IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 8, April 2026
Impact Factor: 8.2

Growth Performance of *Portulaca oleracea* L. under Water Stress Conditions

Vishal V. Naik[1*] and Baburao A. Karadge[2]
[1]Department of Botany
Bharati Vidyapeeth's Matoshri Bayabai Shripatrao Kadam Mahavidyalaya, Kadegaon (MS), India
[2]Department of Botany, Shivaji University, Kolhapur (MS), India- 416 004.
*Corresponding author: purslanevvn@gmail.com

Abstract: *Water stress is one the major constraint for plants throughout the world. Portulaca oleracea Linn., is a C4 succulent belonging to family Portulacaceae, has been studied for induction of CAM under stress conditions. The main objective of present investigation was to study effect of water stress on growth performance of P. oleracea. One month old seedlings grown in acid-free-silica sand in Hoagland's culture medium were water stressed for 4, 8 and 15 days and various growth parameters were investigated and compared against well-watered plants. Results indicated that there was increase in root and shoot length, leaf area, mean internodal length, capsule to leaf ratio, leaf thickness, root diameter of plants water stressed for 8 days. However, leaf area per plant, fresh and dry weights were decreased with increase in all water stress treatments. It is also observed that the growth performance of P. oleracea grown under 15 days of water stress was negatively affected in all studied growth parameters. From the results it is concluded that P. oleracea a is moderate water stress tolerant plant and 15 days of water stress cause reduction in the overall growth performance of the plant.*

Keywords: Portulaca oleracea, growth, leaf area, fresh weight, water stress

I. INTRODUCTION

Water stress (drought) is regarded as one of the common threats to the agricultural systems throughout the world. Today, agriculture accounts for 70% of total water use. In India, about 51% of total area is under cultivation. While, water withdrawal for agricultural purpose is about 90% from total water resources (based on FAO, 2015 data). Hence, water unavailability is major constraint for agricultural production. Water is an essential factor limiting plant's growth and development. The fresh weight of most of the herbaceous plants accounts for 80-90% while, for woody plants it is over 50%[1]. The processes like photosynthesis and mineral uptake require water. Water stress affects overall plant metabolism e.g. carbohydrate and nitrogen metabolism. Low water availability tends towards decreased growth and productivity of plants. Due to water stress, plant shows alterations in their normal metabolism[2].

Portulacaceae is one of 19 families of terrestrial plants in which species having C_4 photosynthesis have been found. The representative species from the genus Portulaca such as *P. oleracea* is a C_4 plant based on carbon isotope values, Kranz anatomy and expression of key C_4 enzymes[3]. *P. oleracea* is one of the water stress tolerant plants. The leaves and stem of *P. oleracea* are succulent. It is one of the plants with high water use efficiency[4]. However, several workers have reported that *P. oleracea* shows weak CAM type of photosynthesis when exposed to water stress[5].

The main objective of the present investigation is to study effect of water stress on various growth parameters of *Portulaca oleracea*.

II. MATERIALS AND METHODS

Plant material and treatments

Seeds of *P. oleracea* were collected from field in the months of February to April. It was germinated in silica sand in plastic pots (32 cm diameter × 12 cm height), each pot containing 6 kg acid free silica sand. Plants were grown for 1 month with the supply of ½ strength Hoagland solution (Table 1) (1:1) alternating with water under natural conditions (Light intensity: 30000 lux; Temperature: 30±2^{0}C) in botanical garden of Shivaji University, Kolhapur (MS). After one month of their growth, plants were watered at an interval of 4, 8 and 15 days separately in separate pots while; control plants were watered every alternate day. Fresh plants from each pot were randomly sampled and washed first with tap water and then with distilled water and blotted dry. Root, stem and leaves were cut into pieces, weighed accurately and immediately used for analysis. All operations were done at room temperature (28±2^{0}C).

Table 1. Preparation of Hoagland's culture medium[6].

