thickness of the cortex of roots of date palm offshoots of Barhi cv., as the treatment of adding the artificial Improver (Super soil) was significantly superior to the rest of the treatments and recorded the highest mean of 860.14 µm, while the treatment without the addition of improvers (Control treatment) recorded the lowest mean of 586.86 µm. As for the effect of irrigation water quality, the Control treatment (4-5 dm^{-1}) was significantly superior to the rest of the treatments and recorded the highest mean of thickness of cortex in the roots, amounting to 863.57 µm, while the salinity treatment (15 dm^{-1}) was the lowest. mean thickness of cortex in roots was 656.81 µm. The interaction between the industrial Improver (Super soil) and the river water (4-5 dsm^{-1}) was recorded the highest mean of thickness of cortex in the roots amounting to 960.21 µm, with a significant difference from the rest of the interactions, while the interference Between treatment without adding Improvers (Control treatment) and irrigation water salinity (15 dsm^{-1}) was recorded the lowest means of thickness of cortex in roots were 470.21µm.

Thickness of cortex	**Irrigation water salinity**	**The effect rate**

Improvers	4-5 dsm^{-1}	8 dsm^{-1}	15 dsm^{-1}	
Control	700.15	590.23	470.21	586.86
Organic improver	930.34	860.18	730.12	840.21
Super soil	960.21	850.11	770.10	860.14
Effect mean of Irrigation water salinity	863.57	766.84	656.81	
L.S.D.	Improvers = 2.365	Salinity = 2.365	Interaction=7.615	

Table (3) Effect of soil Improvers and irrigation water quality on thickness of cortex of the roots of date palm offshoots of Barhi cv. (µm).

3- Thickness of endodermis:

The data shown in table (4) and panel (b-a1) show the effect of soil Improvers and irrigation water quality on thickness of endodermis layer in the roots of date palm offshoots of the Barhi cv. as the treatment of adding the artificial Improver (Super soil) was significantly superior to the treatment of organic fertilizer and the Control treatment. At a mean of 27.67 µm, while the treatment without adding Improvers (Control treatment) recorded the lowest mean of 19.67 µm. The quality of irrigation water also had a significant effect on thickness of endodermis layer in the roots, as the Control treatment (4-5 dsm^{-1}) was significantly superior. The highest mean was recorded at 28.00 µm, while the salinity treatment (15 dsm^{-1}) recorded the lowest mean of thickness of endodermis layer in the roots at 21.00 µm. As for the interactions between the factor of improvers and the factor of irrigation water The interaction between the industrial improver (Super soil) and river water (4-5 dsm^{-1}) was recorded the highest mean of thickness of endodermis layer in the roots was 33.00 µm, with a significant difference from the rest of the interactions, while the interaction between the treatment without adding improvers (Control treatment) and the salinity of the irrigation water (15 dsm^{-1}) was recorded the lowest thickness of endodermis layer in the roots was 18.00µm.

Table (4) The effect of soil improvers and irrigation water quality on thickness of endodermis layer of the roots of date palm offshoots of Barhi cultivar (µm)

Thickness of endodermis	Irrigation water salinity			The effect rate of the enhancers
Improvers	4-5 dsm^{-1}	8 dsm^{-1}	15 dsm^{-1}	
Control	21.00	20.00	18.00	19.67
Organic improver	30.00	25.00	22.00	25.67
Super soil	33.00	27.00	23.00	27.67
Effect mean of Irrigation water salinity	28.00	24.00	21.00	
L.S.D.	Improvers = 0.735	Salinity = 0.735	Interaction=1.312	

4- Thickness of pericycle:

