UNIVERSITI PUTRA MALAYSIA

IMPACT OF SEA WATER, DEAD SEA WATER AND NaCL ON GERMINATION, ANATOMICAL AND ANTIOXIDANT PROFILE OF MOLOKHIA (Corchorus olitorius L. Malvaceace)

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master Science

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August 2017

Chairman : Associate Professor Rosimah Nulit, PhD
Faculty : Science

High salinity is the most severe environmental stress that effects on seed germination, seedlings, and growth in the life cycle of the plants.–Salinity gave negative effect on plant development performance from germination to reproduction such as a reduction in elongation growth, reduction of leaf expansion and reduced stomatal pores and density. Few studies had been done to determine the effect of Sea water and NaCl on the germination, morphology, physiology, and antioxidant activity on Molokhia, and moreover, no study had been on the effect of Dead Sea water on Molokhia plant. This study aimed to understand the response of Molokhia (*Corchorus olitorius* L.) in different concentration of Dead Sea water, sea water, and NaCl at germination stage., anatomical features and antioxidant activity. Twenty-five sterilized Molokhia seeds were germinated in sterilized Petri dishes and treated with 5 ml deionized water (control) or with Dead Sea water, sea water, and NaCl (3‰, 6‰, 9‰, 12‰) (part per thousand), with four replicates for each treatment and were arranged randomly. Germination percentage, germination index, germination rate, salt tolerance and seed vigor were calculated. This study found the germination percentage was highest in control, 3 ‰ of Sea water and 3 ‰ of Dead Sea water (98.4 %, 93.9 %, 93.2%) respectivley, howaver, by increasing salinity concentration, seed germination delayed and decreased. Whereas, salt tolerance and seed vigor declined with increasing salinity concentration except at 3 ‰ of Dead Sea water. Biomass, stomatal conductance, and anatomical leaves of Molokhia seedling as germinated in three different types of salt were studied. Twenty seedlings were selected randomly. The results showed that seedling growth characteristics and stomatal conductance significantly reduced (ANOVA, $P<0.05$) except at 3‰ of Dead Sea water. The highest leaf area was achieved with 3‰ of Dead Sea water (7.60 mm^2). This study found that

the anatomy of seedlings leaves affected by high concentration of NaCl, sea water, and Dead Sea water (9 to 12) ‰ as salinity concentrations increased, the changes of anatomy and arrangement of cells also increased. Moreover, the arrangement of mesophylls tissues was found in disorder. The amount of chlorophyll *a*, *b*, carotenoid, total phenolic content and reduced glutathione were measured spectrophotometrically of Molokhia leaves as responses to Dead Sea water, sea water and NaCl. Around 5g of fully expanded leaves were harvested randomly. The concentration of total phenolic compound and carotenoids increased when salinity increased in all treatments which 3‰ of Dead Sea water showed the highest carotenoids (1.10 mg/ml). However, total chlorophyll, chl *a* and chl *b* decreased whilst salinity concentration increased except in 3‰ (4.70 mg/ml) and 6 ‰ (4.20 mg/ml) of Dead Sea. Reduced glutathione (GSH) is most important molecules in plant as stress marker, 3‰ and 6‰ of Dead Sea water shows the highest GSH 20 µmol/g.FW and 15 µmol/g.FW respectively. The findings of this study revealed that the salt tolerance during germination stage expedient to be used 3‰ of Dead Sea water for germination *C.olitorius* seed due to increase the biomass of seedling and leaf area exists. Therefore, more study should be conducted on Molokhia plant to understand the ecophysiological strategies for the survival under salinity environment conditions especially under 3‰ of Dead Sea water.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN AIR LAUT, AIR LAUT MATI DAN NaCl KE ATAS PERCAMBAHAN, ANATOMI DAN PROFIL ANTIOKSIDAN MOLOKHIA (*Corchorus olitorius* L*,* Malvaceace)