		Reagent	ml taken to prepare 1 litre full strength medium	ml taken to prepare 1 litre half strength medium
A.	**Macro elements**			
	1.	1 M KH_2PO_4	1	0.5
	2.	1 M KNO_3	5	2.5
	3.	1 M $CaNO_3$	5	2.5
	4.	1 M $MgSO_4$	2	1
B.	**Microelements**			
	1.	H_3BO_3 (2.86 g)		
	2.	$MnCl_2.4H_2O$ (1.81 g)		
	3.	$ZnSO_4.7H_2O$ (0.22 g)	1	0.5
	4.	$CuSO_4.5H_2O$ (0.08 g)		
	5.	H_2MoO_4 (0.02 g)		
C.	0.5 % Fe-EDTA		1	0.5

Salts of microelements were as shown above and dissolved in distilled water and diluted to 1 litre with distilled water. One ml/0.5 ml from this stock solution was taken for preparation of the culture medium.

Methods

i) Growth analysis

Five plants from each treatment were carefully uprooted, washed thoroughly with water to remove any dirt and dust particles on the surface of the plant parts and blotted to surface dry. This plant material was analysed for growth and development of plants using various parameters such as-Root length, shoot length, Root to shoot ratio, Number of leaves per plant, Average leaf area, Leaf area per plant, No. of capsules per plant, Mean internodal length, Capsule leaf ratio, Leaf thickness, Root diameter, Stem diameter, Fresh weight per plant, Dry weight per plant, Total fresh weight, Total dry weight, Moisture percentage, Dry matter percentage. Values are expressed in terms of ± Standard Deviation.

ii) Determination of Moisture content

Moisture content of plant parts was determined by the method described in AOAC[7]. The root, stem and leaves of purslane were collected randomly, washed and blotted dry. 10 g of this material was kept in an oven at 70^{0}C for drying till a constant weight was obtained. The loss in weight per 100 g was expressed as moisture content and calculated as follows: Moisture content (%) = [fresh weight (g) - dry weight (g) / fresh weight (g)] ×100.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 8, April 2026
Impact Factor: 8.2

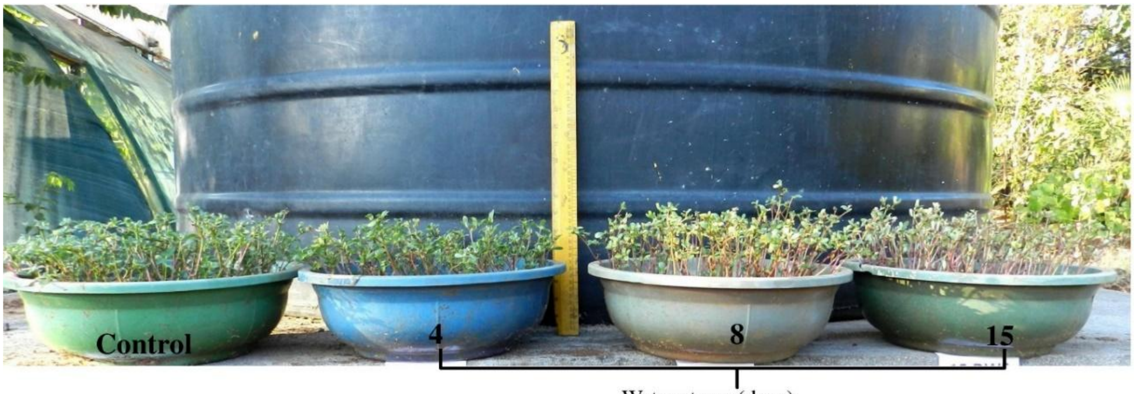

Fig. 1. Effect of water stress on growth and development of *Portulaca oleracea* Linn.

III. RESULTS AND DISCUSSION

Effect of water stress on the growth of *P. oleracea* has been investigated and depicted in Fig. 1 and Table 2. It is evident from the data that water stress of 8 days caused to increase the root and shoot length, root to shoot ratio, average leaf area, number of capsules per plant, mean internodal length, capsule to leaf ratio, leaf thickness and root diameter. However, there was decrease in the root and shoot length, root to shoot ratio, number of leaves per plant, leaf area per plant, number of capsules per plant, mean internodal length, leaf thickness and root and stem diameters due to 15 days of water stress (DWS).