The results shown in table (4) and panel (b-a1) indicate the effect of soil improvers and irrigation water quality on thickness of pericycle in the roots of date palm offshoots of the Barhi cv. The treatment of adding the artificial improver (Super soil) was significantly superior to the treatment of organic fertilizer and the Control treatment. The highest mean was 24.33 µm, while the Control treatment recorded the lowest mean of 21.00 µm. The results of the same table showed that the quality of the irrigation water had a significant effect on thickness of pericycle in the roots, as the Control treatment (4-5 dm^{-1}) excelled significantly and recorded the highest mean of 23.67µm, while the salinity treatment recorded (15 dm^{-1}).) The lowest mean of thickness of pericycle in the roots was 22.33 µm. The interaction between the artificial improver (Super soil) and river water (4-5 dsm^{-1}) recorded highest mean thickness of pericycle in the roots was 26.00 µm with a significant difference from the rest of the interactions, while the interaction between the treatment without adding Improvers (Control treatment) and the salinity of the irrigation water (15 dsm^{-1}) recorded the lowest means Thickness of pericycle in the roots amounting to 21.00 µm.

Table (5) Effect of soil improvers and irrigation water quality on Thickness of pericycle layer of roots of date palm offshoots of Barhi cultivar (µm)

Thickness of pericycle	Irrigation water salinity			The effect rate of the enhancers
Improvers	4-5 dsm^{-1}	8 dsm^{-1}	15 dsm^{-1}	
Control	21.00	21.00	21.00	21.00
Organic improver	24.00	24.00	23.00	23.67
Super soil	26.00	24.00	23.00	24.33
Effect mean of Irrigation water salinity	23.67	23.00	22.33	
L.S.D.	Improvers = 0.434	Salinity = 0.434	Interaction=0.911	

5- Diameter of vascular bundle:

The data of the study shown in table (4) and panel (b-a1) show the effect of soil improvers and irrigation water quality on diameter of vascular bundle in the roots of date palm offshoots of the Barhi cv., as it was noted that the treatment of adding the artificial improver (Super soil) was significantly superior to the treatment of organic fertilizer and the treatment of The Control treatment recorded the highest mean of 1356.67 µm, while the Control treatment recorded the lowest mean of 1230 µm. As for the effect of the irrigation water quality on diameter of vascular bundle in the roots, the Control treatment (4-5 dsm^{-1}) was significantly superior and recorded the highest mean of 1360.00 µm. While the salinity treatment (15 dsm^{-1}) recorded the least mean diameter of vascular bundle in the roots was 1243.33 µm. The interaction between the industrial improver (Super soil) and the river water (4-5 dsm^{-1}) recorded the highest mean of diameter of vascular bundle in the roots amounted to 1430.0µm, with a significant difference from the rest of the interactions, while the mean of diameter of vascular bundle in the roots was 1430.0µm. The interaction between a treatment without adding improvers (Control treatment) and the salinity of the irrigation water (15 dsm^{-1}) recorded the lowest mean of diameter of vascular bundle in the roots was 1200.0 µm.

Table (6) Effect of soil improvers and irrigation water quality on Diameter of vascular bundle of the roots of date palm offshoots of Barhi cultivar (µm)

diameter of vascular bundle	Irrigation water salinity			The effect rate of the enhancers
Improve	4-5 dsm^{-1}	8 dsm^{-1}	15 dsm^{-1}	
Control	1250.00	1240.00	1200.00	1230.00
Organic improver	1400.00	1350.00	1260.00	1336.67
Super soil	1430.00	1370.00	1270.00	1356.67
Effect mean of Irrigation water salinity	1360.00	1320.00	1243.33	
L.S.D.	Improvers = 52.22	Salinity = 52.22	Interaction=66.11	

6- Diameter of phloem:

