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Foliar application of selenium and glycine betaine improve morph-physiological characteristics of peach trees grown under deficit irrigation stress

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ABSTRACT:

The current investigation was carried. out during two successive. seasons of 2017 and 2018 on 8 years old peach trees (*Prunus persica* L. Batsch) cv."Florida Prince" grown on "Nemaguard" rootstock was grown in a newly reclaimed land at a private farm, in Wadi El Natroun District, Beheira Governorate, Egypt to study the response of the drought-stressed peach trees to foliar application of selenium (Se) and Glycine betaine (GB) on vegetative growth and Physiological characteristics, trees grown under deficit irrigation "DI_{70}" (70% of water use) in sandy soil. Glycine betaine (GB) was used to spray the peach tree foliage at 3 levels (0, 25, and 50 mM) and Selenium (Se)was sprayed at (0, 20, and 40 ppm). The Results indicated that the tree was irrigated with highest amount of irrigation water applied "FI_{100}" (100% WU) produced the highest significant values of vegetative growth. "DI_{70}" (70% WU) treatments significantly decreased vegetative growth. Foliar application of GB reduced the negative impacts of water stress, and produced the maximum significant values of averages of shoot length (SL), number of leaves per shoot (NLS), and leaf area LA $(cm)^2$. It was also concluded that, foliar application of GB with 50 mM/l, and Selenium (Se) 20 ppm can be enhanced the vegetative growth and physiological characteristics of peach trees grown under deficit Irrigation Stress "DI_{70}".

KEYWORDS: Vegetative growth, Physiological, *Prunus persica*, deficit irrigation (DI), glycine betaine (GB), selenium (Se).

1. INTRODUCTION:

Egyptian agricultural production has to be well prepared to face the increasing risks of forecasted water stress and extreme drought events which compromise the profitability of fruit production and quality. Irrigated agriculture will take place under water scarcity now and in the future. **(World Bank Group, 2021).** We generally depend on the allocated water charge from the River Nile "about 55.5 billion m^3/ year" where the share per capita of water has dropped to less than 600 m^3/ year which is expected to cause many political conflicts, serious socioeconomic problems, reducing crop yield and limiting the food security. Based on that, Agricultural water management must be carried out as efficiently as possible, with the goal of saving water while increasing yield. **(Seif and Abd El- Samad, 2001 and Abd El-Samad et al., 2007).**

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Therefore, innovations are needed to increase the efficiency of using available water resources. Irrigation water should be devoted towards the production of high economic value crops such as peach trees which may have some physiological drought avoidance mechanisms. According to (**FAO, 2021**), Egypt ranks third order in the Arab production of peaches hence the cultivated acreage in Egypt has rapidly increased to reach 30725 fedden with a total production of 349064 tons. One of the recommended options to realize significant irrigation volume savings is to reduce water applications below the actual water requirements, a practice termed deficit irrigation (DI). This practice must be finely tuned to avoid reductions in the overall tree growth, metabolism, photosynthesis, water relation, yield and quality, photosynthetic pigments, nutrient imbalance and oxidative stress, caused by water stress **(Toumi et al., 2022).**

Deficit irrigation (DI) can be achieved by supplying water below the crop's requirements which can be represented by its evapotranspiration **(Fereres and Soriano, 2007).** In stone fruits, such as. peach, deficit irrigation strategies (DIS) have been used to control excessive vegetative growth **(Ruiz-Sánchez et al., 2010).** High-frequency deficit irrigation (HDI) and controlled deficit irrigation (DI) are two ways to DIS. In the first, the plants are given less water than they need, but at a frequency that keeps the water stress symptoms at bay. **(Duarte, 2016).**

Glycine betaine (GB) is an amino acid derivative that accumulates in a number of plant species as a result of environmental challenges such as high temperatures, salinity, and drought. However, several key agricultural species, such as tomato and potato, are unable to accumulate GB. **(Gorham, 1995).** Glycine betaine (GB), also known as betaine, is one of the compatible solutes that can improve the tolerance of trees to abiotic stresses by improving the tissue water status and protecting the biological membranes from reactive oxidative species (ROS) under drought stress **(Nawaz and Wang, 2020).** As an alternative, exogenous use of GB may be a viable strategy for coping with environmental stress. **(Makela et al., 1996; Yang and Lu, 2005; Chen and Murata, 2008, Seif, et al. 2020 and Habibi et al., 2022).**

Selenium (Se) fertilization, either basal or foliar, is a modern method that protects crop plants against dry stress. Selenite are the principal two kinds found in soil and are readily utilized by plants. It has been found that the administration of Se boosted proline accumulation but had no effect on water uptake capacity or plant biomass during drought conditions. **(Mohtashami et al., 2020).**

The Selenium (Se) is involved in counteracting various types of abiotic stress experienced by plants such as drought, cold, intense light and heavy metal pollutants **(Djanaguiraman et al., 2010 and Kaur et al., 2014).** Foliar application, of Se ions easily diffuse to epidermal cells as they are transported by the phloem and xylem, hence becoming part of the plant form **(Boldrin et al., 2013).** There are several studies carried out about the foliar application of Se on carrots roots **(Kápolna et al., 2009)**, cereals **(Boldrin et al., 2013),** onion and garlic bulbs **(Põldma et al., 2011 and Kápolna et al., 2012),** broccoli **(Šindeláˇrová, et al 2015)**, oilseed crops **(Mohtashami et al., 2020),** etc., resulting in a significant improvement in the growth and yield of crops. Selenium, (Se), is reported to positively affect fruit trees growth, alleviate UV-induced oxidative stress, stimulate chlorophyll biosynthesis, increasing the ant oxidative defenses and regulate the water status of drought-stressed trees **(D'Amato et al., 2018).**

The application of both GB and/or Se in peach production under fully irrigated "FI_{100}" or drought stress "DI_{70}" conditions is not well- investigated. So, the current aim of experiment has been performed to investigate the individual and/ or combined effects of GB foliar application at the rates of (0, 25 and 50 mM) and Se at the rates of (0, 20 and 40 ppm) on mature "Florida Prince" peaches (*Prunus persica* L. Batsch) grown under full irrigation "FI_{100}" 100% WU) or mild drought stress conditions "DI_{70}" (70% WU).

2. MATERIALS AND METHODS:

The current investigation was carried out during the two successive seasons of 2017 and 2018 to study the response of the drought stressed peach to the foliar application of Glycine betaine (GB) and Selenium (Se). 8 years old peach trees (*Prunus persica* L. Batsch)" cv. "Florida Prince" grown on “Nemaguard” rootstock were grown in a new reclaimed land at a private in Tanboul village, Wadi El Natroun District, Beheira Governorate, Egypt. Physical and chemical properties of soil are illustrated in Table (1). Climatic data for Wadi El Natroun District during 2017 and 2018 are illustrated in Table (2).

The trees were spaced 5 m between rows and 4 m within row under drip irrigation system. Two lateral lines with 4 drippers per each tree were installed. The dripper discharge is 8 $l.h^{-1}$). The trees were trained with a single trunk to the cup shape training. The experiment was designed as split plot in randomized complete blocks design with 3 replicates. The irrigation treatments were devoted to the main plots, the foliar applied antioxidant (Glycine betaine GB and Selenium Se) treatments were devoted to the sub main plots.