The root and shoot lengths were increased due to 4 and 8 DWS and that decreased after 15 DWS (Table 5). The total height (root + shoot length) of the plants grown under 8 DWS was the highest (39.24±1.26 cm) while it was the lowest in 15 DWS plants (25.78±1.39 cm). Root : shoot ratio was calculated and it was the highest for plants grown under 8 DWS (0.39±0.03) and the lowest for 15 DWS (0.28±0.089). The mean internodal length was measured and it was found to be increased in 8 DWS (6±0.10 cm) and decreased (4.09±0.28 cm) in 15 DWS. This indicates that growth of *Portulaca* is remains unaffected and the plant can grow luxuriantly and exhibit its water stress tolerance capacity up to 8 days of water stress. However, various values in Table 2 indicated that growth and development of *P. oleracea* is poor when grown under 15 DWS.

Plant growth and productivity are adversely affected by water stress[8]. The quality and quantity of plant growth depend on cell division, cell enlargement and differentiation, which are affected by water deficit[9]. Cell growth is one of the most important drought sensitive processes due to the reduction in turgor pressure[10]. The water stress leads to limitation of plant growth mainly due to reductions in plant carbon balance, which depends on the balance between photosynthesis and respiration[11]. Numbers of workers have reported a decrease in plant height under water stress [12, 13]. Ghane *et al.*[13] investigated growth of Niger (*Guizotia abyssinica* Cass.) under water-deficit stress. They found reduction in root and shoot length followed by number of capitula in niger grown under polyethylene glycol-8000 (PEG) and percent field capacity (FC%)-induced water-deficit stress.

It is evident from the Table 2 that leaf area per plant was decreased with number of leaves per plant grown under 8 and 15 DWS. However, there was slight increase in leaf area in 4 DWS (139.6±8.10 cm^2) as compared to other treatments. Lowest leaf area (88.4±15.34 cm^2) was recorded in plants water stressed for 15 days. As shown in Table 2 value of average leaf area was the highest in 8 days water stressed plants (2.168±0.07 cm^2) and the lowest in control plants (1.73±0.17 cm^2). From this data, it is noticed that average leaf area and leaf area per plant are negatively correlated with each other in *P. oleracea* grown under 8 DWS.

Bhatt and Srinivasa Rao[14] recorded reduced leaf area of okra (*Abelmoschus esculentum* L.) due to water stress. Cakir[15] has also noticed reduced leaf area in corn (*Zea mays* L.) grown under water stress. According to Blanco and Folegatti[16] leaf area is an important variable for most eco-physiological studies in terrestrial ecosystems concerning light

DOI: 10.48175/IJARSCT-33808

ISSN: 2581-9429
Volume 6, Issue 8, April 2026
Impact Factor: 8.2

interception, evapotranspiration, photosynthetic efficiency, fertilizers, and irrigation response and plant growth. Decreased leaf area per plant indicates that there is reduction in evapotranspiration to avoid loss of water through stomata. However, it is also noticed that average leaf area was increased in 4- and 8-days water stressed plants which indicates that the plants under these water stress conditions reduce the leaf number but increase the leaf area. This increased average leaf area/surface might help plants for maximum exposure to sunlight and at the same time reduced leaf number helps to check transpiration. At severe water stress (15 days), plants exhibit reduced number of leaves along with leaf area per plant which suggests the presence of water stress survival mechanism of *P. oleracea* by limiting water transpiration through leaves.

Seed production of *P. oleracea* in terms of number of capsules is recorded in Table 2. It is evident from the values that the highest number of capsules per plant was noticed in 4 DWS (55.6±4.77) plants and that least in the plants grown under 15 DWS (40.6±7.12). As shown in Fig. 8 there was negative correlation between the number of leaves and that of capsules per plant in this plant grown under 4 and 8 DWS. However, plants exposed to 15 DWS have shown a positive correlation between the number of leaves and that of capsules per plant.

Karam *et al.*[17, 18] reported reduction in seed yield in sunflower and soybean cultivated under water stress conditions. Similarly, reduction in seed yield was also noticed by Ahmed and Suliman[19] in cowpea (*Vigna ungiculata* (L.) Walp.) grown under water stress. In the current experimental work, number of leaves and capsules are two independent parameters in *Portulaca* for 4 and 8 DWS which means plant productivity remains unaffected under water stress.

Average leaf thickness and stem diameter of *Portulaca* is depicted in Table 2. It is evident that there was increase in leaf thickness (0.18±0.004 cm) in 8 DWS plants as compared to that in well-watered control (0.15±0.007 cm). The lowest leaf thickness of 0.13±0.007 cm was measured in 15 DWS. Average stem diameter of *Portulaca* for 4 and 8 DWS was 0.56±0.027 and 0.51±0.019 cm respectively and it was decreased to 0.38±0.035 cm due to 15 DWS. Average root diameter was increased in 8 DWS (0.47±0.031 cm) and then decreased in 15 DWS (0.26±0.031 cm) plants.