Oleh

AYAT MOHAMMAD MUTLEQ TANEENAH

Ogos 2017

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Kemasinan memberi kesan negatif dari peringkat percambahan hingga ke peringkat pembiakan pokok. Kajian ini dilakukan untuk mengkaji kesan air laut mati, air laut (sumber: Port Dickson) dan NaCl pada kepekatan yang berbeza terhadap percambahan biji benih, morfologi, fisiologi, dan aktiviti antioksidan Molokhia. Sebanyak 25 biji benih Molokhia yang telah disterilkan disemai ke dalam piring petri dan dirawat dengan 5 ml air ternyahion (sebagai kawalan) atau dengan air laut mati, air laut, dan NaCl (3 ‰, 6 ‰, 9 ‰, 12 ‰). Setiap rawatan mengandungi 4 replikasi dan disusun secara rawak. Peratusan percambahan, indeks percambahan, kadar percambahan, kadar toleransi rerhadap garam dan vigor benih telah dikira. Kajian ini mendapati peratus percambahan adalah paling tinggi pada kawalan, diikuti dengan 3 ‰ air laut dan 3 ‰ air Laut Mati (98.4%, 93.9%, 93.2%). Walaubagaimanapun, peningkatan kemasinan menyebabkan percambahan benih semakin lambat dan berkurangan. Kadar toleransi garam dan vigor benih juga menurun dengan peningkatan kepekatan kemasinan kecuali pada 3 ‰ air Laut Mati. Biomas, aliran stomata, dan perubahan anatomi anak benih Molokhia sebagai gerakbals terhadap kemasinan juga dilakukan. Sebanyak 20 anak benih dipilih secara rawak. Hasil kajian mendapati bahawa pertumbuhan dan aliran stomata menurun (ANOVA, $P < 0.05$) kecuali pada 3 ‰ air Laut Mati. Keluasan daun paling tinggi didapati pada rawatan 3 ‰ air laut mati (7.60 mm^2). Kajian menunjukkan perubahan anatomi dan susunan sel-sel daun sangat ketara pada kepekatan NaCl, air laut, dan air Laut Mati yang tinggi (9 - 12‰). Selain itu, susunan sel-sel dan tisu daun mesofil adalah dalam keadan tidak teratur. Kandungan klorofil, kandungan sebatian fenolik dan kandungan antioksidan pada Molokhia yang dirawat dengan air laut mati, air laut dan NaCl juga dilakukan. Jumlah klorofil *a*, *b*, karotenoid, kandungan fenolik dan glutathion diukur menggunakan

spektrofotometrik. Kandungan sebatian fenolik dan karotenoid meningkat apabila kepekatan kemasinan tinggi dimana 3 ‰ air laut mati menunjukkan karotenoid tertinggi (1.10 mg/ml). Walaubagaimanapun, jumlah klorofil *a* dan *b* menurun dalam kepekatan yang tinggi kecuali 3 ‰ (4.70 mg/ml) dan 6 ‰ (4.20 mg/ml) air Laut Mati. Penurunan kandungan Glutathion (GSH) digunakan sebagai penanda terhadap sesuatu tegasan. Hasil kajian ini mendapati 3 ‰ dan 6 ‰ air laut mati menunjukkan kandungan GSH yang tertinggi (20 µmol/g.FW dan 15 µmol/g.FW). Sebagai kesimpulam, kajian mendalam perlu dijalankan ke atas Molokhia untuk memahami strategi ekofisiologi untuk hidup di dalam persekitaran kemasinan yang tinngi terutamanya di bawah 3 ‰ air Laut Mati. Di samping itu, pada 3 ‰ air laut mati sesuai untuk dimanfaatkan bagi percambahan bijibenih *Corchorus olitorius* L. disebabkan oleh peningkatan dalam biojisim anak benih dan keluasan daun.

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Thank you and with love *Ayat Janeenah*

I certify that a Thesis Examination Committee has met on 18 August 2017 to conduct the final examination of Ayat Mohammad Mutleq Taneenah on his thesis entitled "Impact of Sea Water, Dead Sea Water, and NaCl on Germination, Anatomical, and Antioxidant Profile of Molokhia (*Corchorus olitorius* L. Malvaceace)" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIAIONS

