Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 06 | Issue : 01 | Jan.-Mar. | 2017
Pages:33-44

Studies on Possibility of Alleviating Salt Hazard in Some Leaf Physiological and Anatomical Characteristics of Picual Olive Treatments

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Received: 15 December 2016 / Accepted: 10 February 2017 / Publication date: 20 February 2017

ABSTRACT

Irrigation with saline solution (9000 ppm - SAR 12) and treating with some anti-salt substances (Rizobacterine, Phosphorine, R-Humic, magnetic iron and potassium silicate either solely or in combination), besides tap water irrigation (control) were investigation during 2014 & 2015 experimental seasons regarding their influence on some leaf physiological characteristics (two seasons) and leaf anatomical features (1st season only). Data obtained during both seasons pertaining the response of three evaluated leaf physiological characteristics to salt stress revealed that two conflicted trends were detected. Herein, both leaf water potential (LWP) and leaf succulence grade (LSG) were significantly decreased by salinity as compared to control (tap water irrigation), however the reverse was found with hard leaf character (HLC). Moreover, all alleviating treatments succeeded for repairing partially such salinity disorders and subjected salt stressed transplants to the potassium silicate spray combined with magnetic iron was more effective, in spite of differences between all alleviating treatments were in most cases statistically absent. As for the response of anatomical structures to salinity, three trench were detected i.e., 1- salinity increased (thickness of cuticle & epidermis layers at both leaf surfaces and No of trichomes at lower epidermis), 2- deceased (midrib vascular bundle length & width, thickness of spongy tissues phloem and xylem area and number of both xylem rows in vascular bundle and vassels per each row) and 3- no changes in number of two mesophyll elements (palisade & spongy tissues) particularly 2nd. On the other hand in most cases all alleviating treatments succeeded considerately to correct partially changes in affected anatomical features by salinity, however recovering treatment of potassium silicate spray + magnetic iron tended relatively to be more effective with no significant differences than other recovering treatments.

Key words: Olive, saline water, anti-salt substances, leaf physiological

Introduction

Olive (*Olea europaea*) is one of the oldest cultivated fruits in the world about 8000 years ago.

It was originated in the eastern side of the Mediterraneansea. Nowadays, olive area increased and reached about 152432 Feddans which produced about 558610 metric tons of fruits in 2014 year (FAO, 2015). Agricultural extension needs a great amount of suitable irrigation water which already is not sufficient to meet all the expected demand in this respect, as long as there is an obvious shortage in Nile water, especially for supplying the reclaimed area. So, the projects of reclamation depend on anther sources such as wells, sanitary, drainage, debated sea water …etc.

Generally, salinity and using saline water for irrigation is consideration the limiting factotum for success of reclamation projects due to the presence of higher sodium and other cations concentration and the increase in osmotic pressure the reflected on reduction in water availability to plants. Because of plantation of olive cultivars may be located in the new reclaimed lands (arid & semi – arid zones), there will arise some problems connected with irrigation water sources. Application of some bio-fertilizers conation different strains of micro – organisms i.e., (N-fixation (Rhizobacterine), phosphate- solubilizing micro- organism

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(Phosphorine) and silicate dissolving micro-organisms have definite beneficial role in soil fertility and rebalanced the ratio between nutrients in soil (Saber, 1993a&b).potassium also has a real role in enhancing activities of many enzymes, biosynthesis and translocations of carbohydrates, tolerances to drought, salt stress and nutrients uptake, Nijjar, (1985). Magnetic iron is a revolution in world of agriculture, as it resulted with water an electromagnetic field to help the postage of useful elements to plant and enhancing cation uptake capacity and a positive effect on immobile nutrients uptake (Esitkea and Turm, 2003).

So, the present research paper was designed to investigated the response of Picual olive transplants to the irrigation with relative higher salt concentration and sodium adsorption ratio (9000 ppm & SAR) and possibility of mitigating the expected salt hazard in some leaf physiological characteristics and anatomical feature through application of some anti-salt substances, i.e., two Bio-N P fertilizers (Rhizobacterine & Phosphorine), humic, magnetic iron and potassium silicate.

Materials and Methods

Potted experiment was conducted during two consecutive 2014 & 2015 experimental seasons in a private nursery at El-Mofty village- Sidy Salim region, belonging to Sakha Experimental Station Kafr El-Sheikh Governorate, Egypt. It was aimed to investigate the tolerance of Picual olive transplants to irrigation with a relative higher concentrated saline solution (9000 ppm-SAR 12). Moreover, possibility of minimizing or mitigating the expected salt hazard (disorders) to be taken place and occurred in some leaf physiological characteristics and anatomical features of salt stressed Picual olive transplants through some applicable alleviating (recovering) substances was also included.