Table 2. Growth and development of *Portulaca oleracea* L. under water stress conditions

Treatment (Days of water stress)	R L cm	S L cm	R : S	No. of leaves $plant^{-1}$	L A cm^2	L A $plant^{-1}$ cm^2	No. of caps-ules $plant^{-1}$	Mean inter nodal length cm	C : L	L T cm	R D cm	S D cm	Fresh wt. $plant^{-1}$ (g)			Dry wt. $plant^{-1}$ (g)		
													R	S	L	R	S	L
0 (Control)	8 ±0.46	25.9 ±0.52	0.30 ±0.017	78.4 ±2.70	1.73 ±0.17	135.7	52 ±3.60	5.82 ±0.17	0.64 ±0.067	0.015 ±0.0007	0.39 ±0.033	0.51 ±0.026	0.222 ±0.031	4.69 ±0.15	3.38 ±0.09	0.08 ±0.015	0.50 ±0.04	0.31 ±0.04
4	8.68 ±1.02	25.52 ±0.52	0.34 ±0.047	72.8 ±3.70	1.918 ±0.03	139.6	55.6 ±4.77	5.46 ±0.35	0.75 ±0.049	0.15 ±0.023	0.43 ±0.072	0.56 ±0.027	0.20 ±0.02	4.85 ±0.87	3.90 ±0.80	0.03 ±0.023	0.30 ±0.03	0.2 ±0.01
8	11.02 ±0.76	28.22 ±1.77	0.39 ±0.030	60 ±11.66	2.168 ±0.07	130.0	55 ±8.36	6.00 ±0.10	0.92 ±0.112	0.18 ±0.004	0.47 ±0.031	0.51 ±0.019	0.19 ±0.03	4.84 ±0.43	3.80 ±0.46	0.03 ±0.008	0.19 ±0.01	0.07 ±0.01
15	5.74 ±1.44	20.04 ±1.35	0.28 ±0.089	50 ±3.53	1.76 ±0.27	88.4	40.6 ±7.12	4.09 ±0.28	0.81 ±0.132	0.13 ±0.007	0.26 ±0.031	0.38 ±0.035	0.10 ±0.02	2.98 ±0.13	1.61 ±0.20	0.03 ±0.008	0.15 ±0.01	0.11 ±0.01

± Standard Deviation
R L = Root length; L A = Leaf area; R D = Root diameter; R = Root
S L = Shoot length; C : L = Capsule : Leaf Ratio; S D = Stem diameter; S = Stem
R : S ratio = Root: Shoot ratio; L T = Leaf thickness; L = Leaves

Karaba *et al.*[20] studied water use efficiency of rice growing under drought conditions. They noticed that increase in leaf thickness is responsible for increase in leaf biomass and bundle sheath cells contribute to the enhanced photosynthetic assimilation and efficiency. In the present work, increased leaf thickness of *P. oleracea* growing under 8 days water stress probably contributes to the increased photosynthetic assimilation and efficiency. It was also noticed that the succulent stem and leaves of *P. oleracea* are main water storage regions because there was increase in leaf thickness while stem diameter remains unaffected under 8 DWS and it might have helped the plants to maintain water availability for growth and development.

Fresh and dry weights of root, stem and leaves of *P. oleracea* are recorded in Table 2. It is noticed from the values that fresh weight of root was unaffected after 8 DWS and then decreased after 15 DWS. There was increase in fresh weights of stem and leaves of *Portulaca* grown under 4 and 8 DWS and then decreased significantly after 15 DWS. The highest fresh weight of roots per plant was recorded in control (0.222±0.021 g) and the lowest in 15 DWS (0.10±0.02 g) plants. The highest value recorded for fresh weight of stem per plant was 4.85±0.87 g in 4 DWS and the lowest in 15 DWS