All horticultural practices, including fertilization, irrigation, and pest, disease, weed control, were applied according to the recommendations of the Egyptian Ministry of Agriculture and Soil Reclamation.

The experimental factors:

Irrigation treatments: Two irrigation treatments "regimes" have been investigated consisting of:

1.1. Full irrigation "FI_{100}": trees received irrigation equivalent to their full water requirements 100% of water use (WU) all over the season**.**

1.2. Deficit irrigation "DI_{70}": trees received irrigation equivalent to 70% of their full water requirements 70% of water use (WU) all over the season**.**

The full water requirement, designated as crop water use (WU), has been calculated according to the following equation as described by **Allen et al. (1998):** **WU= $ET_0 \times Kc \times Kr$**

Where: **WU**=water use, **ET_0**=reference evapotranspiration, **K_c**=crop coefficient and **Kr**=reduction factor

Metrological data of Wadi El Natroun district were obtained from the Central Laboratory for Agricultural Climate in Cairo Table 2. Also, ETo 2017= calculate average of ETo from 2012 to 2016 and ETo 2018= calculate average of ETo from 2012 to 2017 " ETo" of Wadi El Natroun district were obtained, from the Central Laboratory, for Agricultural Climate in Cairo table 3.

The used Kc values were as recommended by FAO-56 (**Allen et al., 1998)** as following:

KC dormancy =0.2, KC initial =0.55, KC mid-season =0.9 and KC end =0.65

Calculated crop water use is indicated in Table 3. Irrigation intervals were twice a week from February till middle of April, then three times a week from middle of April till end of August, then two times a week during September, October and then one time a week during November, December and January of each season according to (**Seif and Abd El- Samad, 2001)** .

Table 1: Some physical, and chemical properties of the soil

Physical characteristics							
Depth	Particle, size distribution			Texture	Soil moisture constants %		
	Sand %	Silt %	Clay %		F. C.	W.P.	A.W.
0-30	83.70	5.20	11.10	Loamy sand	17.50	8.90	8.60
30-60	86.20	5.70	10.10	Loamy sand	15.50	9.50	6.80

Chemical characteristics									
Depth	**Soluble cations, SC (meq/L)**				**pH**	**Ece(ds/m)**	**Soluble anionsSA (meq/L)**		
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}			Cl^{-}	HCO_3^{-}	SO_4^{--}
0-30	1.10	0.70	6.90	0.40	8.39	0.91	4.50	2.90	1.70
30-60	2.50	1.00	3.50	0.40	8.41	0.74	3.50	2.30	1.60

Where: F.C. = field capacity, A.W. = available water Ece= electric conductivity and W.P. = wilting point,

Table 2: Average climate data ACD for Wadi El Natrun region, Behera, Egypt in 2017 and 2018 growing, seasons.

Months	**T_{max}**	**T_{min}**	**RH_{max}**	**RH_{min}**	**T_{max}**	**T_{min}**	**RH_{max}**	**RH_{min}**
	2017				**2018**			
January	17.50	7.46	83.42	36.98	18.84	9.52	79.57	40.02
February	19.74	8.13	87.05	35.46	21.80	10.24	88.53	31.96
March	23.16	10.97	80.45	29.73	26.79	11.94	78.08	22.49
April	26.86	12.50	73.35	23.65	29.34	14.23	76.02	25.40
May	31.49	16.88	60.15	19.70	33.50	18.73	72.33	23.70
June	35.29	20.19	66.38	23.61	35.37	20.97	79.43	24.75
July	37.19	22.65	72.58	26.46	36.40	22.52	79.51	28.90
August	35.88	23.10	71.37	30.75	35.94	23.08	79.82	31.08
September	34.18	20.58	72.88	32.35	34.43	21.88	79.85	33.09
October	29.04	17.70	70.73	32.20	30.57	19.27	79.65	33.35
November	24.09	13.97	80.82	39.05	25.60	15.39	89.01	37.56
December	21.19	12.08	81.38	45.04	20.00	11.73	85.25	43.62
Average	**27.97**	**15.52**	**75.05**	**31.25**	**29.05**	**16.62**	**80.59**	**31.33**

Table 3: water use (WU) of peach tree grown under Wadi El Natrun region in 2017, and 2018 seasons.

				Water Use season (2017)			
Months	**ETo***	**Kc**	**kr**	**ETc mm**	**ETc m3/F**	**ETc.L/day/ Irr.100**	**ETc.L/day/Irr.70**
January	1.70	0.55	0.20	0.19	0.79	3.74	2.99
February	2.30	0.90	0.20	0.41	1.74	8.28	6.62
March	3.60	0.90	0.30	0.97	4.08	19.44	15.55
April	4.51	0.90	0.40	1.62	6.82	32.47	25.98
May	5.60	0.90	0.60	3.02	12.70	60.48	48.38
June	6.73	0.65	0.70	3.06	12.86	61.24	48.99
July	6.74	0.65	0.70	3.07	12.88	61.33	49.07
August	6.51	0.65	0.60	2.54	10.66	50.78	40.62
September	5.20	0.65	0.50	1.69	7.10	33.80	27.04
October	3.90	0.65	0.40	1.01	4.26	20.28	16.22
November	2.82	0.65	0.30	0.55	2.31	11.00	8.80
December	1.52	0.55	0.20	0.17	0.70	3.34	2.68
				Water Use season (2018)			
January	1.94**	0.55	0.20	0.21	0.90	4.27	3.41
February	3.02	0.90	0.20	0.54	2.28	10.85	8.68
March	4.23	0.90	0.30	1.14	4.80	22.84	18.27
April	5.83	0.90	0.40	2.10	8.81	41.94	33.55
May	7.18	0.90	0.60	3.88	16.28	77.54	62.04
June	7.81	0.65	0.70	3.55	14.92	71.07	56.86
July	6.70	0.65	0.70	3.05	12.80	60.97	48.78
August	6.16	0.65	0.60	2.40	10.08	48.01	38.41
September	5.35	0.65	0.50	1.74	7.30	34.77	27.82
October	4.18	0.65	0.40	1.09	4.56	21.74	17.39
November	2.83	0.65	0.30	0.55	2.32	11.04	8.83
December	1.68	0.55	0.20	0.18	0.77	3.68	2.95

* ETo 2017= calculate average of ETo from 2012 to 2016 ** ETo 2018= calculate average of ETo from 2012 to 2017

" ETo" of Wadi El Natroun district were obtained, from the Central Laboratory, for Agricultural Climate in Cairo

2- Glycine betaine (GB) and Selenium (Se) foliar application treatments:

Glycine betaine, GB was used to spray the tree foliage at three levels (0 tap water, 25 and 50 mM) Glycine betaine (GB) material $(CH_3)_3N^+CH_2COO^-$) (GB) was foliar applied by dissolving. The Selenium (Se) was foliar sprayed at three levels, (0 tap water, 20 and 40 ppm) 3 times in 3 weeks' intervals. The first spray was applied beginning from 7 days after the fully expanded leaf stage was dissolved in tap water and using Tween 20 as a surfactant (0.1 %, v/v) to ensure optimal penetration into leaf. Glycine betaine (GB) $(CH_3)_3N^+CH_2COO^-$) and Sodium selenate (Na_2SeO_4) were obtained from Sigma-Aldrich, MO state, U.S.A.

