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MITIGATION OF WATER STRESS IN TWO PURSLANE (*PORTULACA OLERACEA* L.) CULTIVARS USING NANO SILICON AND FOLIC ACID

Azza, M. Salama[1], A.E. Ghoniem[2] and Abdel Wahab M. Mahmoud[3]

[1,2]Agricultural Botany Department, Fac. of Agric., Cairo Univ., Giza, Egypt.
[3]Cairo University, Faculty of Agriculture, Plant Physiology Department, Giza, Egypt.

Abstract

A field experiment was carried out at Faculty of Agriculture, Cairo University, Giza, Egypt, during the two successive seasons of 2018 and 2019 to study the effect of foliar spray with nano silicon or folic acid and their combination on morphological, anatomical and chemical characters of two Purslane (*Portulaca oleracea* L.) cultivars (Egyptian and Turkey) under three water levels (100, 50 and 30% of field capacity). The results showed that spraying two cultivars with mixture of nano silicon and folic acid at 30% field capacity exhibited significant promotive effects on morphological and chemical characters compared with untreated plants. Concerning anatomical structure of leaf, treatment with a mixture nano silicon and folic acid at 30% of field capacity increase the thickness of both mid vein and lamina due to the increase in thickness of mesophyll tissue as well as in the dimension of the main mid vein bundle. Likewise, such treatment increased stem diameter of cortex, phloem and xylem tissues and decrease parenchymatous area of the pith compared with control. Spraying plants with mentioned mixture treatment at 30% field capacity increased almost all macro and microelements, besides carbohydrate, phenolic and ascorbic acid. Moreover, mixture treatment revealed significant effects of photosynthetic rate, stomatal conductive and water use efficiency compared with control.

Key word: anatomy*,* Purslane*,* folic acid, nano silicon, chemical composition.

Introduction

Herbs today are typical well-being as opposed to the synthetics that need help considered equally dangerous to the further earth of mankind. However, the visually impaired dependence on synthetics can be in and kin returns with confidence for safety and safety from the natives (Hao *et al*., 2015). The assumption for this use will be that these crops are known as dynamic components (active principles or biologically active principles) that affect physiological (metabolic) processes of living organisms, including people. Mostly incredible numbers of contemporary drugs were also separated from prevalent plant species due to their use of conventional medicine (Graul *et al.,* 2008). Wild crops are not generally eaten daily, but for humans they are a significant source of nutrients. It is known to have elevated concentrations of fatty acids (including -3 and -6), which are vital elements of human health.

Purslane olecracea plant is an outstanding source of vitamin E, vitamin C, beta-carotene and glutathione-like antioxidants. Purslane is a wealthy source of isoleucine amino acids, Lucien, lysine, cysteine, phenylalanine, tyrosine, threonine and valine (Marcela *et al*., 2013). *Portulaca oleracea* is a very important plant because of its specific and ascribed all therapeutic characteristics to the presence of many biologically active compounds, flavonoids and medical functions (myricetin, quercetin, kaempferol, luteolin, apigenin, genistin and genistein), alkaloids, anthraquinone glycoside, respiratory glycoside and elevated content of -3 fatty acids (simopoulos, 2004).

Drought stress is considered as one of the variables restricting crop efficiency a threat to crop success. Drought tolerance is an significant yield-related feature. In terms of plant physiology, dryness creates pressure in plant growth, yielding a 50-30 percent decrease in drought stress owing to low humidity in plant growth resulting from elevated evapotranspiration, elevated sunlight temperature (Ghodsi *et al.*, 1998). In reality, with growing drought stress, the cell wall is wizened and loose, cell volume reduces, pressure reduces and the cell's development potential is lowered based on the potential pressure reduces and growth reduces. The size and amount of leaves in crops are these considerations. Because of drought, leaf mesophyll cells become dehydrated. It was necessary to store the quantity of abscisic acid in the chloroplasts in the guard cells used and to increase the development of ABA in guard cells and mesophyll (Bagheri, 2009).

Nanotechnology is an interdisciplinary field entered in various applied sciences such as chemists, physicists, biologists, physicians and technicians (Perea-de-Lugue and Rubiales, 2009). Depending on the particles of characteristics, nano particles (NPs) communicate with crops causing many morphological and physiological modifications.

Nano-silicon has acquired more consideration over the past few years among nano particles. After oxygen, silicon is abundant in soils and the second most prevalent component on earth and has been acknowledged as a useful nutrient for crop growth and development (Wainwright, 1997; Siddiqui *et al.*, 2015). Silicon increased drought tolerance in crops such as rice (Agarie *et al.*, 1998b), on sorghum (Hattori *et al.*, 2005, 2008a; Ahmed *et al.*, 2011a, b; Sonobe *et al.*, 2011), on cucumber (Hattori *et al.*, 2008b) and (Gao *et al.*, 2004, 2006), on corn (Gong *et al.*, 2005, 2008; Gong and Chen 2012), on pepper (*Capsicum annuum* L.) (Lobato *et al.*, 2009), on sunflower (Gunes *et al.*, 2008). Szerment *et al.*, 2014 and Ghazavi 2015 noted that Si-NPs enhanced the ability of water holding and thus improved soil quality. Due to their unique properties, Si-NPs exhibit great potential in agriculture and may work better in alleviating different abiotic stresses than bulk material (Cui *et al.*, 2017). Nano-silicon layer may reduce plant transpiration and, thus, make plants more resistant to drought, high temperature, and humidity (Anshu Rastogi *et al.*, 2019).