The results of table (7) and panel (b-a1) indicate the effect of soil improvers and the quality of irrigation water on diameter of phloem of the roots of date palm offshoots of the Barhi cv., as the treatment with the addition of the artificial improver (Super soil) recorded a significant superiority over the rest of the treatments and gave the highest mean of 46.33µm. While the treatment without adding improvers (Control treatment) recorded the lowest mean of 31.33µm. The irrigation water quality also had a significant effect on diameter of phloem in the roots, as the control treatment (4-5 dsm^{-1}) was significantly superior and recorded the highest mean of 46.67µm. , while the salinity treatment (15 dsm^{-1}) gave the lowest diameter of phloem in the roots of 34.67 µm. While the interaction between the factor of improvers and the factor of irrigation water quality showed that the interaction between the interaction between the artificial improver (Super soil) and the river water (4-5 dsm^{-1}) gave the highest mean diameter of phloem in the roots amounting to 55.00 µm, with a significant difference from the rest of the interactions, While the interaction between the treatment without adding improvers (Control treatment) and the salinity of the irrigation water (15 dsm^{-1}) gave the lowest means for diameter of phloem in the roots was 28.00 µm

Table (7) Effect of soil improvers and irrigation water quality on diameter of phloem of the roots of date palm offshoots of Barhi cultivar (µm).

Diameter of phloem	**Irrigation water salinity**			**e effect rate of the enhancers**
Improvers	**4-5 dsm^{-1}**	**8 dsm^{-1}**	**15 dsm^{-1}**	
Control	**35.00**	**31.00**	**28.00**	**31.33**
Organic improver	**50.00**	**43.00**	**37.00**	**43.33**
Super soil	**55.00**	**45.00**	**39.00**	**46.33**
Effect mean of Irrigation water salinity	**46.67**	**39.67**	**34.67**	
L.S.D.	**Improvers = 3.222**	**Salinity = 3.222**	**Interaction=5.320**	

7- Diameter of xylem

The data shown in table (8) and panel (b-a1) indicate the effect of soil improvers and irrigation water quality on diameter of xylem of the roots of date palm offshoots of Barhi cv., The highest mean was 127.52 µm, while the Control treatment recorded the lowest mean of 98.78 µm. As for the quality of the irrigation water, it had a significant effect on diameter of secondary xylem in the roots, as the Control treatment (4-5 dm^{-1}) excelled significantly and recorded the highest mean of 127.17 µm, while the salinity treatment recorded (15 dm^{-1}). The lowest mean diameter of secondary xylem in the roots was 104.14 µm. The interaction between the industrial improver (Super soil) and the river water (4-5 dsm^{-1}) recorded the highest mean of diameter of secondary xylem in the roots reaching 140.27 µm, with a significant difference from the rest of the interactions. The interaction between the Control treatment and the salinity of the irrigation water (15 dsm^{-1}) recoded the lowest mean for diameter of secondary xylem in the roots was 88.12 µm.

Table (8) Effect of soil improvers and irrigation water quality diameter of xylem of roots of date palm offshoots cultivar Barhi (µm).

Diameter of xylem	**Irrigation water salinity**			**The effect rate of the enhancers**
Improvers	**4-5 dsm^{-1}**	**8 dsm^{-1}**	**15 dsm^{-1}**	
Control	**106.12**	**102.10**	**88.12**	**98.78**
Organic improver	**135.11**	**123.18**	**110.15**	**122.81**
Super soil	**140.27**	**128.13**	**114.16**	**127.52**
Effect mean of Irrigation water salinity	**127.17**	**117.80**	**104.14**	
L.S.D.	**Improvers = 1.511**	**Salinity = 1.511**	**Interaction=2.765**	

Although date palm trees are among the plants most adapted to the desert environment due to their tolerance of high temperatures, drought and salinity (Govarets and Dransfield, 2005). Salt stress is considered one of the most effective types of stress in the growth and development of the plant, this type of stress leads to exposure of the plant to the second type of stress, which is water stress, where salinity works to reduce the ability of the plant to absorb water, Challa and Van (2004) explained the mechanism of influence direct salinity on the plant through the occurrence of some morphological (phenotypic) and anatomical changes in the plant. Plants growing in desert areas suffer from the fluctuations of environmental and natural factors.