Experiment layout:

In 1st week of March during both 2014&2015 years, healthy uniform as possible one-year-old Picual olive transplants were carefully and transplanted individually in plastic pots 35 cm. in oil meter each had been previously filled with approximately 6 Kg planting medium (clay & sand at equal reoperation by volume). Soil physical and chemical proportions were determined just before transplanting after Jackson, (1967). As shown in Table (1-a & b). Irrigation with fresh (tap) water was successively applied twice weekly at the rate of one liter / pot till investigated treatments were started in 1st week of May of each seasons. Moreover, all pots were supplied with a complex NPK fertilizer (1:1:1), as well as Fe, Mn and Zn micro elements in chelated from were also applied. Regularly at the rate of Chapman and Pratt, (1961). one time weekly from mid March till late April just before irrigation with saline water and application of recovering treatments were started on early May during two seasons of study.

Saline solution used for irrigation was prepared after Sharaf *et al.,* (1985) as shown in Table (1).

Table 1: Preparation of 9000 ppm and SAR-12 saline solution used in this study.

Salt solution	Salt added /Liter*												SAR**	Cl	SO_4
	$CaCl_2$		$MgSO_4$		KCl		K_2SO_4		Na_2SO_4		NaCl				
9000ppm	g	meq	g	meq		meq	g	meq	g	meq	g	meq	12	meq/L	meq/L
	2.05	36.94	2.00	33.33		-	0.40	4.60	2.20	30.99	2.35	40.17		1 : 1	

*salts added in grams were estimated as anhydrous form.**SAR = Sodium adsorption ratio

$$= \frac{meq\ .Na}{\sqrt{\frac{Ca\ +\ Mg}{2}}}$$

Meanwhile, magnetic iron, potassium silicate, Rhisobacterine, phosphorene and R- humic (liquid nature commercially marketing as humic acid sawra at 40% were the evaluated recovering solutions, all were soil drench applied except potassium silicate as foliar spray, regularly of each was applied solely or in combination with other. So, eleven investigated saline irrigations and recovering treatment were as follows:

T1- Continuous irrigation with fresh /tap water (control).
T2- Continuous irrigation with saline solution (9000 ppm & SAR 12).
T_3- (T_2) + Rhizobacterine soil drench (20.0 g/pot).
T_4- (T_2) + Phosphorine soil drench (20.0 g/pot).
T_5- (T_2) + Humus compound (R.Humic) soil drench (5.0 ml/pot).
T_6- (T_2) + Magnetic iron soil drench (25.0 g/pot).
T_7- (T_2) + Potassium silicate 10. Ml/liter foliar spray.
T_8- (T_2) + Rhizobacterine (T_3) + Potassium silicate (T_7).
T_9- (T_2) + Phosphorine (T_4) + Potassium silicate (T_7).
T_{10}- (T_2) + Rich Humic (T_5) + Potassium silicate (T_7).
T_{11}- (T_2) + Magnetic iron (T_6) + Potassium silicate (T_7).

The complete randomized block design with five replications was employed for arranging the aforesaid eleven investigated treatments, whereas each replicate was represented by two treatments (pots). So, 110 transplant were devoted for this work and classified according to their vigour into five categories each included 22 ones besides 5 additional ones, so a reserve would be available whereas the twenty-two Picual olive transplant devoted for every category were randomly subjected to receive the whole eleven investigated treatments (2 plant / treatment).

Application of the eleven investigated treatment was started on early May during both season and extended until mid-October 2014&2015 years i.e., just two weeks' prior experiment termination. Whereas irrigation with either tap water (control T_1) or 9000 ppm SAR 12 reline solution for other (T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11}) treatments was regularly provided at rate of one-liter/pot twice weekly to avoid salts accumulation all pots were fortnightly irrigated with fresh water at the same rate, then re-watering with the saline solution next day. All recovering treatments were applied at two weeks' interval starting from early may till mid-October during each season. Taking into consideration that transplant of all investigated treatments even control was also relegated to fresh water spray at two-week interval accept there treated with potassium silicate spray either solely or complained to other.

As the field experiment was cared on late October during each experimental seasons the response to the investigated saline solution and recovering treatments was evaluated in fresh leaves regarding the changes in some of their physiological characteristics and anatomical structures.

Leaf physiological characteristics:

In this regard leaf water potential (LWP), leaf succulence grade (LSG) and hand leaf character (HLC) in response to investigated treatments were determined during both seasons after Hassan, (1998), Laz, (1999) and Nomir, (1994).

Leaf anatomical structure.

At the end of 1st experimental al season (late October 2014), three fresh leaves per each replicate were collected immediately Killed, foxed in FAA solution, dehydrated with normal futile alcohol and paraffin wax (56-58 c) for infiltration and embedding. Serial trans v-erase sections were prepared (saffranin and fast-green stain technique were followed, then washed in Canada balsam) then examined microscopically and photographed, after Jhanson, (1940) and Nasser and El-Sahhar, (1998). The thickness of both cuticle and epidermis layers of both upper and lower leaf surfaces, axial diameters(length & width) of midrib vascular bundle, thickness of fibers in vascular bundle, thickness & number of palisade and spongy tissues layers, number of trichomes at lower epidermis, thickness of both phloem & xylem in vascular bundle, number of xylem rows in vascular bundle and number of vassels in xylem row were the 16^{th} evaluated leaf anatomical structures, after Ibrahim, (2001) and Osman, (2005).