Folic acid is vital in the metabolism of amino acids and in the synthesis of nucleic acids (Andrew *et al.*, 2000). Folic acid increased proline biosynthesis under stressful conditions, thus helping the plant to gain endurance against stress (Burguieres *et al.*, 2007). It allows crops to generate RNA, a nucleic acid that carries data from DNA to ribosomes and helps a plant to synthesize protein (Poudineh *et al.*, 2015).

The present research aims to study the effect of applied nano silicon and folic acid alone or mixture on growth and anatomical parameters as well as chemical composition of Purslane plant under water deficit stress compared to normal plants.

Materials and Methods

A field experiment was carried out in Faculty of Agriculture, Cairo University, Giza, Egypt during 2018 and 2019 seasons on two cultivars (Egyptian and Turkey) of *Portulaca oleracea* L. to study the response of plant to application of nano silicon and folic acid and their interaction under drought condition. Purslane seeds for both cultivars were secured from pharmaceutical commercial company for cosmetic products and tested for 2 months as initial investigation. Both nano silicon and folic acid were obtained from Sigma-Aldrich Company (NSi, with 5-15 nm and purity of 99.5%). nano silicon was sprayed monthly for 5 months at concentrations of 2 mM, the first one after 3 weeks from sowing, TEM (transmission electronic microscope) image (a) was done in TEM lab (FA-CURP) Faculty of Agriculture Cairo University Research Park to determine the nano size of silicon.

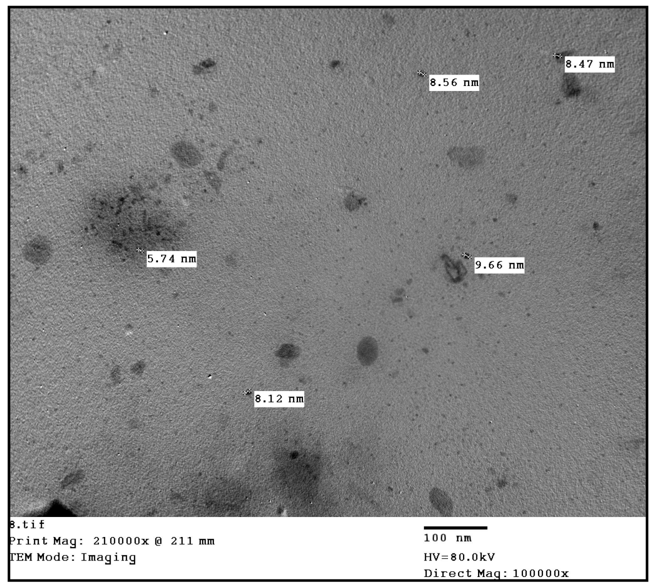

Fig. 1: silicon nano particle size from (5.74 to 9.66 nm).

Whereas, folic acid was sprayed monthly for 4 months at concentration of 20 mM, the first one after 3 weeks from sowing using an atomizer for both of them. The control plants were sprayed with tap water.

Seeds sown on 12th February in both seasons in hills spaced 10 cm. Plants were thinned to two plants per hill after 30 days from sowing. Irrigation treatments were applied 15 days after sowing.

The experiment was made in a randomized complete block design with three replicates. Each replicate be divided into 4 plots for each cultivar, each contained one treatment. The plot was 2×4 m and consisted of 8 rows, 50 cm apart, distances between plants were 40 cm. The treatments were:

1- Control (tap water) at 100% FC (Felid Capacity)

2- Nano silicon at 50% FC

3- Folic acid at 50% FC

4- Nano silicon + folic acid at 30% FC

A field capacity was calculated under dripping irrigation when zones of water overlap each other on the line.

The following data were recorded:

Morphological characters

1. Plant height (cm).
2. Leaf area (cm^2)
3. Number of leaves/stem
4. Stem girth (cm)
5. RWC%
6. Leaves fresh weight (g)/plant.
7. Leaves dry weight (g)/plant.
8. Root fresh weight (g)/plant
9. Root dry weight (g)/plant

Yield characters

Harvesting took place on 22th August 2018 and 2019 for both 1st and 2nd seasons; respectively. At harvest time, ten plants were randomly taken from the central ridges to determine the following traits:

1- Seeds capsules number / plant.

2- Seeds number /capsules.

3- Root length (cm)

4- Number of Flowers/ plant

Anatomical investigation

A microscopical study was carried out to investigate the anatomical structure of Purslane leaf was taken from the 5th internode and the stem, represented by the 5th internodes counted from the plant tip at the age of 90 days. All the specimens were fixed in F.A.A. solution (10 ml formalin, 5 ml glacial acetic acid, 50 ml ethyl alcohol 95%, 35ml distilled water). The materials were left in the fluid for three days, after which they were washed in 50% ethyl alcohol and gradually dehydrated in a normal butyl alcohol series before being embedded in paraffin wax (melting point 52-54°C). Transverse sections, 20µ thick, were cut using a rotary microtome and stained with double crystal violet/erythrosine combination and mounted in Canada balsam (Nassar and El-Sahhar, 1998). The slides were microscopically examined and photomicro-graphed to detect histological manifestations of noticeable responses resulted from treatments.

Chemical analysis

Samples from mature dried seeds for two cultivars from the second growing seasons were subjected to determine total nitrogen (N), Phosphorus (P), Potassium (K), Magnesium (Mg), Calcium (Ca) and Sodium (Na) and calculated as percentage of dry weight according to (A.O.A.C., 1999), at Faculty of Agriculture, Cairo University Research Park (CURP).