3. Studied parameters:

3.1. Vegetative, growth parameters:

3. 1. 1. Shoot length (SL), number of shoots per tree (NST) and number of leaves, per shoot (NLS):

Shoot length (SL) cm. was estimated by measuring ten shoots per tree at the third week of August. Moreover, number, of shoots per tree, and number of leaves per shoot were recorded.

3.1.2. Leaf area (LA) cm^2:
Samples of fifty leaves that have fully expanded per tree were picked at the third week of October to determine leaf area, Leaf width "W" and leaf length "L" were measured using digital caliber, and then the leaf area, was calculated according to **Demirsoy et al., 2004** using the following equation:

LA= – 0.5 + 0.23 × L/W + 0.67 × L × W,
Where: LA is leaf area cm^2, and L is leaf length cm and W is leaf width cm.

3.1.3. Dry pruning weight (DPW) Kg/tree:
At the time of winter pruning, fresh pruning weight of each tree was recorded immediately following commercial hand pruning. Pruning weight was estimated as Kg fresh weight/vine. A Sample of 500g fresh pruning was taken and dried to constant weight in an electric oven at 70 oC to measure percentage of dry matter then pruning dry weight was calculated.

3.2 Physiological Parameters
The Relative chlorophyll content, SPAD reading was determined using a SPAD-502 m device (Minolta, Osaka, Japan).

3.3. Leaf chemical composition:

A Hundred leaves from middle of the annual shoots were taken between 15 July and 15 August for leaf analysis. Then dried to constant weight in an electric oven at 70 ºC. The dry leaves were finely ground. then stored in air-tight bags for the following determinations:

3.3.1. Total carbohydrates (TC) % was determined according to **Herbert, *et al.* (1971).**

3.3.2 Free proline (FP) mg/100 g was extracted by sulfa salicylic acid 3%, then determined calorimetrically using acid ninihydrin reagent as mentioned by **Bates, *et al.* (1973)** and calculated as mg/100 g on dry weight basis.

4. Statistical analysis
ANOVA data analysis was performed with the GenStat statistical package (VSN International Ltd, Oxford, UK). Multiple comparisons of means were performed using the Duncan test at p = 0.05. The data was statistically analyzed in accordance with **Snedecor and Cochran (1994).**

3. RESULTS AND DISCUSSION:

1. Vegetative growth parameters:

1.1: Shoot length (cm).

Data in Table, 4 indicate that the average shoot length (SL) cm values were significantly affected with the irrigation treatments; of maximum values of shoot length (SL) (49.70 and 43.70 cm) were obtained when the tree irrigated with highest amount of irrigation water applied "FI_{100}"(100% WU) under two seasons, respectively. On the other hand, minimum values (41.78 and 37.56 cm) were recorded for less amount of irrigation water applied "DI_{70}" (70% WU). Regarding the antioxidant treatment, results of the two seasons showed maximum values of SL cm (50.83 and 46.16 cm) when spraying the first concentration of glycine betaine GB 25 mM and selenium Se 10 ppm together; on the other hand, the control treatment recorded minimum values of SL (38.33 and 34.50 cm) in two seasons, respectively. The interaction effect of irrigation treatments and antioxidant on SL was insignificant in both experimental seasons. The application of Se significantly increased root water intake while decreased transpiration rate **(Ahmad et al., 2016).**

1.2-Number of leaves per shoot (NLS)

treatment, the results of the two seasons the maximum values of NLS (46.67 and 44.17) when spraying the GB 25 mM and selenium Se 20 ppm, on the other hand, the control treatment recorded the minimum values of (NLS) (37.17 and 35.33) in two seasons, respectively. The interaction effect of irrigation treatments and antioxidants on (NLS) was insignificant in two experimental seasons.

According to the data in Table 5, the average number of leaves per shoot (NLS) values were significantly affected with the irrigation treatments of the maximum values of NLS (44.22 and 43.30) were obtained when, the trees were irrigated applied "FI_{100}" under both seasons, respectively. On the other hand, the minimum values of NLS (36.85 and 34.93) were recorded for the irrigation water applied "DI_{70}". Regarding antioxidant

Table 4: Effect of foliar application of glycine betaine and selenium on shoot length (cm) of peach grown under deficit irrigation during 2017 and 2018 seasons

Shoot length SL (cm)						
Season Treatment	2017			2018		
	FI_{100}	DI_{70}	**Mean**	FI_{100}	DI_{70}	**Mean**
Control	39.00e-g	37.67g	**38.33B**	37.33e-i	31.67i	**34.50D**
GB1	50.33a-d	40.67c-g	**45.50A**	47.67ab	38.00d-i	**43.00AB**
GB2	51.00a-c	45.33b-g	**48.67A**	44.33a-d	42.33a-f	**43.33A**
Se1	53.33ab	42.33c-g	**47.83A**	43.67a-e	32.33hi	**38.00CD**
Se2	48.33a-f	40.00d-g	**44.17AB**	45.00a-c	34.67g-i	**39.83BC**
GB1Se1	54.67ab	47.00a-e	**50.83A**	48.00a	44.33a-d	**46.16A**
GB1Se2	49.33a-e	42.67c-g	**46.00A**	43.67a-e	40.33c-g	**42.00A-C**
GB2Se1	51.00a-c	38.00fg	**44.50AB**	42.67a-f	36.00f-i	**39.33BC**
GB2Se2	48.33a-e	41.33c-g	**44.83AB**	41.00b-g	38.33c-h	**39.67BC**
Mean	49.70A	41.78B		43.70A	37.56B	

Values marked with the, same letter(s)within the main and interaction effect are statistically, similar using Duncan test 1-Control, 2-GB1=25 mM glycine betaine , 3-GB2=50 mM glycine betaine ,4-S1=20 ppm selenium 5-S2=40 ppm selenium , 6- GB1S1=25 mM glycine betaine+20ppm selenium, 7-GB1S2=25 mM glycine betaine + 40ppm selenium 8- GB2S1=50 mM glycine betaine+20ppm selenium, 9- GB2S2= 50 mM glycine betaine+ 40ppm selenium -"FI100" =full irrigation ,DI=deficit irrigation

Table 5: The effect of foliar glycine betaine and selenium application on Number of leaves per shoot(NLS) of peach grown under deficit irrigation during 2017 and 2018 seasons.