%	Percentage
‰	Salinity symbol
° C	Degree celsius
DS	Dead sea water
S	Sea water
NaCl	Sodium chloride
FW	Fresh weight
DW	Dry weight
LA	Leaf area
GP	Germination percentage
GI	Germination index
GT	Germination rate
SV	Seed vigor
ST	Seed tolerance
µmol	Micromole
seeds day-1	Seeds per day
G	Gram
mg	Milligram
cm	Centimeter
g/area	Gram per area
mm	Millimeter
mm^2	Millimeter square
µm	Micrometer
ml	Milliliter
w/v	Weight per volume
ppt	Part per thousand
CRD	Complete random design

$\mu mol\ m^{-2}\ s^{-1}$	Light density unit
SC	Stomatal conductance
RCBD	Randomized complete block design
ROS	Reactive oxygen species
v/v	Volume per volume
nm	Nanometer
A_{663}	Value of absorption at wavelength 663 nm
A_{645}	Value of absorption at wavelength 645 nm
Chl *a*	Chlorophyll *a*
Chl *b*	Chlorophyll *b*
µl	Microlieter
FFA_{70}	Preservative (1 Formalin: 1 Acetic acid: 17 70% Ethanol alcohol)
Na_2CO_3	Sodium carbonate
mM	Millimol
ANOVA	Analysis of variance

CHAPTER 1

INTRODUCTION

Salinization is a major abiotic stress factors considered to be the main source of the delayed germination, yield reduction and limiting plant development. The salinity of soil and water is caused by soluble salts due to the deterioration and dissolving of rock, as well as concentrated as a result of evaporation. Plants are divided into two groups based on the difference in their ability to tolerate high salt concentrations; Glycophytes are highly susceptible to salinity and tolerate low concentration of salts whereas halophytes can grow and survive in saline environments and tolerate moderate-to-high concentration of salts (Munns and Tester 2008). Most crops, for example, *Corchorus olitorius*, belong to glycophyte group which gets affected by salinity due to which yield reduction and development issue rises. Furthermore, halophytes show signs of reduction when salinity reaches a certain threshold and become toxic (Shabala, 2013).

Corchorus olitorius is herbal plant, belong to glycophytes group which is popularly known as Molokhia in Middle East and highly consumed especially in Egypt, Palestine, and Jordan. It is an essential green, leafy edible vegetable that is mainly known for its fiber product, jute, iron, vitamins A, C, K and folate (Imbamba, 1973). Salinity associated with low soil moisture causes salt stress which affect seed germination, seedling growth and crop establishment.

The salinity of soil and irrigation water one of the greatest environmental strains affecting plant growth and development. Salinity influences agricultural production in many parts of the world (Shahbaz *et al*., 2012; Taneenah *et al*., 2015). The increase in the salinity of soil and water lead to the reduction of crop production, thereby adding to the continuing impact on the validity of agricultural land, and turning it into the marginal land (Paul, 2012). At least 20% all of irrigated lands and 50% of cropland have been detected to be under the effect of salt stress (Pitman and Lauchli, 2002; Machado and Serralheiro, 2017). Continuous using of saline irrigation water intensifies the problem of salinity and leads to soil degradation which will become more acute in the future (Yan *et al*., 2015; Machado and Serralheiro, 2017); hence, threaten the food security worldwide.

At present, salinity stress extent in all climatic regions also found in places below sea level, such as the area around the Dead Sea and in high mountainous regions (Pitman and Läuchli, 2002; Manchanda and Garg, 2008). Dead Sea water is the lowest spot on earth, which is located in the Middle East, between Jordan and Palestine. Dead Sea water is 10 times saltier than the ocean water. Salts carried into the river going to the Dead

Sea will not escape the sea, salts are kept and accumulated through water evaporation. In many developing countries, there are extensive costal lands where sea water and harvested water were utilized for crop production. These water resources are usually neglected, and can be used for growing halophytes (Radulovich *et al*., 2017). The greatest advantage of seawater agriculture is that it is opens up coastal lands, which were previously unusable for agricultural production due to the fresh water shortage (Magbol *et al*., 1996). Until to date, there is no comparison study had been conducted on the effect different salinity sources on the seed germination of Molokhia. Therefore, this study aimed using three different sources of salinity which are Dead Sea water, sea water and NaCl on the germination, anatomical, and growth and antioxidant of Molokhia.