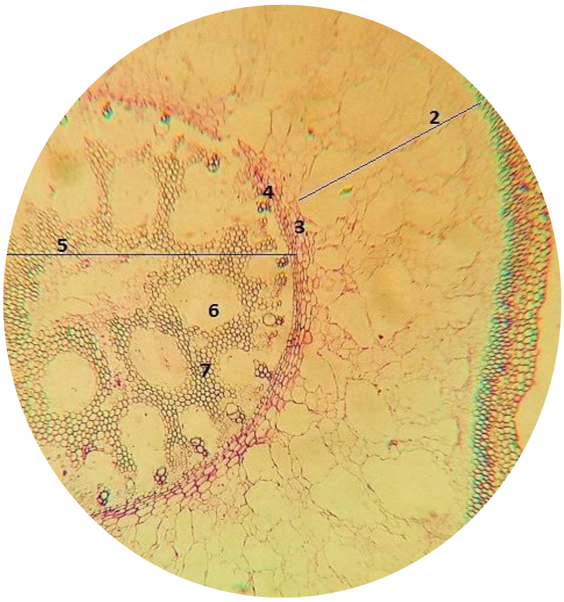
ISSN NO: 2771-8840
Date of Publication: 28-04-2023

These conditions are specific factors for plant growth and development. enabled it to survive under unfavorable conditions (Abdul-Wahid, 2003).

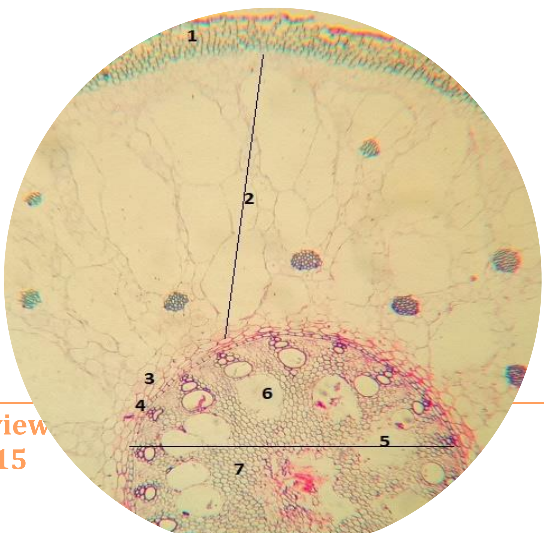
It is noted from the results of the current study the significant effect of soil improvers in improving the anatomical characteristics of the roots of date palm offshoots. The reason for this may be due to the joint effect of each of the artificial improver (Super soil) and organic matter in improving soil properties and reducing the harmful effect of salinity and thus increasing the absorption of water and what is for that. A role in the growth and development of roots and maintaining the water content of cells compared to those grown under saline conditions. This, in turn, led to an increase in the activity of cell division and an improvement in the growth conditions of the offshoots, which are represented in the anatomical characteristics of the roots (David and Nilsen, 2000).

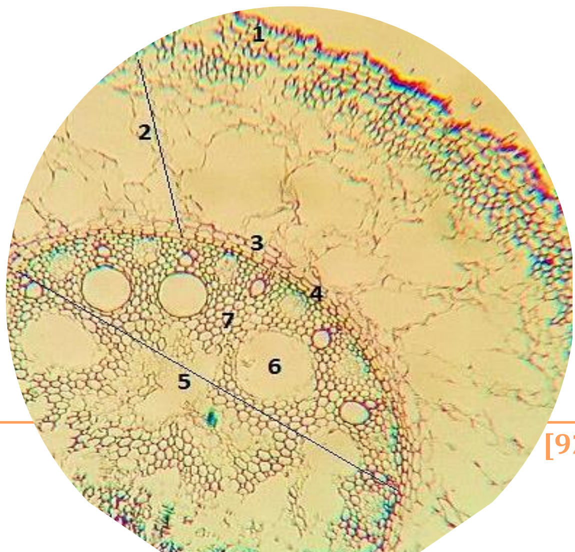
Also, the anatomical characteristics of the roots may be associated with the amount of nutrients absorbed from the soil, which enabled the offshoots to grow and develop, since the increase in the amount of organic matter added to the soil causes an increase in the concentration of ready-made nutrients in the soil, which increases the plant's absorption of them. Issa (1990) indicated addition of fertilizers may lead to increased root growth, which may be due to the improvement of their anatomical characteristics.