Number of leaves per shoot (NLS)						
Treatment	**2017**			2018		
	FI_{100}	DI_{70}	**Mean**	FI_{100}	DI_{70}	**Mean**
Control	45.00a-d	29.33g	**37.17C**	43.33a-d	27.33g	**35.33C**
GB1	43.33a-e	36.67b-g	**40.00A-C**	44.33a-c	32.67d-g	**38.50bC**
GB2	48.33ab	46.33a-c	**47.33A**	46.67ab	47.00ab	**46.83A**
Se1	34.33d-g	41.00a-f	**37.67C**	34.33c-g	37.33b-g	**35.83C**
Se2	43.33a-e	35.33c-g	**39.33B-C**	43.33a-c	34.33c-g	**38.83BC**
GB1Se1	54.67a	41.67a-f	**46.67AB**	49.00a	39.33a-f	**44.17B**
GB1Se2	43.33a-e	32.67e-g	**38.00C**	41.00a-e	30.00f-g	**35.50C**
GB2Se1	44.67a-d	31.00fg	**37.83C**	45.00a-c	31.33e-g	**38.17BC**
GB2Se2	44.00a-e	37.67b-g	**40.83A-C**	42.67a-d	35.00c-g	**38.83BC**
Mean	44.22A	36.85B		43.30A	34.93B	

Values marked with the same letter(s)within the main and interaction effect are statistically similar using Duncan test 1-Control, 2-GB1=25 mM glycine betaine , 3-GB2=50 mM glycine betaine ,4-S1=10 ppm selenium 5-S2=20 ppm selenium , 6- GB1S1=25 mM glycine betaine+10ppm selenium, 7-GB1S2=25 mM glycine betaine + 20ppm selenium 8- GB2S1=50 mM glycine betaine+10ppm selenium, 9- GB2S2= 50 mM glycine betaine+ 20ppm selenium -"FI100" =full irrigation ,DI=deficit irrigation

1.3: Leaf area (LA) cm^2:

In Table 6, the results show the significant effect of spraying the antioxidants GB and Se individual and the interaction between antioxidants and irrigation treatments together on the LA cm^2 of peach trees growing under “FI_{100}” and “DI_{70}” treatments. The LA cm^2 increased under the influence of the previous treatments compared to the control. In the 2017 irrigation treatment the results were not significant, while, the second year of 2018, the results were (23.28 and 19.82 cm^2) under the influence of irrigation treatments. the influence of spraying antioxidants GB (50mM) (26.81 and 25.36 cm^2) compared to the control (17.12 and 15.66 cm^2) in both experimental seasons, respectively. while the effect of the interaction was not significant in the growing season.

1.4-Number of shoots per tree (NST)

Data in Figure 1 concerning the number of shoots per tree (NST), show the significant effect of irrigation, on the number of NST. The NST increased at a full irrigation level of “FI_{100}” (186 and 184) compared to the, NST under the level of water stress “DI_{70}” (171 and 168) in both experimental seasons, respectively. The effect of spraying antioxidants GB and Se was significant on NST, (188.67 and 184.17) as the number of exudations increased when treated with spraying with (GB 50 mM) and selenium (Se 20 ppm) compared to control (169.33 and 170.00). On the other hand, the effect of the interaction between irrigation treatments and antioxidants was also significant, as spraying GB and Se reduced the acute effect of water stress compared to control in two experimental seasons. Additionally, plants treated with GB showed better ability to recover from wilting than untreated plants.

1.5: Pruning wood weight (PWW) kg.

The results in Table 7 show the effect of irrigation and the antioxidant treatments glycine and selenium and the interaction between them on the weight of pruning wood (PWW) of peach trees grown under water stress, the average PWW values were significantly affected by irrigation treatments of the maximum values of PWW (3.80 and 3.77 kg) were obtained when the trees were irrigated water applied "FI_{100}" in 2017 and 2018 seasons, respectively. On the other hand, the minimum values of PWW (3.30 and 3.20 kg) were recorded for the less amount of irrigation water applied "DI_{70}" in 2017 and 2018 seasons, respectively. Regarding to antioxidant treatment, results of two seasons as on maximum values of (PWW) (3.85 and 3.97 kg) when spraying the Glycine Betaine GB 50 mM and selenium Se 40 ppm together, on the other hand, control treatment recorded the minimum values of PWW (3.03 and 2.92 kg) in both seasons, respectively. The interaction effect of irrigation treatments and antioxidant on PWW was insignificantly in both experimental seasons.

These results show that vegetative growth is very sensitive to deficit Irrigation "DI_{70}", and similar finding have been observed for numerous deciduous fruit trees, including peach **(Rahmati et al., 2015).** Deficient irrigation inhibited the vegetative growth of adult early maturing peach trees, with the intensity varying according to the organs trunk, wood pruning, and shoot length growth **(Abrisqueta et al., 2010).** Moreover, this phenomenon was attributed to carbohydrate limitations, inducing a decrease in organ growth **(Sala et al., 2012)**. The vegetative growth of woody trees is known as the most vulnerable to DI. Reduced shoot growth in response to water constraints results in smaller trees and canopies **(PerezPastor et al., 2009).** Exogenous application of GB increased leaf area and shoot fresh biomass in several experiments **(Tahir et al., 2009; Hadiarto and Tran, 2011; and Cha-um et al., 2013).** Furthermore, **Delifani et al., (2022)** Glycine betaine (GB) has been shown to reduce drought damage in a variety of fruit species.

Under drought stress, GB can improve tree tolerance to abiotic pressures by enhancing tissue water status and protecting biological membranes from reactive oxidative species (ROS) **(Nawaz and Wang, 2020).** Exogenous application of GB, improved fruit trees growth subjected to different abiotic stress and, may be a viable way of tolerate environmental stress (**Makela et al., 1996; Yang and Lu, 2005; Chen and Murata, 2008; Seif, et al. 2020** and **Habibi et al., 2022).**

3.2 Physiological Parameters

Relative chlorophyll content (SPAD)

Data in Fig (2) indicated that SPAD significantly affected by irrigation treatment during the two growing successive seasons of 2017 and 2018. It is clear data the average SPAD were significantly effect by irrigation treatments, the maximum values of SPAD (64.70 and 68.27 %) were obtained when the trees were irrigated at "FI_{100}", while the minimum values of SPAD (63.20 and 66.77%) were recorded for the "DI_{70}", during the two seasons, respectively. Regarding to antioxidant treatments, the maximum values of SPAD (67.15 and 70.95%) were obtained with the GB2 50 mM and Se2 40 ppm, on the other hand, the minimum values of SPAD (58.57 and 62.23%) were recorded for the control in both successive seasons respectively, On the other side the interaction effect of irrigation treatments and antioxidant on SPAD was insignificantly in the both experimental seasons.

These results show that deficit Irrigation "DI_{70}" decreased Relative chlorophyll content (SPAD) and enhanced by exogenous application of GB , similar findings have been reported, by **Guizani et al. (2019)** discovered that deficit irrigation (DI) reduced net photo synthesis rate, stomatal conductance, and trans piration rates. **Yang and Lu (2005)** discovered that spraying GB (20, 40 mM/l) increased chlorophyll and protein content in tomato plants during drought stress.

Table 6: Effect of foliar application of GB and Se on Leaf area (cm^2) of peach grown under deficit irrigation during 2017 and 2018 seasons.