Objectives of study are:

1. To study the effect of the Dead Sea water, sea water, and NaCl on the germination of Molokhia seeds.

2. To study the effect of the Dead Sea water, sea water, and NaCl salinity on the growth, stomatal conductance, and anatomical leaves of Molokhia seedlings.

3. To study the antioxidant profiling of Molokhia leaves as response to Dead Sea water, sea water and NaCl.

REFERENCES

Achakzai, A. K. K. (2009). Effect of water potential on seedling growth of sorghum cultivars. *Sarhad Journal of Agriculture*. 25:385-390.

Acosta-Motos, J. R., Ortuño, M. F., Bernal-Vicente, A., Diaz-Vivancos, P., Sanchez-Blanco, M. J., & Hernandez, J. A. (2017). Plant Responses to Salt Stress: Adaptive Mechanisms. *Agronomy*. *7*(1).18. 10.3390

Apel, K., & Hirt, H. (2004). Reactive oxygen species: metabolism, oxidative stress, and signal transduction. *Annual Review of Plant Biology*. 55: 373-399.

Agastian, P., Kingsley, S.J., Vivekanandan, M., (2000). Effect of Salinity on Photosynthesis and Biochemical Characteristics in Mulberry Genotypes. *Photosynthetica*. 38: 287–290.

Al-Yousef, H. M., Amina, M., & Ahamad, S. R. (2017). Comparative study on the chemical composition of Corchorus olitoriusl leaf and stem dry oils. *Biomedical Research*. *28*(10).

Amini, F., & Ehsanpour, A. A. (2005). Soluble proteins, proline, carbohydrates and Na^+/K^+ changes in two tomato *(Lycopersicon esculentum* Mill.) cultivars under *in vitro* salt stress. *American Journal of Biochemistry and Biotechnology*. 1(4): 212-216.

Amirjani, M. R. (2010). Effect of NaCl on some physiological parameters of rice. *European Journal of Biological Sciences.*3(1): 6-16.

Anuradha, C. (2014). Effect of salt stress on seedling growth of sunflower (*Helianthus annuus* L.). *Biotechnology*. *3*(9).

Asch, F. and Wopereis, M. (2001). Responses of field-grown irrigated rice cultivars to varying levels of floodwater salinity in a semi-arid environment*. Field Crops Research.* 70(2): 127- 137.

Ashraf, M., and Wu, D. L. (1994). Breeding for salinity tolerance in plants. *Critical Reviews in Plant Sciences.* 13(1): 17-42.

Ashraf, M. (1994). Organic substances responsible for salt tolerance in *Eruca sativa*. *Biologia Plantarum.* 36(2): 255-259.

Ashraf, M. (2009). Biotechnological approach of improving plant salt tolerance using antioxidants as markers. *Biotechnology Advances*. 27: 84-93.

Ashraf, M., Athar, H. R., Harris, P. J. C., & Kwon, T. R. (2008). Some prospective strategies for improving crop salt tolerance. *Advances in Agronomy.* 97: 45-110.

Ashraf, M., & Foolad, M. R. (2005). Pre-sowing seed treatment-a shotgun approach to improve germination, plant growth and crop yield under saline and non-saline conditions. *Advances in Agronomy.* 88: 223-271.

Athar, H. R., & Ashraf, M. (2009). Strategies for crop improvement against salinity and drought stress: An overview. In *Salinity and Water Stress,* pp. 1-16. Netherlands. Springer.

Atia, A., Ben Hamed, K., Debez, A., and Abdelly, C. (2006). Salt and seawater effects on the germination of *Crithmum maritimum*. *Biosaline Agriculture and Salinity Tolerance in Plants.* 1: 29-33.

Atkinson, N.J. and Urwin, P.E., (2012). The interaction of plant biotic and abiotic stresses: from genes to the field. *Journal of experimental botany.* 63(10): 3523-3543.

Aziz, I. and Khan, M. A. (2001). Effect of seawater on the growth, ion content and water. *Journal of Plant Research.* 114 (3): 369- 373.

Babu, M.A., Singh, D. and Gothandam, K.M., (2012). The effect of salinity on growth, hormones and mineral elements in leaf and fruit of tomato cultivar PKM1. *Journal of Animal and Plant Sciences.* 22(1):159-164.