Statistical analysis:

Data obtained of the physiological characteristics during both 2014 & 2015 seasons were subjected to analysis of variance and significant differences among means were determined according to Snedecor and Cochran, (1972) and distinguished according to the Duncan's multiple least lest range, Dunan, (1955) using capital letters for differentiating between values of investigated treatments.

Results and Discussion

The impact of salinity (continuously irrigation with 9000 ppm-SAR saline solution) and the mine investigated alleviating treatments (Rhizobacterine, Phosphorine, R-Humic, magnetic iron and potassium silicate each solely or in combination) were evaluated regarding the response of the following Picual olive transplants measurements.

Some leaf physiological characteristics:

Table (2) displays obviously that the three evaluated leaf physiological characteristics (leaf water potential - LSG and hard leaf character- HLC) reacted considerably to salinity and investigated recovering treatments during both 2014 & 2015 experimental seasons with comparison to control (continuously irrigation with fresh / tap water). However, two conflicted trends were detected regarding the response to saline irrigation water. Herein, both leaf water potential & leaf water succulence grade was decreased, while the reverse was true with hard leaf character during both seasons. On the other hand, all investigated alleviating treatments irrigated salinity hazard i.e., increased LWP & LSG but decreased HLC of salt stressed Picual olive transplants. However, recovering treatments of applying potassium silicate spray + magnetic iron soil added was the most effective, descendly followed by potassium silicate spray plus either Phosphorine, Rhizobacterine or R-Humic, as well as magnetic iron or potassium silicate (each solely), irrespective of the evaluated leaf physiologic effective, descendly followed by potassium silicate spray plus either Phosphorine, Rhizobacterine or R-Humic, as well as magnetic iron or potassium silicate (each solely), irrespective of the evaluated leaf physiologic characteristic properties are supported by the early findings of several investigators. Meiri and Poljakoff – Meyber, (1970) and Hassan, (2005) on some olive cvs. all reported that the rate of water entry into plants depends on both water potential gradient and root resistance. Whereas, the water diffusion gradient between medium and roots decreased appreciably as the salt of irrigation water was increased and this certainly will be reflected on leaf water content and the related leaf physiological characteristics like as (leaf water potential and leaf succulent grade). Moreover, findings of El-Hefnawi, (1986) on Guava found the same trend with leaf succulence and Nomir, (1994) on Kaki go in line with our results regarding the response of leaf succulence grade to the saline irrigation water.

Table 2: Some leaf physiological characteristics (leaf water potential -L.W.P., leaf succulence grade-L.S.G. and hared leaf character-H.L.C.) of Picual olive transplants in response to salinity and some recovering treatments during 2014 & 2015 experimental seasons.

Treatments		Leaf water potential H_2O (g) /100 g F. Wt.		Leaf succulent grade (L.S.G) H_2O(g) /Dec^2.		Hard leaf character (H.L.C) Dr. matt. (g) /Dec^2.	
		2014	2015	2014	2015	2014	2015
T1	Tap water irrig. (control).	76.85 A	77.26 A	8.00 A	8.40 A	2.89 H	3.03 G
T2	Saline water irrigation.	73.71 B	74.45 C	6.00 B	6.20 C	4.32 A	4.84 A
T3	Sal. W. irrig. + Rizobacterine .	74.58 B	75.20 BC	6.40 B	6.65 BC	3.45 CD	3.85 B
T4	Sal. W. irrig. + Phosphorine.	74.75 B	75.35 BC	6.55 B	6.70 BC	3.55 C	3.94 B
T5	Sal. W. irrig. + R.Humic.	73.95 B	75.00 BC	6.25 B	6.40 C	3.75 B	4.05 B
T6	Sal. W. irrig. + Magnetic iron.	75.00 B	75.90 B	6.70 B	7.20 BC	3.25 F	3.55 DE
T7	Sal. W. irrig. + K-Silicate.	74.68 B	75.75 B	6.80 B	7.00 BC	3.35 DE	3.65 CD
T8	Sal. W. irrig. +K-Sili. + Rhizob.	74.79 B	75.80 B	6.90 B	7.10 BC	3.25 F	3.50 DE
T9	Sal. W. irrig. + K-Sili + Phosph.	75.03 B	75.85 B	6.95 B	7.10 BC	3.15 FG	3.40 EF
T10	Sal. W. irrig. + K-Sili + R.Humic.	74.89 B	75.80 B	6.85 B	7.00 BC	3.20 F	3.60 D
T11	Sal. W. irrig. + K-Sili + Mag. Iron.	75.25 B	76.10 B	6.95 B	7.50 B	3.05 G	3.25 F

Means within each column followed by the same letter/s didn't significantly differ at 5% level.