Leaf area $(cm)^2$						
Treatment	**2017**			2018		
	FI_{100}	DI_{70}	**Mean**	FI_{100}	DI_{70}	**Mean**
Control	17.32gh	16.91gh	**17.12D**	14.81f	16.50f	**15.66D**
GB1	24.54a-d	17.88f-g	**21.21AB**	23.84a-d	19.07c-e	**21.46BC**
GB2	28.89a	24.72a-d	**26.81A**	27.32ab	23.40a-d	**25.36A**
Se1	23.84a-e	21.67c-g	**22.76A-C**	25.93a-c	21.84c-e	**23.89AB**
Se2	23.02a-e	20.10d-g	**24.06AB**	21.79c-e	21.57c-e	**21.68BC**
GB1Se1	22.45b-f	17.58f-h	**20.02CD**	21.43c-e	18.00ef	**19.72C**
GB1Se2	20.34d-g	19.44e-g	**19.89CD**	28.02a	19.24d-e	**23.63AB**
GB2Se1	26.13a-c	20.82d-g	**23.48AB**	23.15b-d	17.56ef	**20.35C**
GB2Se2	27.18ab	20.07e-g	**23.63AB**	23.26b-d	21.22c-e	**22.24A-**
Mean	23.75A	19.13A		23.28A	19.82B	

Table 7: Effect of foliar application of GB and Se on pruning wood weight (kg) of peach grown under deficit irrigation during 2017 and 2018 seasons.

Pruning wood weight PWW (kg)						
Treatment	**2017**			**2018**		
	$\mathbf{FI_{100}}$	$\mathbf{DI_{70}}$	**Mean**	$\mathbf{FI_{100}}$	$\mathbf{DI_{70}}$	**Mean**
Control	3.20e-h	2.87h	**3.03C**	3.03f-g	2.80g	**2.92D**
GB1	3.90a-d	3.03f-h	**3.47B**	3.67b-d	2.80fg	**3.33C**
GB2	4.10a	3.00g-h	**3.55AB**	3.93b	3.43c-f	**3.68AB**
Se1	4.00a	3.57b-g	**3.80A**	4.23a	3.20d-g	**3.72A**
Se2	3.63a-f	3.27e-h	**3.45B**	3.743bc	3.20d-g	**3.47BC**
GB1Se1	4.03a	3.50c-g	**3.82A**	4.00ab	3.10e-g	**3.55A-C**
GB1Se2	3.67a-e	3.53b-g	**3.60AB**	3.63b-d	3.13e-g	**3.38BC**
GB2Se1	3.60b-g	3.40d-h	**3.50AB**	3.53b-e	3.23d-g	**3.38BC**
GB2Se2	3.99a	3.57b-g	**3.85A**	4.20ab	3.73bc	**3.97A**
Mean	3.80A	3.30B		3.77A	3.20B	

Values marked with the same letter(s)within the main and interaction effect are statistically similar using Duncan test 1-Control, 2-GB1=25 mM glycine betaine , 3-GB2=50 mM glycine betaine ,4-S1=20 ppm selenium 5-S2=40 ppm selenium , 6- GB1S1=25 mM glycine betaine+20ppm selenium, 7-GB1S2=25 mM glycine betaine + 40ppm selenium 8- GB2S1=50 mM glycine betaine+20ppm selenium, 9- GB2S2= 50 mM glycine betaine+ 40ppm selenium -"FI100" =full irrigation ,DI=deficit irrigation

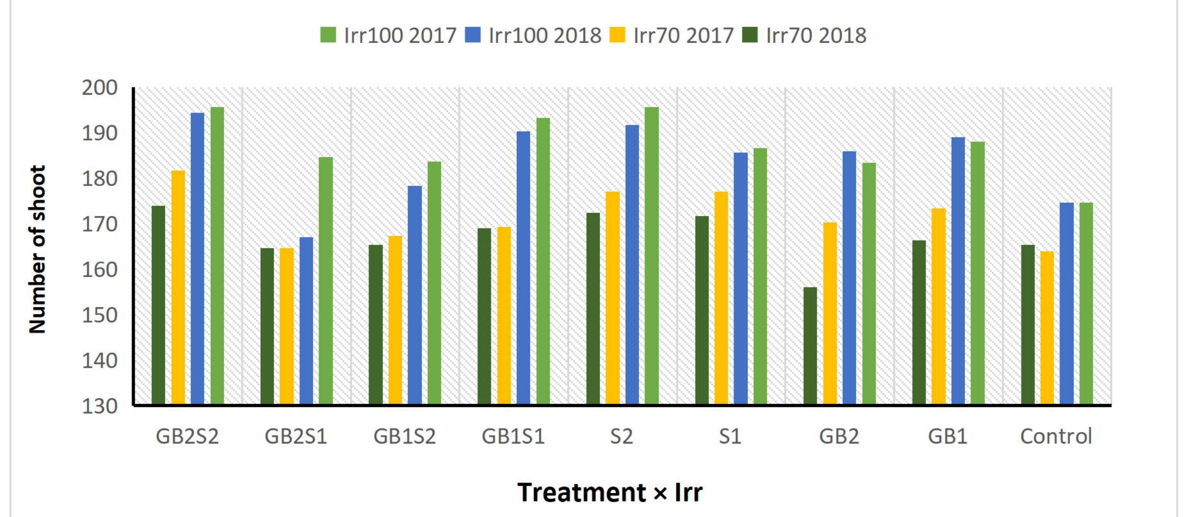

Fig (1). Effect of foliar application of GB and Se on number of shoot per tree (NST) of peach grown under deficit irrigation during 2017 and 2018 seasons.

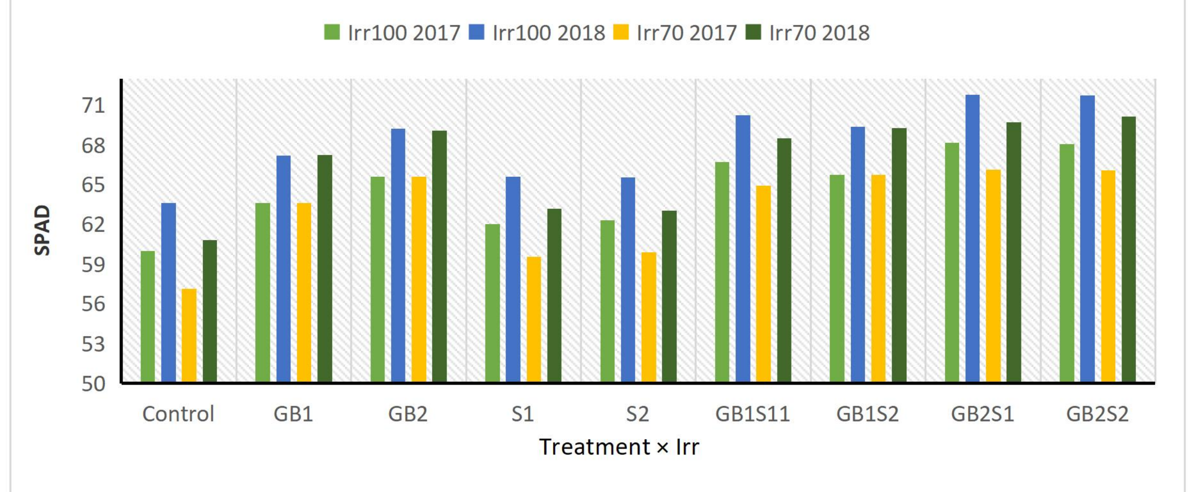

Fig (2) SPAD in peach as affected foliar application of GB and Se subjected to irrigation levels