-Concentrations of iron (Fe), zinc (Zn), manganese (Mn) and cupper (Cu) in plant samples were determined using atomic absorption spectrophotometer with air-acetylene and fuel and calculated in ppm. (Pye Unicam, model SP-1900, US).

-Total chlorophyll was measured by spectrophotometer and calculated according to the equation described by Moran (1982).

-Total carbohydrates in plant herbs were determined by phosphomolybdic acid method according to Helrich (1990).

-Total phenolic contents of the extracts were determined spectrophotometrically according to the Folin–Ciocalteu colorimetric method (Singleton & Rossi 1965).

-Total flavonoid was determined using the method of Meda *et al*., (2005).

-Total tannin contents were determined using Folin-Ciocalteu reagent method as described by Chahardehi *et al*., (2009).

-Thiamine in seeds was carried out using a method described by Rapala-Kozik *et al*., (2008).

-Total fatty acids in seeds were converted into their methyl esters using 3% sodium methylate in methanol according to the method described by Cecchi *et al*., (1985).

-Ascorbic acid was determined in seeds and estimated per 100 ml fresh weight, according to Helrich (1990) method.

-Photosynthesis and transpiration rate on an area basis (µmol CO_2 $m^{-2}s^{-1}$), leaf stomatal conductance (mol H_2O $m^{-2}s^{-1}$) and Relative Water Contents (RWC) of five different leaves per treatment were monitored using a LICOR 6400 (Lincoln, Nebraska, USA) infrared gas analyzer (IRGA).

Results and Discussion

Morphological characters

Data present in table 1 show that plant height, leaf area, number of leaves/stem, percentage of Relative Water Contents, leaves fresh and dry weight and root fresh and dry weight of Purslane plants were significantly affected by application of nano silicon and/or folic acid compared with untreated plants. Except stem girth showed no significant effect.

Results in table 1 indicate that the most increasing values of growth characters of two cultivars were observed when plants sprayed with the mixture of nano silicon and folic acid at 30% of FC. Egyptian surpassed Turkey in all growth traits.

The maximum plant height recorded 46.1 cm for Egyptian cultivar, being 96.2% more than control, whereas Turkey recorded 41.5 cm, being 92.1% over control.

Concerning leaf area and the number of leaves per stem, they were increased by 51.8 and 76.8%, respectively more than control for Egyptian cultivar and by 60.9 and 50% for Turkey cultivar respectively. Percentage of Relative Water Contents recorded the highest increasing percentage 11.5% for Egyptian cultivar and 11.9% for Turkey cultivar compared with untreated plants.

As to the same effect on leaves fresh and dry weight, data proved that Egyptian cultivar recorded 169.1 and 167.0%, respectively more than control. On the other hand Turkey cultivar recorded 141.3 and 180.9% over control for leaves fresh and dry weight, respectively. As well as root fresh and dry weight recorded the maximum in Egyptian being 18.6 and 25.2% respectively more than untreated plants, whereas in Turkey recorded 24.4 and 39.7% respectively over control.

Drought stress caused significant decreases for the morphological characters due to the reduction of water flow from the xylem to the different cells, which regulates cell division, elongation and development as well as meristematic activity. Drought reduced sunflower development and productivity (*Heliantus annuus* L.) due to declines in leaf water potential, cell division rates, and enlargement due mainly to turgor loss (Kiani *et al.*, 2007; Hussain *et al.*, 2009). Drought also reduced leaf area due to turgor loss and reduced numbers of leaves (Farooq *et al.*, 2010a). Similarly, in Asian red sage (*Salvia miltiorrhiza* L.), drought significantly decreased shoot and root dry weights, although roots were less affected than shoots (Liu *et al.*, 2011). Drought stress circumstances have a negative impact on melon development parameters, leaf relative water content, membrane damage index and shoot and root in K and Ca ions, plant height, number of leaves, and leaf area ; however, stress tolerance rates for genotypes that absorb more K and Ca ions have increased significantly (Kabay and Sensoy, 2016).

Improving growth parameters through foliar application of $nSiO_2$ can be attributed to encouraging certain elements that are transported in xylem sap (Mg, Fe, etc.), improving water and fertilizer absorption capacity, stimulating the activity of certain major enzymes such as nitrate reductase, increasing indole-3-acettic acid (IAA) concentration and improving antioxidant activity (Lu *et al.*, 2002; Le *et al.*, 2014).

In stressful circumstances, folic acid improved proline biosynthesis, thus helping the plant achieve strength against pressure (Burguieres *et al.*, 2007). In addition, Ibrahim *et al.*, (2015) discovered that folic acid considerably enhanced growth parameters including potato plant length, leaf area relative to controls. Youssif 2017 revealed that foliar application of folic acid solely or in combination in sandy soil significantly increased the growth of potato plants, tuber yield and its components as well as chemical composition and total chlorophyll. Ashkavand *et al.*, 2018 mentioned that Relative leaf water content (RWC) decreased in *Prunus mahaleb* with increasing severity of the drought, but it was not affected by SNPs pre-treatments.

Yield and its components

Data presented in table 2 show that the maximum significant increase in seeds capsules per plant, seeds per capsules, root length and the number of flowers per

Table 1: Effect of nano silicon, folic acid and combination of them on morphological characteristics of *Purslane* (*Portulaca oleracea L.*) plant at 30% field capacity.