Meanwhile, the increase in hard leaf character resulted by saline irrigation water is confirmed with findings of Hassan, (2005) on some olive cvs., Sawrsan, Madlen, (2006) on some pomegranate cvs. and Abd-Rahman, Amira, (2016) on Crimson seedless and Superior grape cvs. transplants. As for the effect of some anti-salinity substances on leaf water potential, hard leaf character and leaf succulence grade, the present results are on harmony with those found by Abdel Aal and Oraby, (2013) on Mango transplants and Abd El-Rahman, Amira, (2016) on two grape cvs. transplants who reported that silicon application increased leaf water content of salt stressed transplants. As well as later author, she cleared that both potassium silicate and magnetic iron application resulted in increasing leaf water potential and leaf succulence grade, while the reverse was true with hard leaf character.

Leaf anatomical structure:

Concerning the response of the differential evaluated leaf anatomical traits of Picual olive transplant to the various investigated treatments (irrigation with 9000 ppm - SAR saline solution either treated with some ant salinity solution i.e., (Rhizobacterine, phosphorine, R-humic, magnetic iron and potassium silicate or not, besides irrigation with yap water as control), data obtained during 2014 season are tabulated in Tables (3, 4, 5) and illustrated by photos (1, 2, 3, 4 and 5).

It is quiet evidence that various leaf anatomical features responded considerably to salinity (continues irrigation with 9000 ppm. SAR 12 saline solution with no recovering application). Such trend was true with all sixteenth evaluated leaf structure except with the number of spongy tissues layers, which was the unique constant anatomical trait slowed the same value in all olive transplants used various investigated treatments.

Anyhow, the response to salinity flowered two conflicted trends with composition the T_2 treated transplants with the analogous ores of control (tap water irrigation), whereas some anatomical feature was increased leaf salinity, while the never was found with others. Herein, saline irrigation water resulted in an obvious increase in (thickness of cuticle of epidermis leafs at both upper and lower leaf surfaces, thickness and number of palsied tissue layers and number of trichomes at lower epidermis), while the reverse was true with (the mid-rib vascular bundle diameters i.e length of width, thickness of fibers, phloem and xylem in vascular bundle, spongy tissue thickness of mesocarp and number of both xylem rows in vascular bundle and vessels per each row).

On the other hand, all recovering treatments succeed to great for repairing salinity disorders exhibited in the evaluated leaf anatomical structural of salt stressed Picual olive transplant. however such efficiency varied from one recovering treatment to other anyhow, salt stressed olive transplants subjected to potassium silicate spray + magnetic iron (T_{11})was generally the most effective alleviating treatment, particularly as the responses of salinity disorders dealing with thickness of both cuticle and epidermal layers at upper and lower leaf surfaces, length of width of mid-rip vascular bundle thickness of fibers in vascular bundle, thickness of both palisade & spongy tissues and number of trichomes at lower epidermis to various investigated alleviating treatments were concerned. Meanwhile, thickness of phloem & xylem and number of vassels in xylem row each showed approximately the same rate of response to all alleviating treatments. Sourial *et al.,* (1978) non Hindy mango seedlings found that salinity increased cuticle layers and palisade tissue. Gasser, (1992) on 2 grape cv., pointed out that increasing salinity concentration was accompanied by increasing salinity thickness of leaf blade and palisade tissues, but decreased phloem layer, diameter of xylem vessels. Draz, (1986) on bitter almond seedling showed that water shortage increased both cuticle and epidermal (upper& lower) layers, while decreased depth of palisade tissue and midrib area of the vascular bundle. Maksoud, (1988) on mango seedlings showed that blade and palisade thickness was increased by salinity, while thickness of main vein and dimensions of vascular system were decreased. Abd El-Karim, (1991) on mango mentioned that prence of salts in irrigation water raised cuticle and palisade thickness, but decreased vascular elements (phloem & xylem) in leaves. Hassan, (2005) on apple seedlings found that salinity decreased spongy tissue and vascular elements (phloem & xylem) area. Darwesh, (2006) on transplants of MM106 apple and *Pyrus communis* rootstocks, revealed that salinity increased thickness of cuticle & epidermis layers (at two leaf surfaces) and palisade tissue, but spongy tissue thickness and xylem rows in vascular bundle were decreased. Mohamed, (2008) on mango transplants found that saline solution decreased some leaf histological traits (palisade and dimensions of the vascular bundle).

Table 3: Some leaf anatomical traits (Cuticle & epidermal layers of upper & lower leaf surface), (length & width of midrib vascular bundle) and fibers in vascular bundle of Picual olive cv. in response to salinity and recovering treatments during 2014 experimental season.