3. Leaf chemical composition

3.1. **Total carbohydrate (TC) (g /100 g):**

Data presented in Fig (3) indicated that total carbohydrate (TC) significantly affected with irrigation treatment during 2017 and 2018 seasons. It is clear data the average TC values were significantly affect with irrigation treatments the maximum values of TC (15.82 and 15.65%) were obtained, when the trees were irrigated applied "FI_{100}" while the minimum average TC values, were recorded for "DI_{70}" (14.63 and 15.11%) in 2017 and 2018 seasons, respectively. Regarding to antioxidant treatment, the maximum values of TC (15.89 and 16.09%) were obtained with the GB 50 Mm and Se 40 ppm, on the other hand, the minimum values of TC (14.28 and 14.42%) were recorded for control in 2017 and 2018 seasons, respectively. The interaction effect of irrigation treatments and antioxidant on TC was significantly the maximum values of TC (16.13 and 16.24%) were obtained with "FI_{100}", GB2 50Mm and Se2 40 ppm. On the other hand, the minimum values of TC (13.51 and 13.77%) were recorded for the control and "DI_{70}" results of the two successive seasons, respectively.

2.2- **Free proline (FP) (mg/100 g)**:

Data in Fig (4) indicated that it is clear data the average free proline values were significantly affect with irrigation treatments the maximum values of FP (138.52 and 122.04 %) were obtained when the trees were irrigated applied "DI_{70}" during 2017 and 2018 seasons, respectively while the minimum values of FP (95.77 and 79.28%) were recorded for the trees were irrigated applied "FI_{100}" in two successive seasons, respectively. Regarding to antioxidant treatment, the maximum values of FP (124.78 and 108.52%) were obtained with, GB 50Mm and Se 40 ppm. On the other hand, the minimum values of free proline (FP) (103.30 and 88.12%) were recorded for control of the two seasons, respectively

The interaction effect of irrigation treatments and antioxidant on FP was significant, the maximum values of FP (148.96 and 132.33%) were obtained with applied "DI_{70}" and GB50 mM and Se40 ppm, respectively. On the other hand, the minimum values of FP (85.98 and 69.97%) were recorded for the control and "FI_{100}" of both successive seasons, respectively.

These results show that deficit Irrigation "FI_{100}" decreased **FP** and enhanced by exogenous application of GB. Similar findings have been reported, by **Yang and Lu, (2005)** under drought stress found that the contents of soluble sugar and proline in the leaves of tomato are increased enhanced by spraying GB (20, 40 mM/l)**.**

Se improves plant growth by accumulating starch in the chloroplast **(Mozafariyan et al., 2017)**. Besides, Se can also regulate the activities of several antioxidant enzymes and metabolites providing oxidative stress tolerance to plants **(Helaly et al., 2017)**.

Se in other environmental stresses (drought, UV, cold, and high temperature) are also mentioned. According to the literature, a positive effect of Se is dependent on both dose and plant genotype and is primarily associated with activation of anti-oxidative defense in plants cells **Sieprawska et al., (2015)** Furthermore, Se is a beneficial substance that functions as an antioxidant and anti-senescent agent, as well as being involved in active defense against abiotic and biotic stresses. It has been reported to be closely related to increased antioxidant activity. **(Száková et al., 2017 and Djanaguiraman et al., 2010).**

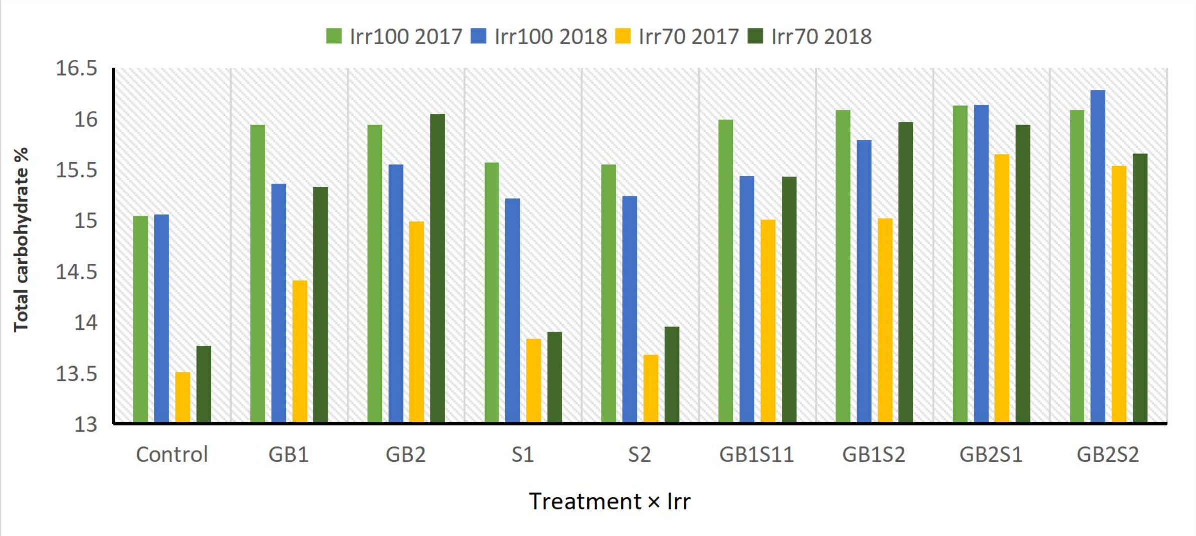

Fig 3 Total carbohydrate % in peach trees as affected foliar application of GB and Se to irrigation levels

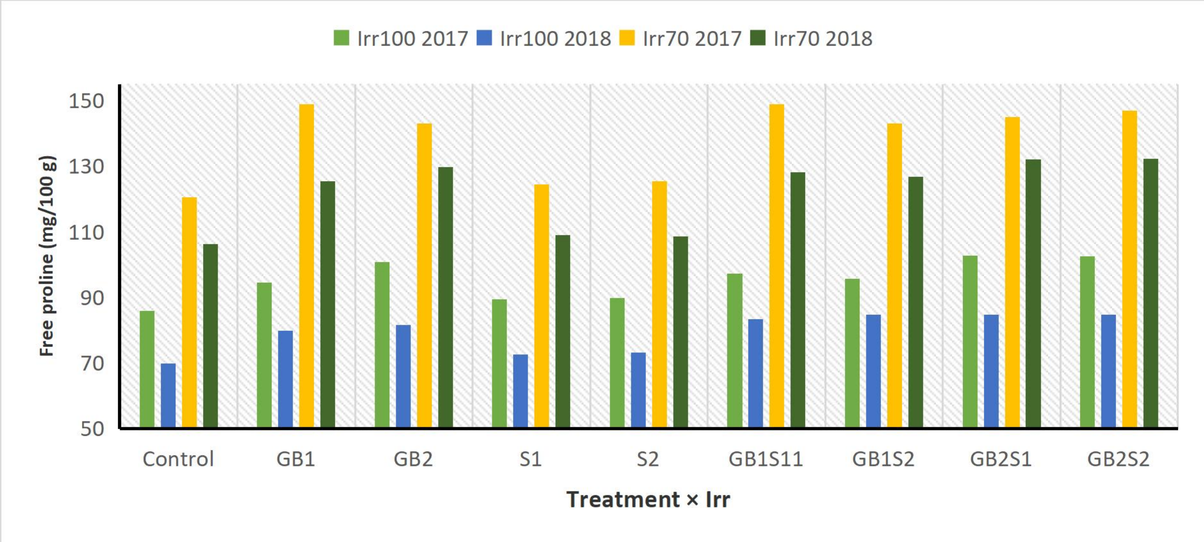

Fig (4) Free Proline (FP) (mg/100 g) in peach trees as affected foliar application of glycine betaine and selenium subjected to irrigation levels

CONCLUSION:

It can be concluded that water stress was characterized by inducing a dramatic decline of all physiological responses of peaches trees. Meanwhile, (GB and SE) foliar application combination significantly improves morphological and physiological characteristics, and maintained the growth and trees performance under water stress.