Barku VYA, Opoku-Boahen Y, Owusu-Ansah E, Mensah EF. (2013) Antioxidant activity and the estimation of total phenolic and flavonoid contents of the root extract of *Amaranthus spinosus*. *Asian Journal of Plant Sciences.* 3(1): 69–74.

Barrs, H.D. and Weatherley, P.E., (1962). A re-examination of the relative turgidity technique for estimating water deficits in leaves. *Australian Journal of Biological Sciences.* 15(3):413- 428.

Basak, U.C., Gupta, N., Rautaray, S. and Das, P., (2004). Effects of salinity on the growth of mangrove seedlings. *Journal of Tropical Forest Science.* 16(4): 437-443.

Bendaly, A., Messedi, D., Smaoui, A., Ksouri, R., Bouchereau, A., and Abdelly, C. (2016). Physiological and leaf metabolome changes in the xerohalophyte species *Atriplex halimus* induced by salinity. *Plant Physiology and Biochemistry.* 103: 208- 218.

Bewley, J.D. and Black, M. (1994). Seeds: *Physiology of Development and Germination*, pp. 1-33, New York. Plenum Press.

Blumenthal-Goldschmidt, S. and Poljakoff-Mayber, A., (1968). Effect of substrate salinity on growth and on submicroscopic structure of leaf cells of *Atriplex halimus* L. *Australian Journal of Botany.* 16(3): 469-478.

Borghesi, E., González-Miret, M. L., Escudero-Gilete, M. L., Malorgio, F., Heredia, F. J., & Meléndez-Martínez, A. J. (2011). Effects of salinity stress on carotenoids, anthocyanins, and color of diverse tomato genotypes. *Journal of Agricultural and Food chemistry.* 59(21): 11676-11682.

Borzouei, A. (2012). Partitioning water potential and specific salt effects on seed germination of Kochia scoparia. *Indian Journal of Science and Technology*. *5*(1): 1907-1909.

Bose J, Rodrigo-Moreno A, Shabala S (2013). ROS homeostasis in halophytes in the context of salinity stress tolerance. *Journal of Experimental Botany.* 65 (5): 1241-1257.

Boughalleb, F., Denden, M. and Tiba, B.B., (2009). Anatomical changes induced by increasing NaCl salinity in three fodder shrubs, *Nitraria retusa*, *Atriplex halimus* and *Medicago arborea. Acta Physiologiae Plantarum.* 31(5):947-960.

Boyer, J.S., James, R.A., Munns, R., Condon, T.A. and Passioura, J.B., (2008). Osmotic adjustment leads to anomalously low estimates of relative water content in wheat and barley. *Functional Plant Biology.* 35(11): 1172-1182.

Bruns, S., Hechtbuchholz, C., (1990). Light and Electron-Microscope Studies on the Leaves of Several Potato Cultivars After Application of Salt at Various Developmental Stages. *Potato Research.* 33: 33–41.

Carvajal, M., Martínez, V., & Alcaraz, C. F. (1999). Physiological function of water channels as affected by salinity in roots of paprika pepper. *Physiologia Plantarum.* 105(1): 95-101.

Cave, G., Tolley, L. C., & Strain, B. R. (1981). Effect of carbon dioxide enrichment on chlorophyll content, starch content and starch grain structure in Trifolium subterraneum leaves. *Physiologia Plantarum*, *51*(2), 171-174.

Çavuşoğlu, K., Kılıç, S. and Kabar, K. (2007). Some morphological and anatomical observations during alleviation of salinity (NaCl) stress on seed germination and seedling growth of barley by polyamines. *Acta Physiologiae Plantarum.* 29(6): 551-557.

Cha-um, S. A., Charoenpanich, S., & Roytrakul, C. (2009). Sugar accumulation, photosynthesis and growth of two indica rice varieties in response to salt stress. *Acta Physiologiae Plantarum.* 31: 477–486.

Chaves, M. M., Pereira, J. S., Maroco, J., Rodrigues, M. L., Ricardo, C. P. P., Osório, M. L., & Pinheiro, C. (2002). How plants cope with water stress in the field? Photosynthesis and growth. *Annals of botany.* 89(7): 907-916.