DOI: 10.48175/IJARSCT-33808

ISSN 2581-9429 IJARSCT

(2.98±0.13 g) plants. Fresh weight of leaves per plant is recorded and it was the highest after 4 DWS (3.90±0.80 g) and the lowest in 15 DWS (1.61±0.20 g) plants. Dry weight of root, stem and leaves of *P. oleracea* was decreased due to water stress. It was noticed that the highest value for dry weight of root and stem per plant was 0.08±0.015 and 0.50±0.04 g respectively in control plants and it was the lowest in 15 DWS (0.03±0.008 and 0.15±0.01 g respectively) plants. Furthermore, dry weight of leaves per plant was the highest for control (0.31±0.04 g) and the lowest for 8 DWS (0.07±0.01 g) plants. However, dry weight of leaves in 15 DWS plants was increased as compared to that in 8 DWS plants. From fresh and dry weight of root, stem and leaves of *P. oleracea*, total fresh and dry weights per plant were calculated. It is noticed that total fresh weight per plant for 4 DWS was maximum (8.95±0.17 g) and the minimum in 15 DWS (4.69±0.11 g) plants. It is also noticed that the highest total dry weight per plant was recorded in control (0.89±0.031 g) and that lowest in 8 and 15 DWS plants. From this data, it is evident that fresh weight of root, stem and leaves of *Portulaca* was maintained during 8 DWS and it was decreased significantly after 15 days of water stress. Dry weight per plant however, was decreased with increasing the duration of water stress.

Akinci and Losel[21] reported reduction in fresh and dry weights of root, stem and leaves of two cucumber species grown under water stress. Ings *et al*.[22] investigated physiological and growth responses to water deficit in *Miscanthus* x *giganteus* a sterile hybrid between *M. sacchariflorus* and *M. sinensis*. They found decrease in fresh weight and increase in dry weight of *M.* x *giganteus* grown under water stress. According to Benesova *et al*.[23], harmful effects of drought stress on stomata closure and photosynthesis rate result in lowering the growth capacity and a decrease in biomass accumulation. In the present investigation, fresh weight of plant parts of *Portulaca* was maintained during 8 DWS but it was decreased significantly after 15 DWS. This suggests that *P. oleracea* can tolerate 8 DWS and after that plant might be going under survival mechanism. The dry weight of root, stem and leaves of *Portulaca* showed proportionate decrease with increase in water stress. The dry weight of plant includes carbohydrates, proteins, vitamins, minerals etc. In *Portulaca*, decrease in total dry weight was noticed during 4 and 8 DWS and it was maintained during 15 DWS. It is also noticed that dry weight of leaves of 15 DWS plants was higher than that in 8 DWS plants. This suggests that leaves might be the major site of storage of dry matter in *P. oleracea* under water stress.

IV. CONCLUSION

From the results, it is concluded that *P. oleracea* is a moderate water stress tolerant succulent plant. The growth parameters studies revealed that *P. oleracea* can tolerate water stress effectively up to 8 days of water stress. Earlier studies reported that *P. oleracea* show induction of CAM pathway under water stress conditions. The increase in succulence of leaf and stem suggests adaptation of this plant to store more water under stress condition.

REFERENCES

[1] Kramer, P. J. and Boyer, J. S. (1995) Water relations of plants and soils. Academic Press. San Diego.

[2] Imadi, S. R., Gul, A., Dikilitas, M., Karakas, S., Sharma, I., & Ahmad, P. (2016). Water stress: Types, causes, and impact on plant growth and development. Water stress and crop plants: a sustainable approach, 2, 343-355.

[3] Voznesenskaya, E. V., Koteyeva, N. K., Edwards, G. E., and Ocampo, G. (2010). Revealing diversity in structural and biochemical forms of C4 photosynthesis and a C3-C4 intermediate in genus Portulaca L. (Portulacaceae). Journal of Experimental Botany, 61(13): 3647-3662.

[4] Hou, P., Yun, P., Qu, M., Li, A., Ahmed, H. A. I., Khan, W. U. D., & Luo, B. (2023). Portulaca oleracea under drought stress. In Medicinal Plant Responses to Stressful Conditions (pp. 347-368). CRC Press.

[5] Jin, R., Shi, H., Han, C., Zhong, B., Wang, Q., & Chan, Z. (2015). Physiological changes of purslane (Portulaca oleracea L.) after progressive drought stress and rehydration. Scientia Horticulturae, 194, 215-221.