4. REFERENCES:

Abd El-Samad, G.A.; Sief, S.A; Morsi, M. E. and H. R. Hussien 2007. Effect of different irrigation regimes on some grapevine cultivars grown in new reclaimed land conditions. b- Physiological responses: growth, fruit quality and leaf chemical composition. Annals of Agric. Sc. Moshtohor, 45 (1) 369-386.

Abrisqueta, I.; Tapia, L.M.; Conejero W.; Sanchez-Toribio, M.I. ; Abrisqueta, J.M. ; Vera, J. and Ruiz-Sanchez, M.C. 2010 Response of early-peach *Prunus persica* (L.) trees to deficit irrigation. Spanish Journal of Agricultural Research, 8(S2), 30–39.

Ahmad, R.; Waraich, E.A.; Nawaz, F.; Ashraf, M.Y.; Khalid, M. 2016. Selenium (Se) improves drought tolerance in crop plants—A myth or fact? J. Sci. Food Agric., 96, 372–380.

Allen, R. G., Pereira, L. S., Raes, D., and M. Smith, 1998. "Crop evapotranspiration: Guidelines for computing crop requirements." Irrigation and Drainage Paper No. 56, FAO, Rome, Italy.

Bates L., Waldren R.P. and Teare I.D. 1973. Rapid determination of free proline for water stress studies. Plant Soil; 39:205-207

Boldrin, P.F.; Faquin, V.; Ramos, S.J.; Boldrin, K.V.F.; Ávila, F.W. and Guilherme, L.R.G. 2013. Soil and foliar application of selenium in rice biofortification. J. Food Compos. Anal., 31, 238–244.

Cha-um, S., Samphumphuang T.h. and Kirdmanee, C. 2013. Glycine betaine alleviates water deficit stress in indica rice using proline accumulation, photosynthetic efficiencies, growth performances and yield attributes. Australian Journal of Crop Science., 7(2): 213-218.

Chen, T.H.H. and Murata, N. 2008. Glycinebetaine: an effective protectant against abiotic stress in plants. Trends Plant Sci., 13:499–505.

D'Amato R, De Feudis M, Hasuoka P.E, Regni L, Pacheco P.H, Onofri A,

Businelli D, and Proietti, P. 2018. The Selenium Supplementation Influences Olive Tree Production and Oil Stability Against Oxidation and Can Alleviate the Water Deficiency Effects. Front Plant Sci., 15 (9):1191.

Delfani, K., Asadi, M., Golein, B., Babakhani, B., & Razeghi Jadid, R. 2022. Foliar Application of Glycine Betaine Affects Morpho-physiological, Biochemical and Fruit Quality Traits of Thomson Navel Orange Under Deficit Irrigation. Journal of Plant Growth Regulation.

Demirsoy, H. Demirsoy, L S. Uzun, S. and Ersoy B. 2004. Non-destructive leaf area estimation in peach. European Journal of Horticultural Science. 69 (4) 144-146.

Djanaguiraman, M.; Prasad, P.V.V. and Seppanen, M. 2010. Selenium protects sorghum leaves from oxidative damage under high temperature stress by enhancing antioxidant defense system. Plant Physiol. Biochem., 48: 999–1007.

Duarte, A.C. 2016. A rega da cultura do pessegueiro. In +Pêssego - Guia prático da produção. M. P. Simões, coord. (Alcobaça: Centro Operativo e Tecnológico Hortofrutícola Nacional), pp. 123-144

FAO (2021). FAOSTAT. Statistical Databases, Food and Agriculture Organization of United Nations, Agriculture Data Collection (Primary Crops), Available from: http://faostat.fao.org.

Fereres, E., and Soriano, M.A. 2007. Deficit irrigation for reducing agricultural water use. J. Exp. Bot., 58(2): 147-159.

Gorham, J. 1995. Betaines in higher plants – biosynthesis and role in stress metabolism. In Amino Acids and Their Derivatives in Higher Plants (ed. R.M. Wallsgrove), 171–203. Cambridge University Press, Cambridge.

Guizani, M., Dabbou, S., Maatallah, S.,

Montevecchi, G., Hajlaoui, H., Rezig, M., Helal, A. N., & Kilani-Jaziri, S. 2019. Physiological responses and fruit quality of four peach cultivars under sustained and cyclic deficit irrigation in center-west of Tunisia. Agricultural Water Management, 217, 81–97.

Habibi F, Guillén F, María Serrano, and Valero, D. 2022 Postharvest treatment with glycine betaine enhances chilling tolerance of blood orange fruit by increasing antioxidant defense systems and osmoregulation during cold storage, ScientiaHorticulturae,305,111352.

Hadiarto, T. and Tran, L.S.P. 2011. Progress studies of drought responsive genes in rice. Plant Cell Rep 30:297-310.

Helaly, M.N.; El-Hoseiny, H.; El-Sheery, N.I.; Rastogi, A.; Kalaji, H.M. 2017. Regulation and physiological role of silicon in alleviating drought stress of mango. Plant Physiol. Biochem. 118: 31–44.

Herbert, D., Phippls, P. J. and Strang, R. F. 1971. Determination of total carbohydrates. method in Microbian. 5(B): 209-344.

Kápolna, E.; Hillestrøm, P.R.; Laursen, K.H.; Husted, S.; Larsen, E.H. 2009. Effect of foliar application of selenium on its uptake and speciation in carrot. Food Chem., 115, 1357–1363.

Kápolna, E.; Laursen, K.H.; Husted, S.; Larsen, E.H. 2012 Bio-fortification and isotopic labelling of Se metabolites in onions and carrots following foliar application of Se and 77Se. Food Chem., 133, 650–657.

Kaur, N.; Sharma, S.; Kaur, S.; Nayyar, H 2014. Selenium in agriculture: A nutrient or contaminant for crops? Arch. Agron. Soil Sci., 60, 1593–1624.

Makela, P., Peltonen-Sainio, P. Jokinen, K. Pehu, E. Setaia, H. Hinkkanen, R. and Somersalo, S. 1996. Uptake and translocation of foliar-applied glycine betaine in crop plants. Plant Sci., 121, 221–230.