Treatment	Plant height		Leaf area (cm^2)		Number of leaves/stem		Stem girth (cm)		RWC %		Leaves F.W\g		D.W\g Leaves		Root F.W\g		Root D.W\g	
	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E
Control	21.6[c]	23.5[d]	2.02[c]	2.18[c]	78[d]	82[c]	2.9[a]	3.2[a]	75.2[b]	76.5[b]	95.8[c]	113.4[c]	19.72[b]	26.31[b]	145.3[c]	155.6[c]	33.5[c]	38.1[b]
Nano silicon	25.8[c]	28.4[c]	2.15[b]	2.26[c]	85[c]	90[c]	3.1[a]	3.4[a]	77.5[b]	78.2[b]	112.5[b]	117.2[b]	20.45[b]	28.71[b]	166.2[b]	171.8[b]	39.1[b]	40.8[b]
Folic acid	30.5[b]	36.4[b]	2.17[b]	2.47[b]	97[b]	113[b]	3[a]	3.5[a]	78.4[b]	80.2[a]	115.4[b]	122.8[b]	22.63[b]	31.40[b]	174.5[a]	183.2[a]	41.1[b]	46.5[a]
Nano silicon + Folic acid	41.5[a]	46.1[a]	3.25[a]	3.31[a]	117[a]	145[a]	3.5[a]	3.5[a]	84.2[a]	85.3[a]	231.2[a]	305.2[a]	55.41[a]	70.23[a]	180.7[a]	184.5[a]	46.8[a]	47.7[a]

Values are average of both seasons (2018 and 2019)- Means with the same letter in a column are not significantly different by DMRT 5%, T: Turkey E: Egypt.

plant were achieved plants treated with mixture of nano silicon and folic acid at 30% of FC, being 59.6, 104.5, 31.7 and 71.4 % more than control, respectively for Turkey. The same trend was observed with Egyptian cultivar, whereas the percentages of increases over control were 89.4, 58.1, 16.7 and 63.6 % for the same characters. Jabari *et al*., (2007) showed that with drought stress grain yield decreased about 83 percent because of decreasing in weight of 1000 grains and number of grains head. Bao-shan *et al*., (2004) noted that nano-silica has enhanced Larix seedlings ‘development and quality. Nano silicon showed the largest average height and length of the primary root. Stakhova *et al*., (2000) have achieved that folic acid improves *pisum sativum* productivity by influencing seed yield, weight and quality. Al-Said and Kamal, (2008) discovered that folic acid foliar spray improved yield and sweet pepper quality. Poudineh *et al*., 2015 stated that folic acid reduces the adverse impacts of drought stress on the sunflower plant’s quantitative and qualitative characteristics. Hamid *et al*., 2017 mentioned that application of SiO_2 nanoparticles under water stress condition could have more beneficial effects on yield component of barley genotypes.

Table 2: Effect of nano silicon, folic acid and combination of them on morphological characteristics of *Purslane* (*Portulaca oleracea* L.) plant at 30% field capacity.

Treatment	Seeds capsules\plant		Seeds\capsules		Root length (cm)		Number of Flowers\plant	
	T	E	T	E	T	E	T	E
Control	57^d	66^c	22^c	31^d	6.3^b	7.8^b	7^b	11^b
Nano silicon	70^c	83^b	30^b	38^c	7.1^b	8.2^b	9^b	13^b
Folic acid	78^b	86^b	36^b	44^b	7.4^b	8.5^b	11^a	15^a
Nano silicon + Folic acid	91^a	125^a	45^a	49^a	8.3^a	9.1^a	12^a	18^a

Values are average of both seasons (2018 and 2019)- Means with the same letter in a column are not significantly different by DMRT 5%, T: Turkey E: Egypt.

Table 3: Effect of mixture of nano silicon and folic acid at 30% FC on histological features on the 5th leaf of Egyptian and Turkey Purslane.

Characters	Treatments			
	Egyptian control	Nano silicon and folic acid at 30% FC	Turkey control	Nano silicon and folic acid at 30% FC
Mid vein thickness	525	805	568	692
Lamina thickness	265	375	305	340
Mesophyll thickness	210	275	238	267
Dimensions of the main vascular bundle of mid vein				
-Length	125	198	150	155
-Width	282	304	230	248
Xylem	90	105	88	10
Phloem	47	60	55	58

Anatomical studies

Anatomy of leaf blade

Certain microscopical characters of leaf developed on the 5th internode of the main stem of two cultivars (Egyptian and Turkey) as affected by mixture of nano silicon and *folic* acid at 30% FC were followed up in form of measurements of the transverse sections and microphotographs explicating such treatment.

It is recognized from table 3 and Fig. 2 that spray with mixture of nano silicon and folic acid at 30% FC gave the best results of two Purslane cultivars related to leaf structure as compared to the untreated plants. The increase in mid vein and lamina thickness were 53.3 and 41.5 % for Egyptian, whereas in Turkey increased by 21.8 and 11.5% over control. The promotive effect of this mixture at 30% FC on leaf thickness may be due to an increase in thickness of mesophyll tissue by 30.9 % for Egyptian, but in Turkey recorded 12.2% increase over control. In the present investigation, the dimensions of vascular bundle in Egyptian increased in length by 58.4% and width by 7.8%. On the other hand, the increase in length and width in Turkey were 3.3 and 7.8%, respectively. Likewise, xylem increased by 16.7 and 17.0% over control for Egyptian and Turkey cultivars, respectively. Also, phloem tissue increased by 27.6% in Egyptian, while increased by 5.4% in Turkey. Due to impaired enzyme activity, loss of turgor, and reduced energy supply, both cell division and cell enlargement are influenced by drought (Kiani *et al*., 2007; Farooq *et al*., 2009a; Taiz and Zeiger 2010).