[6] Hoagland, C. R. and Arnon, D. I. (1950). The solution culture method for growing plants without soil. California Agric. Exp. Cir. 347. Berkeley, California.

[7] AOAC. (1980). Determination of plant water content: Official methods of analysis, 10th ed. Washington D.C.

[8] Osakabe, Y., Osakabe, K., Shinozaki, K. and Tran, L.-S. P. (2014). Response of plants to water stress. Frontiers in Plant Science, 5: 1-8.
[9] Farooq, M., Wahid, A., Kobayashi, N., Fujita, D. and Basra, S. M. A. (2009). Plant drought stress: effects, mechanisms and management. In Sustainable Agriculture. Springer Netherlands. pp. 153-188.
[10] Taiz L. and Zeiger E. (2006). Plant Physiology. 3rd Ed. Sinauer Associates Inc., Publishers Sunderland, Massachusetts U.S.A.
[11] Flexas, J., Bota, J., Galmes, J., Medrano, H., and Ribas-Carbó, M. (2006). Keeping a positive carbon balance under adverse conditions: responses of photosynthesis and respiration to water stress. Physiologia Plantarum, 127(3): 343-352.
[12] Boutraa, T., Akhkha, A., Al-Shoaibi, A. A. and Alhejeli, A. M. (2010). Effect of water stress on growth and water use efficiency (WUE) of some wheat cultivars (Triticum durum) grown in Saudi Arabia. Journal of Taibah University for Science, 3: 39-48.
[13] Ghane, S. G., Lokhande, V. H. and Nikam, T. D. (2012). Differential growth, physiological and biochemical responses of niger (Guizotia abyssinica Cass.) cultivars to water-deficit (drought) stress. Acta physiologiae plantarum, 34(1): 215-225.
[14] Bhatt, R. M. and Srinivasa Rao, N. K. (2005). Influence of pod load on response of okra to water stress. Indian Journal of Plant Physiology, 10(1): 54-59.
[15] Cakir, R. (2004). Effect of water stress at different development stages on vegetative and reproductive growth of corn. Field Crops Research, 89(1): 1-16.
[16] Blanco, F. F. and Folegatti, M. V. (2005). Estimation of leaf area for greenhouse cucumber by linear measurements under salinity and grafting. Scientia Agricola, 62(4): 305-309.
[17] Karam, F., Lahoud, R., Masaad, R., Kabalan, R., Breidi, J., Chalita, C. and Rouphael, Y. (2007). Evapotranspiration, seed yield and water use efficiency of drip irrigated sunflower under full and deficit irrigation conditions. Agricultural water management, 90(3): 213-223.
[18] Karam, F., Masaad, R., Sfeir, T., Mounzer, O. and Rouphael, Y. (2005). Evapotranspiration and seed yield of field grown soybean under deficit irrigation conditions. Agricultural Water Management, 75(3): 226-244.
[19] Ahmed, F. E., and Suliman, A. S. H. (2010). Effect of water stress applied at different stages of growth on seed yield and water-use efficiency of cowpea. Agriculture and Biology Journal of North America, 1(4): 534-540.
[20] Karaba, A., Dixit, S., Greco, R., Aharoni, A., Trijatmiko, K. R., Marsch-Martinez, N., Krishnan, A., Nataraja, K. N., Udaykumar, M. and Pereira, A. (2007). Improvement of water use efficiency in rice by expression of HARDY, an Arabidopsis drought and salt tolerance gene. Proceedings of the National Academy of Sciences, 104(39): 15270-15275.
[21] Akıncı, S. and Lösel, D. M. (2009). The soluble sugars determination in Cucurbitaceae species under water stress and recovery periods. Adv. Environ. Biol., 3(2): 175-183.
[22] Ings, J., Mur, L. A., Robson, P. R. and Bosch, M. (2013). Physiological and growth responses to water deficit in the bioenergy crop Miscanthus x giganteus. Frontiers in plant science, 4: 1-12.
[23] Benesova, M., D. Hola, L. Fischer, P. L. Jedelsky, F. Hnilicka, N. Wilhelmova, O. Rothova, M. Kocova, D. Prochazkova, J. Honnerova, Fridrichova L. and Hnilickova, H. (2012). The physiology and proteomics of drought tolerance in maize: early stomatal closure as a cause of lower tolerance to short term dehydration. PLoS ONE 7: e38017. 21. Online.