Treatments		Cuticle thickness (μ)		Epidermal thickness (μ)		Midrib vascular bundle (μ)		Thickness of fibers in vascular bundle (μ)
		Upper	Lower	Upper	Lower	Length	Width	
T1	Tap water irrig. (control).	10.35	8.10	20.70	15.30	348.30	468.00	48.60
T2	Saline water irrigation.	14.40	12.60	26.10	21.60	282.15	388.35	36.90
T3	Sal. W. irrig. + Rizobacterine .	14.00	10.00	23.00	20.7	292.05	387.00	37.90
T4	Sal. W. irrig. + Phosphorine.	12.00	9.90	24.00	19.9	298.80	409.50	42.00
T5	Sal. W. irrig. + R.Humic.	11.00	9.00	25.00	18.9	294.75	373.50	37.50
T6	Sal. W. irrig. + Magnetic iron.	11.00	9.50	23.40	19.00	300.15	400.50	38.00
T7	Sal. W. irrig. + K-Silicate.	12.00	9.40	23.40	17.80	309.80	448.20	40.00
T8	Sal. W. irrig. +K-Sili. + Rhizob.	11.50	9.50	21.60	18.00	314.00	423.00	41.00
T9	Sal. W. irrig. + K-Sili + Phosph.	12.00	9.80	24.30	19.00	326.70	450.00	42.00
T10	Sal. W. irrig. + K-Sili + R.Humic.	10.80	9.00	22.50	18.00	309.40	387.00	40.40
T11	Sal. W. irrig. + K-Sili + Mag. Iron.	10.50	8.50	20.80	16.00	346.5	468.00	45.00

Table 4: Some leaf anatomical traits (Thickness & number of both palisade & spongy tissue layers and No. of trichomes at lower epidermis) of Picual olive cv. in response to salinity and recovering treatments during 2014 experimental season.

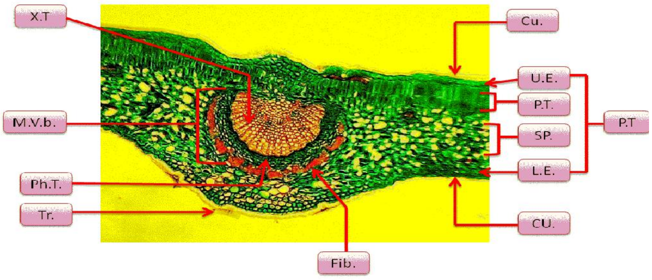
Treatments		Palisade tissue Thickness	No. of Palisade tissue layers	No. of spongy tissue layers	Spongy tissue Thickness	No. of trichomes at lower epidermis
T1	Tap water irrig. (control).	87.30	2.00	9.00	241.20	28.00
T2	Saline water irrigation.	137.00	3.00	9.00	209.00	39.00
T3	Sal. W. irrig. + Rizobacterine .	117.00	3.00	9.00	212.00	34.00
T4	Sal. W. irrig. + Phosphorine.	115.00	3.00	9.00	208.00	37.00
T5	Sal. W. irrig. + R.Humic.	120.00	3.00	9.00	212.00	36.00
T6	Sal. W. irrig. + Magnetic iron.	107.00	3.00	9.00	225.00	33.00
T7	Sal. W. irrig. + K-Silicate.	109.00	2.00	9.00	219.00	33.00
T8	Sal. W. irrig. + K-Sili. + Rhizob.	108.00	3.00	9.00	225.00	33.00
T9	Sal. W. irrig. + K-Sili + Phosph.	103.80	2.00	9.00	227.00	33.00
T10	Sal. W. irrig. + K-Sili + R.Humic.	108.00	2.00	9.00	220.00	29.80
T11	Sal. W. irrig. + K-Sili + Mag. Iron.	101.00	2.00	9.00	234.00	29.00

Table 5: Some leaf anatomical traits (Thickness of both phloem & xylem tissues in vascular bundle), No. of xylem rows in vascular bundle and No. of vessels in the xylem rows of Picual olive cv. in response to salinity and recovering treatments during 2014 experimental season.

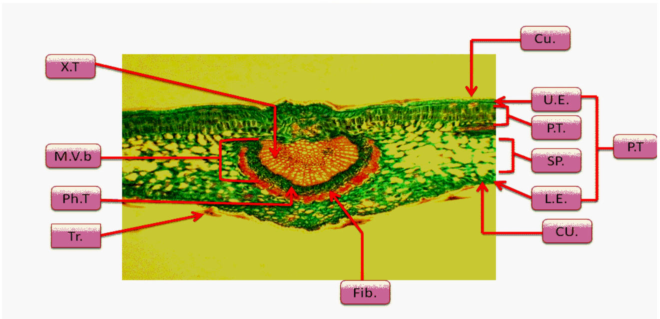
Treatments		Thickness of phloem in vascular bundle	Thickness of xylem in vascular bundle	No. of xylem rows in vascular bundle	No. of vessels in the xylem row
T1	Tap water irrig. (control).	72.00	236.00	30.00	13.00
T2	Saline water irrigation.	51.00	184.00	20.00	4.00
T3	Sal. W. irrig. + Rizobacterine .	61.00	197.00	23.00	9.50
T4	Sal. W. irrig. + Phosphorine.	62.00	194.00	23.00	10.00
T5	Sal. W. irrig. + R.Humic.	61.00	202.00	24.00	10.00
T6	Sal. W. irrig. + Magnetic iron.	63.00	211.00	23.00	10.00
T7	Sal. W. irrig. + K-Silicate.	62.00	210.00	26.00	9.50
T8	Sal. W. irrig. + K-Sili. + Rhizob.	59.00	214.00	25.00	9.50
T9	Sal. W. irrig. + K-Sili + Phosph.	60.00	208.00	26.00	10.00
T10	Sal. W. irrig. + K-Sili + R.Humic.	65.00	208.00	24.00	10.00
T11	Sal. W. irrig. + K-Sili + Mag. Iron.	60.00	211.00	25.00	10.00