Das, K., & Roychoudhury, A. (2016). Reactive oxygen species (ROS) and response of antioxidants as ROS-scavengers during environmental stress in plants. *Redox Homeostasis Managers in Plants under Environmental Stresses*. 53. 10.3389 .

Das, P., Nutan, K. K., Singla-Pareek, S. L., & Pareek, A. (2015). Oxidative environment and redox homeostasis in plants: dissecting out significant contribution of major cellular organelles. *Redox Homeostasis Managers in Plants under Environmental Stresses*. 9. 10.3389.

Daszkowska-Golec, A., & Szarejko, I. (2013). Open or close the gate–stomata action under the control of phytohormones in drought stress conditions. *Frontiers in Plant Science*. *4*.10.3389.

Dayal, B., and Singh, N. (2015). Molokhia-The Wealth for a Better Health. *International Journal of Research.* 2(2): 658 - 661.

Deinlein, U., Stephan, A. B., Horie, T., Luo, W., Xu, G., & Schroeder,J. (2014). Plant salt-tolerance mechanisms. *Trends in plant science*. 19(6): 371-379.

De-Pascale, S., Ruggiero, C., Barbieri, G. and Maggio, A., (2003). Physiological responses of pepper to salinity and drought. *Journal of the American Society for Horticultural Science.* 128(1): 48-54.

Debez, A., Saadaoui, D., Ramani, B., Ouerghi, Z., Koyro, H.W., Huchzermeyer, B. and Abdelly, C., (2006). Leaf H^+-ATPase activity and photosynthetic capacity of *Cakile maritima* under increasing salinity. *Environmental and Experimental Botany.* 57(3):285-295.

Delfine, S., Alvino, A., Zacchini, M., Loreto, F., (1998). Consequences of salt stress on conductance to CO_2 diffusion, Rubisco characteristics and anatomy of spinach leaves. *Australian Journal of Plant Physiology.* 25: 395–402.

Demidchik, V. (2015). Mechanisms of oxidative stress in plants: from classical chemistry to cell biology. *Environmental and Experimental Botany*. *109*: 212-228.

Doganlar, Z. B., Demir, K., Basak, H., & Gul, I. (2010). Effects of salt stress on pigment and total soluble protein contents of three different tomato cultivars. *African Journal of Agricultural Research*. 5 (15): 2056-2065.

Dong, H. (2012). Technology and field management for controlling soil salinity effects on cotton. *Australian Journal of Crop Science*, *6*(2): 333-341.

Edmonds, J. M. (1990). Systematic and ecogeographic studies on crop gene pools 4. *Herbarium Survey of African Corchorus L. species* (pp.284). IBPGR/IJO, Rome, Italy.

El-Rahman, H. S. A., & Abd–ELHak, N. A. (2015). Xanthine oxidase inhibitory activity and antigout of celery leek parsley and molokhia. *Advances in Biochemistry*. *3*(4): 40-50.

El-Kharbotly, A., Mahgoub, O., Al-Subhi, A. and Al-Halhali, A., (2003). Indigenous grass species with potential for maintaining rangeland and livestock feeding in Oman. *Agriculture, ecosystems and environment.* 95(2):.623-627.

El-Meleigy, E. A., Gaber, M. F., Mohamed, F. M., & Ismail, M. A. (2004). Responses to NaCl salinity of tomato cultivated and breeding lines differing in salt tolerance in callus cultures. *International Journal of Agriculture Biology.* 6(1): 19-26.

Emongor, V., Pule-Meulenberg, F. and Phole, O., (2004). Effect of promalin on growth and development of kale (*Brassica oleracea L. var. Acephala DC*). *Journal of Agronomy.* 3(3): 208-214.

Erturk, U., Sivritepe, N., Yerlikaya, C., Bor, M., Ozdemir, F., & Turkan, I. (2007). Responses of the cherry rootstock to salinity *in vitro*. *Biologia Plantarum.* 51(3): 597-600.

Eryilmaz, F. (2006). The relationships between salt stress and anthocyanin content in higher plants. *Biotechnology and Biotechnological Equipment.* 20: 47-52.