Anatomy of the main stem

It is clear from table 4 and Fig. 3 that foliar application with mixture of nano silicon and folic acid at 30% FC increased the diameter of the main stem in Egyptian and Turkey by 9.6 and 10.3 %, respectively more than control. This increase was mainly due to the noticeable increment in stem cortex thickness by 10.3 and 26.7% over the control for Egyptian and Turkey Purslane. Parenchyma cell diameter was increased by 37.0% in Egyptian, whereas in Turkey increased by 4.3% more than control.

On the other hand, the thickness of phloem and xylem tissues was markedly increased in Egyptian under the same conditions by10.1 and 30.7%, respectively. Whereas in Turkey the increasing were15.6 and 4.2%, respectively. A decrease in parenchymatous pith thick observed in Egyptian by 7.6% but in Turkey recorded 4.5% below control. The diameters of the vessels were lower in the stressed root, stem, and leaf than in the unstressed plants. Ristic and Cass (1991) indicated that low soil moisture reduced the region of the vascular tissue. Studies have shown a decreased vessel diameter during drought (Kulkarni *et al*., 2010; Plavcová and Hacke, 2012), Strout *et al*., 2013 found that after absorption, Silicon nanoparticles were observed to form a binary film on the epidermal cell wall, which could decrease the transpiration of plant and thus make plant more resistant to drought, elevated temperature and humidity.

Table 4: Effect of mixture of nano silicon and folic acid at 30% FC on histological features on the 5th internode on main stem of Egyptian and Turkey Purslane.

Characters	Treatments			
	Egyptian control	Nano silicon and folic acid at 30% FC	Turkey control	Nano silicon and folic acid at 30% FC
Main stem diameter	3950	4330	3766	4155
Cortex thick	938	1035	840	1065
Parenchyma cell diameter	100	137	115	120
phloem tissue thick	79	87	77	89
Xylem tissue thick	130	170	144	150
Parenchymatous pith thick	1610	1488	1540	1470

Chemical composition

Mineral elements content

Data presented in table 5 indicated the effect of foliar application of nano silicon, folic acid and the mixture of nano silicon and folic acid at 30% FC on percentages of macro elements (Nitrogen, Phosphor, Potassium, Magnesium, Calcium and Sodium) as well micro elements (iron, zinc, manganese and cupper) in ppm of Purslane plants. Spraying plants with mixture of nano silicon and folic acid at 30% FC increased significantly percentage of nitrogen, phosphor, magnesium and calcium in seeds by 60.8, 75.3, 244.8 and 188.9%, respectively in Egyptian cultivar as compared with control. As well, in Turkey cultivar a significant increased in previous mentioned elements by 53.4, 67.3, 254.5 and 66.7%, respectively compared with control. Whereas recorded a decrease in Potassium and Sodium percentage in Egyptian by 25.0 and 20.8% below control. Also, a decrease