Karimi, *et al.,* (2009) on one-year-old olive transplants found that increasing salinity (NaCl) resulted in decreasing spongy tissue thickness, but increased palisade tissue. Soliman, (2010) on apple found that salinity increased thickness of (upper & lower) layers of both cuticle and epidermis and palisade tissue, which spongy tissue and xylem rows in vascular bundle in leaf mid-rib were decreased. Hassani *et al.,* (2014) on olive transplants found that NaCl resulted in thin diameter of the xylem.

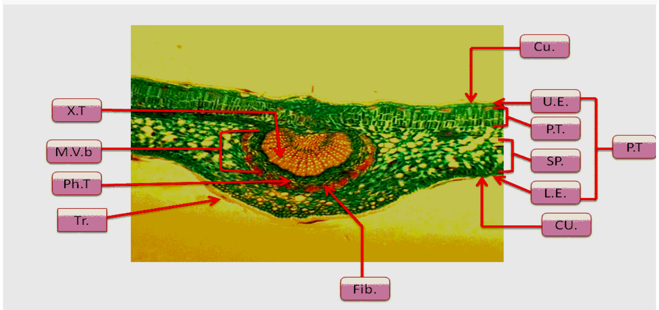
(T_1)



(T_2)



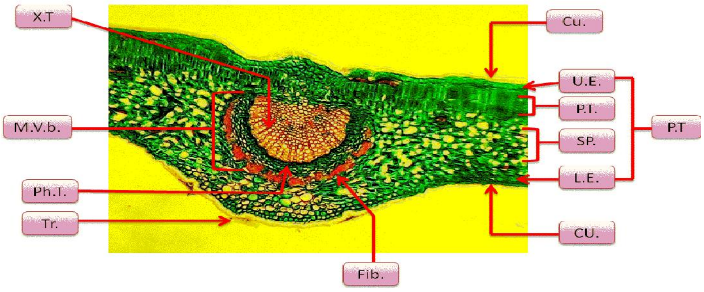
(T_3)



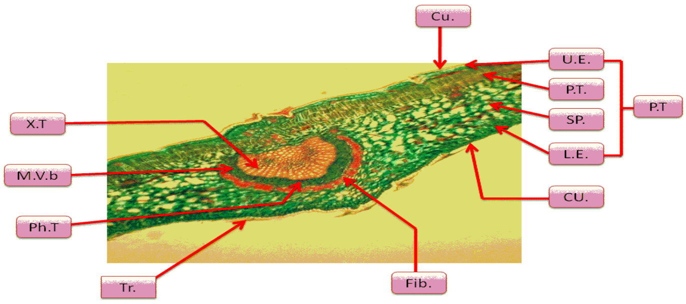
Cu. = Cuticle (U, L)
U.E. = Upper Epidermis
L.E. = Lower Epidermis
M V.b. = Midrib vascular bundle
Fib. = Fibers
Pl. = Palisade tissue
Sp. = Spongy tissue
Tr. = Trichomes
Phl. = Phloem
X. = Xylem

Photo 1: Effect of salt stress (T_2), salt stress + Rhizobacterine (T_3) and tap water irrigation (control-T_1) on some leaf anatomical structure of Picual olive transplants.

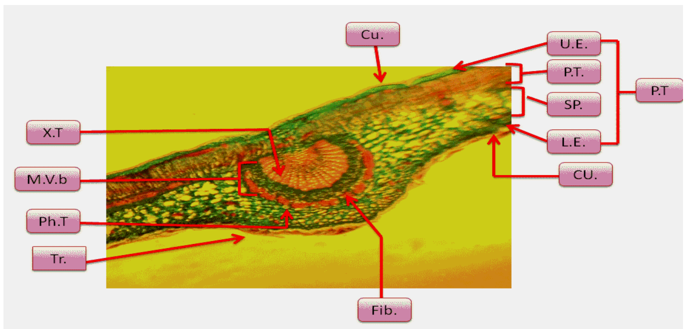
(T_1)



(T_4)



(T_5)