Mohtashami, R.; Movahhedi, M.D.; Balouchi, H. and Faraji, H. 2020. Improving yield, oil content and water productivity of dryland canola by supplementary irrigation and selenium spraying. Agric. Water Manag., *232*.

Mozafariyan, M.; Pessarakli, M.; Saghafi, K. 2017. Effects of selenium on some morphological and physiological traits of tomato plants grown under hydroponic condition. J. Plant Nutr., 40, 139–144.

Nawaz, M., and Wang, Z. 2020. Abscisic acid and glycine betaine mediated tolerance mechanisms under drought stress and recovery in Axonopus compressus: a new insight. Sci. Rep. 10:6942.

Perez-Pastor, A., Domingo, R., Torrecillas, A. and Ruiz-Sanchez, M.C. 2009 Response of apricot trees to deficit irrigation strategies. Irrigation Science, 27 (3): 231–242.

Põldma, P.; Tõnutare, T.; Viitak, A.; Luik, A. and Moor, U. 2011 Effect of selenium treatment on mineral nutrition, bulbsize, and antioxidant properties of garlic (*Allium sativum* L.). Agric. Food Chem., 5*9*: 5498–5503.

Rahmati, M., Davarynejad, G.H., Génard, M., Bannayan, M., Azizi, M. & Vercambre, G. (2015) Peach water relations, gas exchange, growth and shoot mortality under water deficit in semi-arid weather conditions. PLoS ONE, 10(4).

Ruiz-Sánchez, M., Domingo, R., and Castel, J. 2010. Review: deficit irrigation in fruit trees and vines in Spain. Span. J. Agric. 8, 5–20.

Sala, A., Woodruff, D.R. & Meinzer, F.C. 2012 Carbon dynamics in trees: feast or famine? Tree Physiology, 32(6), 764–775.

Sief, A. S. and Abd El-Samad, G. A. 2001. Effect of irrigation deficit on vegetative growth, productivity, water use efficiency and root length density of three peach cultivars. Annals Agric. Sci. Moshtohor, 39: 2307- 3223.

Seif, A. S; Zeinab, A. Ibrahim., Beheiry, H.R and Asmaa, G. A. Abd El-Samad 2020. Physiological responses and nutrient contents of 'superior' grapevine cv. Transplants grown under salinity stress as affected by biochar soil application and glycine betaine foliar spraying. *Fayoum J. Agric. Res,&Dev., Vol. 34 No. 1(B)*

Sieprawska, A., Kornaś, A., & Filek, M. 2015. Involvement of selenium in protective mechanisms of plants under environmental stress conditions - Review. Acta Biologica Cracoviensia Series Botanica, 57(1), 9–20. https://doi.org/10.1515/abcsb-2015-0014

Šindeláˇrová, K.; Száková, J.; Tremlová, J.; Mestek, O.; Praus, L.; Kaˇna, A. and Najmanová, J.T.P. 2015 The response of broccoli (*Brassica oleracea* convar. *italica*) varieties on foliar application of selenium: Uptake, translocation, and speciation. Food Addit. Contam. Part A, (32): 2027–2038.

Snedecor, G. W. and Cochran, W. G. 1994. Statistical Methods. 6th edition. Oxford and J.B. Publishing Co.

Száková, J.; Praus, L.; Tremlová, J.; Kulhánek, M.; Tlustoš, P. 2017. Efficiency of foliar selenium application on oilseed rape (*Brassica napus* L.) as influenced by rainfall and soil characteristics. Arch. Agro. Soil Sci., 63: 1240–1254.

Tahir, M., Asraf, M. and Shahbaz, M. 2009. Dose exogenous application of glycine betaine as a pre-sowing seed treatment improve growth and regulate some key physiological attribute in wheat plants grown under water deficit conditions? Pak. J. Bot., 41(3): 1291-1302.

Toumi I, Zarrouk O, Ghrab M, and Nagaz, K. 2022. Improving peach fruit quality traits using deficit irrigation strategies in Southern Tunisia Arid Area. Plants, 23;11(13):1656. doi: 10.3390/plants11131656. PMID: 35807607; PMCID: PMC9269496.

World Bank Group, 2021, *Water in Agriculture*, https://www.worldbank.org/en/topic/water-in-agriculture#1.

Yang, X. and C. Lu. 2005. Photosynthesis is improved by exogenous glycine betaine in salt-stressed maize plants. Physiologia Plantarum, 124: 343-352.

الملخص العربي

الرش الورقي بالسيلينيوم والجلاسين بتايين لتحسين الصفات الخضرية والفسيولوجية لاشجار الخوخ الناميه تحت ظروف الاجهاد المائي

سمير احمد سيف اليزل و حمادة رجب حسين و محمد سالم عطية و حمدي عبد النبي زكي حسين
قسم البساتين كلية الزراعة جامعة الفيوم.

اجريت التجربه البحثيه في موسمين متتاليين 2017-2018 علي اشجارخوخ صنف فلوريدا برنس عمر 8 سنوات المنزرعه علي اصل النيماجارد في منطقه وادي النطرون محافظه البحيره –مصر لدراسة تاثيرالمعامله بالرش الورقي بمضادات الاكسدة (الجلاسين بتايين وكذا السيلينيوم) علي النمو الخضري لاشجار الخوخ الناميه تحت تاثير الاجهاد المائي 70% من الاحتياجات المائيه المقننه طبقا لمعادلة "Penman"المعدله (Dorembos واخرون 1979) ومعادلة (Allen واخرون 1998) .
الاشجار منزرعة علي مسافات 5 امتار × 5 امتار تحت نظام الري بالتنقيط (خرطومين علي جانبي خط الاشجار) و أربع نقاطات / شجرة , تصريف التقاط 8 لتر / ساعة , الأشجار مرباه بالطريقه الكأسية المفتوحة صممت التجربة علي شكل قطع منشقة في قطاعات كامله العشوائية مع استخدام 3 مكررات (أشجار) لكل معاملة .
- تم استخدام 3 تركيزات من الجلاسين بتايين وهما (0,25,50 ppm.) و 3 تركيزات من السيلينيوم هما (0,20,40 .ppm) واظهرت النتائج ان النمو الخضري لأشجار الخوخ تأثر سلبياً بالأجهاد المائي وأن المعاملة بمضادات الأكسدة (جليسين بيتايين والسيلنيوم) قللت من التاثير السلبي للأجهاد المائي علي النمو الخضري للأشجار وشجعت النمو الخضري لأشجار الكنترول"FI_{100}". كما أظهرت النتائج ايضاً زيادة طول الفرع وعدد الاوراق علي الافرع ووزن خشب التقليم ومساحة الورقة وعدد الافرع علي الشجرة مع أشجارالكنترول بينما تاثرت سلبيا بالأجهاد المائي "DI_{70} " في حين ادي الرش الورقي بالجليسين بيتايين 50mM والسيلينيوم 40 ppm الي تحسين صفات النمو الخضري والتقليل من الأضرار السلبية للإجهاد المائي .

الكلمات المفتاحيه: النمو الخضري – الاجهاد المائي – الجلايسين بتايين – السيلينيوم – مضادات الاكسده