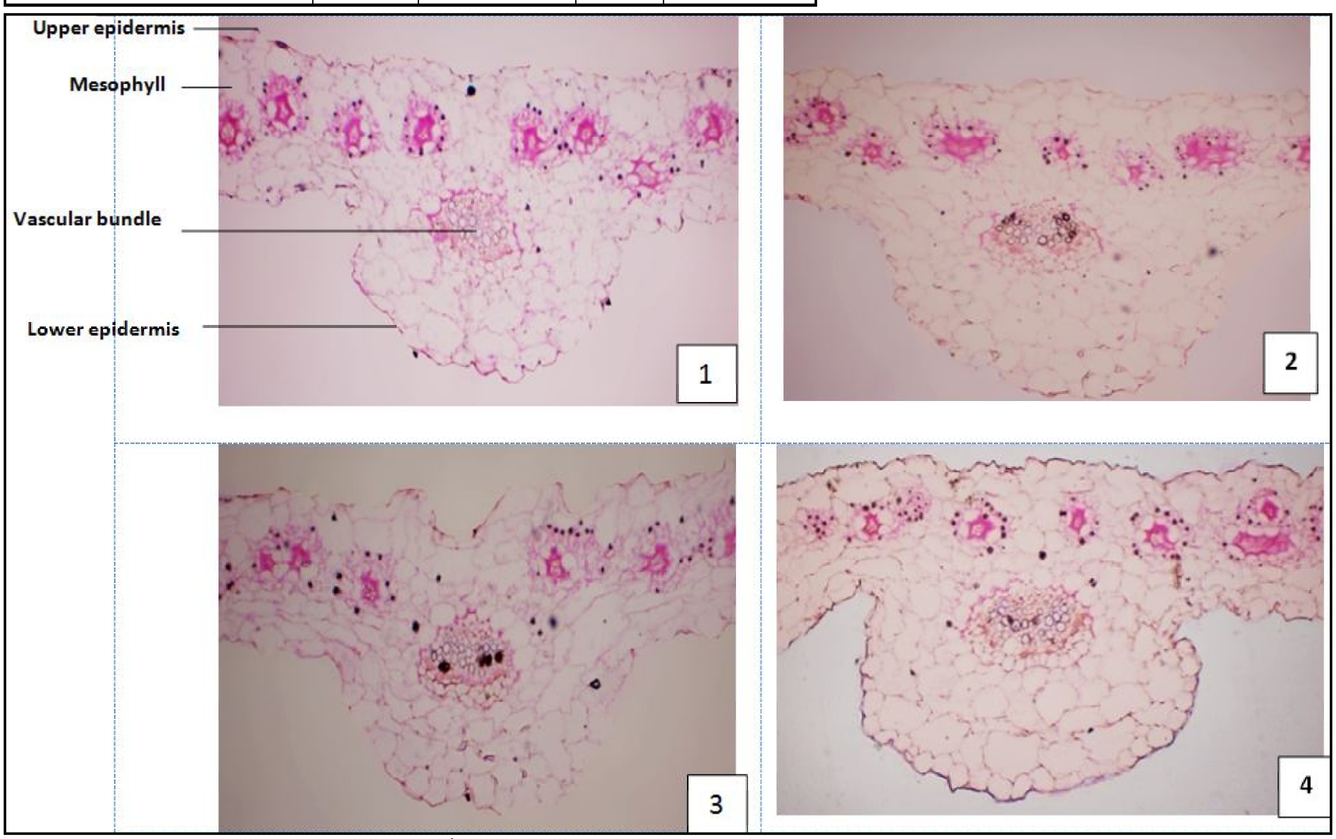

Fig. 2: Transverse sections through the 5th leaf of Egyptian and Turkey of Purslane at 90 days as affected by combination of nano silicon and folic acid (X 100).

1- Egyptian control plant (at 100% FC) 2- Egyptian plant treated with combination of nano silicon and folic acid (at 30% FC) 3- Turkey control plant (at 100% FC) 4- Turkey plant treated with combination of nano silicon and folic acid(at 30% FC).

noticed in Turkey by 37.3 and 28.6% for Potassium and Sodium, respectively compared with control. Results in table 5 mentioned that treatment with mixture of nano silicon and folic acid at 30% FC in Purslane cv. Egyptian increased percentage of iron (94.2%) compared with control. While percentage increase in Turkey was (110.4%) over control. The percentages increase of zinc, manganese and cupper were 65.7, 51.2 and 127.4% for Turkey and 64.3, 49.9 and 100.7% for Egyptian; respectively. Ashkavand *et al*., 2018 indicated that the concentration of N and P in leaf tissues in seedlings of *Prunus mahaleb* exposed to drought was enhanced by pretreatment with high doses of SNPs (*i.e.* 50 and 100 mg L-1) compared to those non-pretreated. In the case of K, SNPs application did not affect the concentration of K in leaves.

Total chlorophyll and carbohydrates, phenolic, flavonoids, tannins, thiamine, fatty acids, ± linolenic