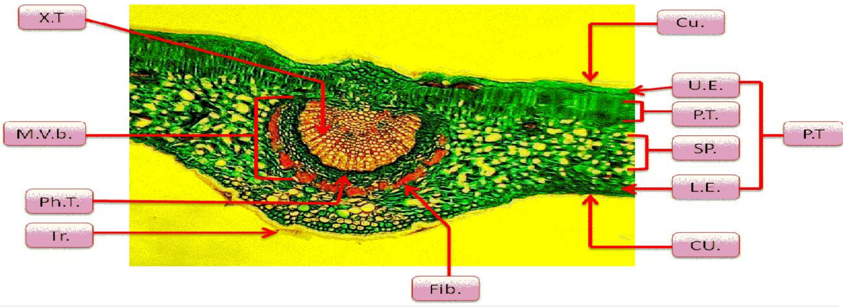


Cu. = Cuticle (U, L)
U.E. = Upper Epidermis
L.E. = Lower Epidermis
M V.b. = Midrib vascular bundle
Fib. = Fibers

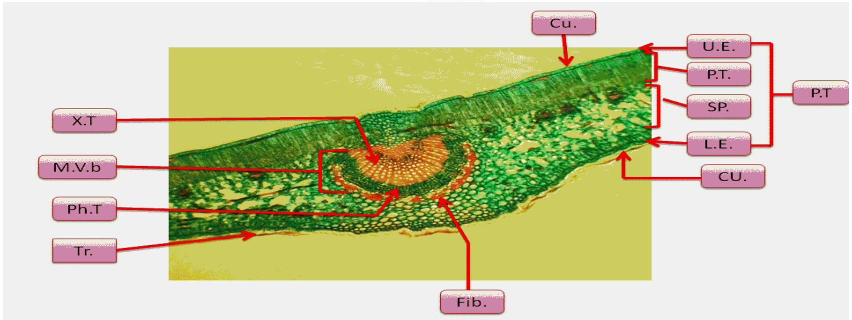
Pl. = Palisade tissue
Sp. = Spongy tissue
Tr. = Trichomes
Phl. = Phloem
X. = Xylem

Photo 2: Effect of salt stress + Phosphorine (T_4), salt stress + R.Humic (T_5) and tap water irrigation (control-T_1) on some leaf anatomical structure of Picual olive transplants.

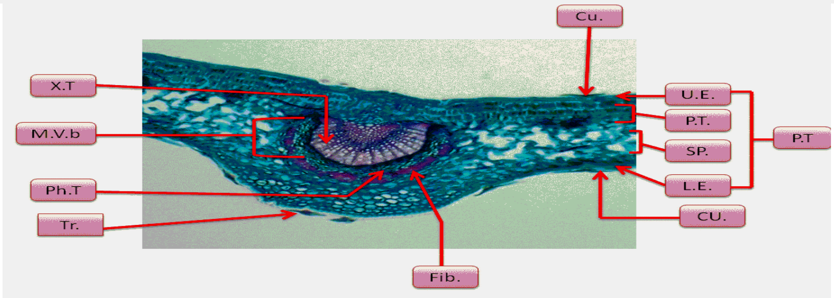
(T1)



(T6)



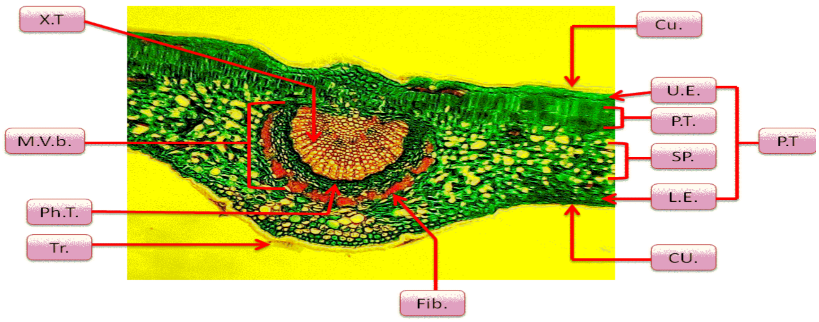
(T7)



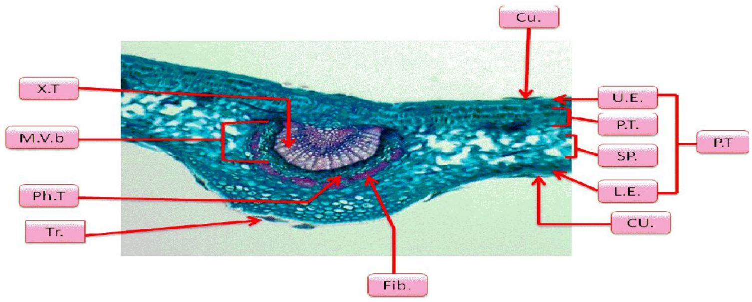
Cu. = Cuticle (U, L)	Pl. = Palisade tissue
U.E. = Upper Epidermis	Sp. = Spongy tissue
L.E. = Lower Epidermis	Tr. = Trichomes
M V.b. = Midrib vascular bundle	Phl. = Phloem
Fib. = Fibers	X. = Xylem

Photo 3: Effect of salt stress + magnetic iron (T_6), salt stress + potassium silicate (T_7) and tap water irrigation (control-T_1) on some leaf anatomical structure of Picual olive transplants.