The current anatomical study also showed the possibility of using anatomical characteristics to describe the environmental adaptation of date palm under salt stress conditions. As the anatomical features have been used in many biological and taxonomic studies as indicators of the type of conditions that the plant lives in (ALnajjar *et al*., 2020). The results of this study agreed with those of Doaigey *et al*. (2013) which showed some anatomical characteristics of date palm seedlings treated with some chemicals and the extent of those anatomical differences. The results of the study of Al-najjar and Al-presem (2018) to identify some anatomical aspects associated with the conditions of salt stress and water stress for date palm seedlings.



Control



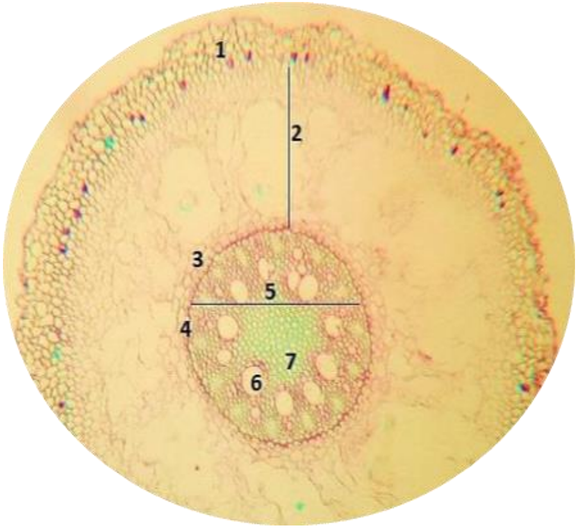


ISSN NO: 2771-8840
Date of Publication: 28-04-2023

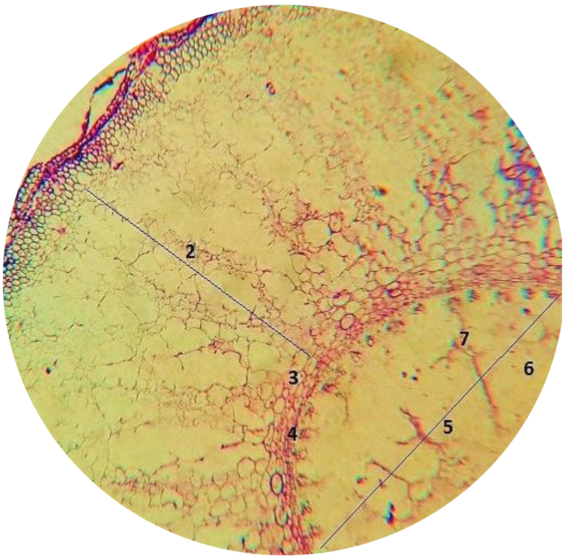
Industrial improver (Super soil) Organic fertilizer

Plate (1-a) Effect of soil c improvers and irrigation water quality on the anatomical characteristics of the roots of date palm offshoots Barhi cv.showing (1-epidermis 2-cortex 3-endodermis 4-pericycle 5-vascular bundle 6-xylem 7-phloem).

Salinity (8 dsm^{-1})



Salinity (15 dsm^{-1})



Salinity (4-5dsm^{-1}) + Super soil

Salinity (15dsm^{-1}) + Super soil

Plate (1-b) Effect of soil c improvers and irrigation water quality on the anatomical characteristics of the roots of date palm offshoots Barhi cv.showing (1-epidermis 2-cortex 3-endodermis 4-pericycle 5-vascular bundle 6-xylem 7-phloem).

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