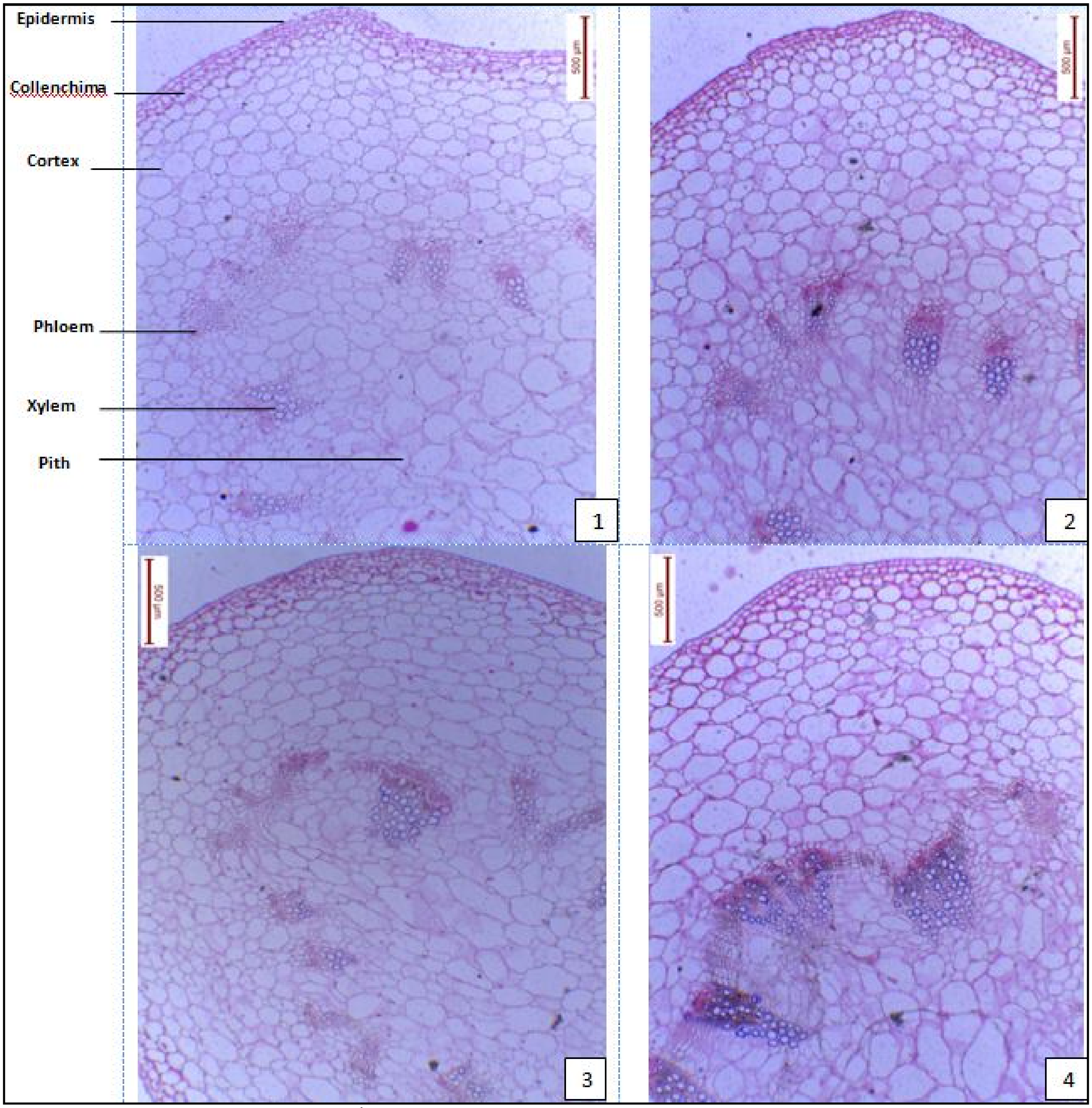

Fig. 3: Transverse sections through the 5th internode of Egyptian and Turkey of Purslane at 90 days as affected by combination of nano silicon and folic acid (X 40).

1-Egyptian control plant (at 100% FC) 2- Egyptian plant treated with combination of nano silicon and folic acid (at 30% FC) 3- Turkey control plant (at 100% FC) 4- Turkey plant treated with combination of nano silicon and folic acid(at 30% FC).

acid and ascorbic acid

Treatment with mixture of nano silicon and folic acid at 30% FC increased total chlorophyll and carbohydrates table 6. Whereas total chlorophyll significantly increased by 154.2% in Turkey, while in Egyptian increased by 126.6% over control. Total carbohydrates also increased significantly (21.8%) in Turkey compared with control. Also, in Egyptian the percentage increase was 24.9%. Data shown in Table 6 revealed that spraying nano silicon and folic acid at 30% FC significantly increased total phenolics in Turkey and Egyptian cultivars by (39.9 and 50.7%) over control. On the other hand, there was significant increase in total flavonoids resulting from the same treatments in comparison with control by 80.3 and 71.1% for Turkey and Egyptian Purslane.

There was significant increase in tannins, which recorded increase of 629.1 and 439.2% in Turkey and Egyptian, respectively, over control. While, thiamine recorded the same increasing percentage (166.7%) over control in Turkey and Egyptian as a result of treatment with mixture of nano silicon and folic acid at 30% FC table 6.

Total fatty acids in Turkey and Egyptian cultivars, significantly increased by (43.8 and 40.3%), respectively as a result of nano silicon and folic acid treatment compared with control. Also, α linolenic acid increased significantly by 70.2 and 55.0% for Turkey and Egyptian cultivars compared with control.

The same trend was obtained with ascorbic acid where in Turkey, treatment significantly increased the percentage of ascorbic acid (29.3%) over control. Also in Egyptian, there was an increase recorded (24.3%) compared to control. Chlorophyll content in soybean leaves was significantly reduced under drought stress (Makbul *et al.*, 2011). Kalteh *et al.*, 2014 disclosed that chlorophyll content improved with the use of silica nanoparticles in basil (*Ocimum basilicum*) leaves.In addition, Ibrahim *et al.*, (2015) discovered that, compared to the control, folic acid considerably enhanced chlorophyll, total soluble carbohydrates and total soluble protein in potato. Ashkavand *et al.*, 2018 mentioned that SNPs pretreatment (50 and 100 mg L^{-1}) enhanced chlorophyll concentration in seedlings subjected to severe drought in *Prunus mahaleb* leaf.

Photosynthetic and transpiration rate, stomatal conductivity and water use efficiency

Table 5: Effect of nano silicon, folic acid and combination of them on elements content of (*Purslane* (*Portulaca oleracea L.*) plant at 30% field capacity.

Treatment	N %	P %	K %	Mg%	Ca %	Na %	Feppm	Znppm	Mnppm	Cuppm										
	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E
Control	2.04^{b}	2.12b	2.45^{c}	2.79^{c}	0.11^{a}	0.16^{a}	0.022^{c}	0.029^{c}	0.039^{b}	0.045^{b}	0.042^{a}	0.048^{a}	28.55^{b}	35.12^{c}	22.58^{c}	27.09^{d}	13.08^{b}	14.01^{b}	3.10^{b}	3.00^{b}
Nano silicon	2.11^{b}	2.17b	2.67^{c}	3.03^{b}	0.072^{b}	0.081^{b}	0.032^{b}	0.043^{b}	0.040^{b}	0.052^{b}	0.031^{b}	0.039^{b}	30.46^{b}	37.42^{c}	24.91^{b}	30.46^{c}	15.03^{b}	17.12^{b}	5.05^{a}	4.01^{b}
Folic acid	2.15^{b}	2.25b	3.03^{b}	3.13^{b}	0.044^{c}	0.063^{c}	0.035^{b}	0.048^{b}	0.031^{c}	0.038^{c}	0.012^{c}	0.019^{c}	35.69^{b}	43.19^{b}	28.32^{b}	37.55^{b}	14.22^{b}	16.09^{b}	7.03^{a}	6.11^{a}
Nano silicon + Folic acid	3.13^{a}	3.41a	4.10^{a}	4.89a	0.069^{b}	0.12^{a}	0.078^{a}	0.1^{a}	0.065^{a}	0.13^{a}	0.030^{b}	0.038^{b}	60.07^{a}	68.21^{a}	37.41^{a}	44.51^{a}	19.78^{a}	21.01^{a}	7.05^{a}	6.02^{a}

Values are average of both seasons (2018 and 2019)- Means with the same letter in a column are not significantly different by DMRT 5%, T: Turkey E: Egypt.