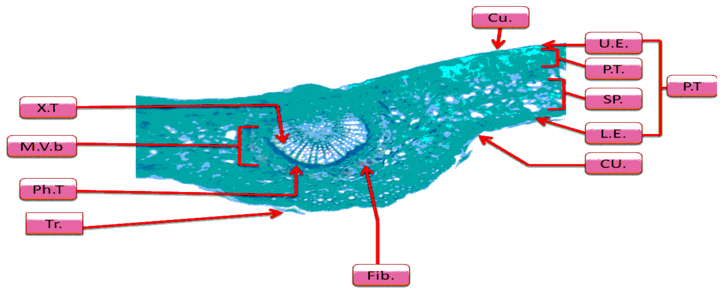
(T1)



(T8)



(T9)



Cu. = Cuticle (U, L)
U.E. = Upper Epidermis
L.E. = Lower Epidermis
M V. b. = Midrib vascular bundle
Fib. = Fibers

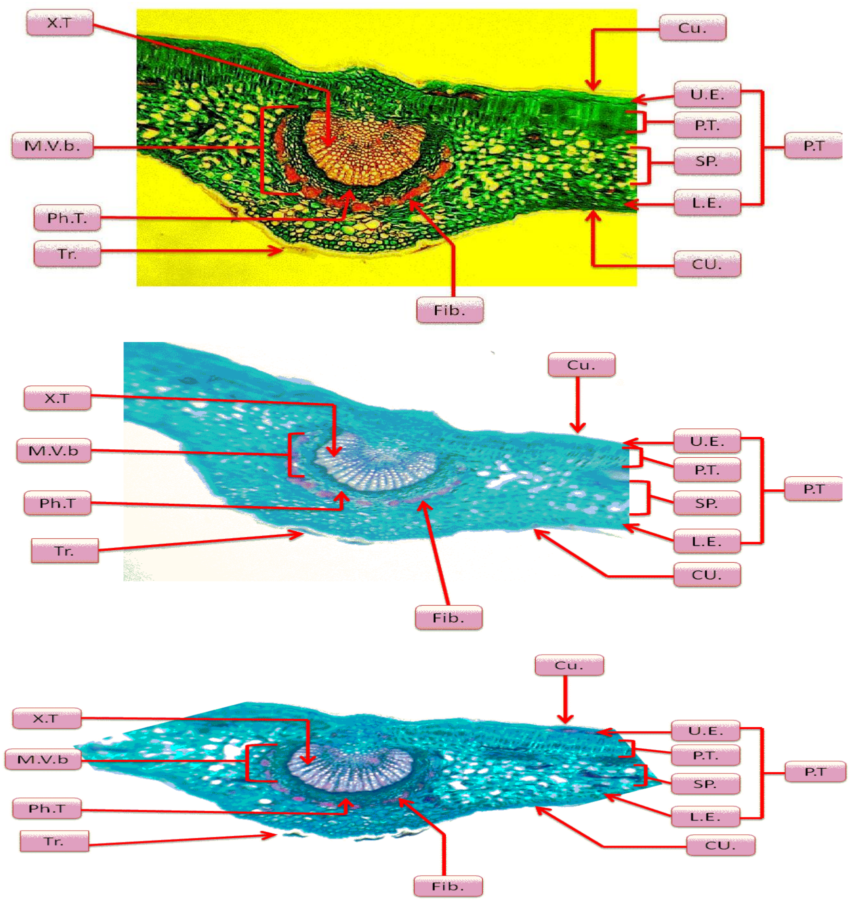
Pl. = Palisade tissue
Sp. = Spongy tissue
Tr. = Trichomes
Phl. = Phloem
X. = Xylem

Photo 4: Effect of salt stress + K-Silicate + Rizobacterine (T_8), salt stress + K-Silicate + Phosphorine (T_9) and tap water irrigation (control-T_1) on some leaf anatomical structure of Picual olive transplants.

(T_1)

(T10)

(T_{11})



Cu. = Cuticle (U, L)
U.E. = Upper Epidermis
L.E. = Lower Epidermis
M V.b. = Midrib vascular bundle
Fib. = Fibers

Pl. = Palisade tissue
Sp. = Spongy tissue
Tr. = Trichomes
Phl. = Phloem
X. = Xylem

Photo 5: Effect of salt stress + K-Silicate + R-Humic (T_{10}), salt stress + K-Silicate + magnetic iron (T_{11}) and tap water irrigation (control-T_1) on some leaf anatomical structure of Picual olive transplants.

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