Table 6: Effect of nano silicon, folic acid and combination of them on total chlorophyll and carbohydrates, phenolic, flavonoids, tannins, thiamine, fatty acids, ± linolenic acid and ascorbic acid of *Purslane* (*Portulaca oleracea L.*) plant at 30% field capacity.

Treatment	Total chlorophyll		Total carbohydrate		Total phenolic (mg GAE/100 g)		Total flavon-oids (g/100g)		Total tannins (mg /g DW)		Thiamin (mg)		Total fatty acids(mg· DW)		α Linolenic acid(mg·g DW)		Ascorbic acid (g/100g)	
	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E
Control	10.08c	13.19d	57.11d	63.66d	186.8d	191.5d	22.8d	27.3d	0.055d	0.079d	0.03d	0.06c	15.5d	19.6d	12.4d	17.8d	60.4d	67.8d
Nano silicon	12.63b	15.73c	63.46c	70.39c	197.8c	210.6c	27.7c	35.5c	0.096c	0.186c	0.05c	0.08b	17.8c	21.4c	15.5c	19.3c	66.5c	70.6c
Folic acid	13.41^{b}	18.05b	67.33b	76.86b	215.3^{b}	234.8b	33.5^{b}	40.8b	0.297b	0.308b	0.06^{b}	0.10b	20.5^{b}	24.3b	18.4^{b}	22.5b	74.3b	79.2b
Nano silicon + Folic acid	25.62^{a}	29.89a	69.21a	79.56a	261.5^{a}	288.6a	41.1^{a}	46.7a	0.401a	0.426a	0.08a	0.16a	22.3^{a}	27.5a	21.1^{a}	27.6a	78.1a	84.3a

Values are average of both seasons (2018 and 2019)- Means with the same letter in a column are not significantly different by DMRT 5%, T: Turkey E: Egypt.

Table 7: Effect of nano silicon, folic acid and combination of them on rate of photosynthesis and transpiration, stomatal cond and water use efficiency of *Purslane* (*Portulaca oleracea L.*) plant at 30% field capacity.

Treatment	Photosynthesi rate		Transpira -tion rate		Stomatal cond.		Water use efficiency	
	T	E	T	E	T	E	T	E
Control	18.77±0.03c	22.68±0.01b	1.42a	1.18a	0.098d	0.103c	13.2d	19.2d
Nano silicon	19.42±0.14c	23.87±0.03a	1.15b	0.79b	0.118c	0.177b	16.8c	30.2c
Folic acid	20.08±0.2b	24.03±0.11a	1.07c	0.57c	0.198b	0.201a	18.7b	42.15b
Nano silicon + Folic acid	22.31±0.13a	24.29±0.21a	0.96d	0.42d	0.202a	0.218a	23.5a	58.1a

Values are average of both seasons (2018 and 2019)- Means with the same letter in a column are not significantly different by DMRT 5%, T: Turkey E: Egypt.

Data in table 7 showed that, application of mixture of nano silicon and folic acid at 30% FC significantly provided higher value of photosynthesis rate in Turkey 22.31±0.13 compared to control 18.77±0.03, where in Egyptian recorded 24.29±0.21 over control 22.68±0.01.

Concerning transpiration rate, the results mentioned in table 7 cleared that, the highest significant value of transpiration rate out came from control 1.42 compared with treatment of nano silicon and folic acid at 30% FC which gave 0.96 in Turkey. While in Egyptian the lowest value came from treatment 0.42 in comparison with control 1.18. A similar effect was observed in Turkey. Stomatal conductive in Egyptian was increased by 111.6% more than control but the percentage increase in Turkey was 106.1%. Moreover water use efficiency donated significant increasing under the same application by 202.6% over control in Egyptian, while in Turkey recorded 78% compared with untreated plants. Rosales *et al*., 2004 indicated that the stomatal conductivity and transpiration rate of bean crops under severe drought are increasing. Ashkavand *et al*., 2018 revealed that positive effect of SNPs pre-treatments on photosynthesis rate and stomatal conductance was evident after 19 days of no irrigation (severe water stress) in *Prunus mahaleb*.

Conclusions

Based on our findings mentioned above, it could be concluded that, Egyptian surpassed Turkey in all growth traits. Treatment with nano silicon and/or folic acid proved significant increase in morphological and yield parameters of two purslane cultivars compared with untreated plants under drought stress conditions. Application of mixture of nano silicon and folic acid at water stress level (30% of FC) had the highest values for morphological, yield and anatomical characters. All measured chemical composition in seeds such as percentages of nitrogen, phosphor, magnesium and calcium besides iron, manganese, zinc and copper were positively affected by the mixture of nano silicon and folic acid at 30% of FC. In this investigation spraying plants with nano silicon and folic acid under water deficit treatment demonstrate its significant importance for total chlorophyll and carbohydrates, phenolic, flavonoids, tannins, thiamine, fatty acids, a linolenic acid and ascorbic acid compared with untreated plants.

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