Fahad, S., Hussain, S., Matloob, A., Khan, F. A., Khaliq, A., Saud, S., & Faiq, M. (2015). Phytohormones and plant responses to salinity stress: a review. *Plant growth regulation*. *75*(2): 391-404.

Farshidi, M., Abdolzadeh, A. and Sadeghipour, H.R., (2012). Silicon nutrition alleviates physiological disorders imposed by salinity in hydroponically grown canola (*Brassica napus L.)* plants. *Acta physiologiae plantarum.* 34(5): 1779-1788.

Fidalgo, F., Santos, A., Santos, I., & Salema, R. (2004). Effects of long-term salt stress on antioxidant defense systems, leaf water relations and chloroplast ultrastructure of potato plants. *Annals of Applied Biology.* 145(2): 185-192

Fitter, A. H., and Hay, R. K. (2012). *Environmental physiology of plants*. UK. Academic press..

Foolad, M. R. (2004). Recent advances in genetics of salt tolerance in tomato. *Plant Cell, Tissue and Organ Culture.* 76(2): 101-119.

García Osuna, H.T., Benavides Mendoza, A., Escobedo Bocardo, L., Villarreal Quintanilla, J.A. and Cornejo Oviedo, E., (2011). Control de la hiperhidricidad en brotes in vitro de Turbinicarpus valdezianus (Möller) GL & F. *Phyton (Buenos Aires)*. *80*(2): 175-179.

Ghoulam, C. and Fares, K., (2001). Effect of salinity on seed germination and early seedling growth of sugar beet (*Beta vulgaris L.*). *Seed science and Technology.* 29(2): 357-364.

Ghoulam, C., Foursy, A. and Fares, K. (2002). Effects of salt stress on growth, inorganic ions and proline accumulation in relation to osmotic adjustment in five sugar beet cultivars. *Environmental and Experimental Botany.* 47: 9-50.

Gill, S.S., and Tuteja, N. (2010). Reactive oxygen species and antioxidant machinery in abiotic stress tolerance in crop plants. *Plant Physiology and Biochemistry.* 48: 909-930.

Gül, V., Dinler, B. S., & Sarisoy, U. (2017). Effect of Different NaCl Concentrations on Germinations Period of Oil Sunflower Seeds (*Helianthus annuus* L.) Grown in the Black Sea Region. *Journal of Agricultural Science*. *9*(4).10.5539.

Gulzar, S., Khan, M. A. and Ungar, I. A. (2001). Effect of salinity and temperature on the germination of *Urochondra setulosa* (Trin.) C. E. Hubbard. *Seed Science and Technology.* 29: 21-29.

Gulzar, S., Khan, M.A. and Ungar, I.A., (2003). Salt tolerance of a coastal salt marsh grass. *Communications in Soil Science and Plant Analysis*. 34(17-18): 2595-2605.

Gupta, B., & Huang, B. (2014). Mechanism of salinity tolerance in plants: physiological, biochemical, and molecular characterization. *International journal of genomics*, 701596.

Gururani, M. A., Venkatesh, J., & Tran, L. S. P. (2015). Regulation of photosynthesis during abiotic stress-induced photoinhibition. *Molecular plant*. *8*(9): 1304-1320.

Hadas, A. (2004). Seedbed Preparation: The Soil Physical Environment of Germinating Seeds. In: *Handbook of Seed Physiology*: *Applications to Agriculture* (pp. 3-49). New York. Food Product Press.

Hafsi C, Romero-Puertas MC, Río LA, Sandalio LM, Abdelly C (2010) Differential antioxidative response in barley leaves subjected to the interactive effects of salinity and potassium deprivation. *Plant and soil*. 334:449–460.

Haghighi, M., Afifipour, Z., & Mozafarian, M. (2012). The effect of N-Si on tomato seed germination under salinity levels. *Journal of Biological and Environmental Sciences*. *6*(16): 87-90.

Hakim, M.A., Juraimi, A.S., Hanafi, M.M., Ismail, M.R., Rafii, M.Y., Islam, M.M. and Selamat, A., (2014). The effect of salinity on growth, ion accumulation and yield of rice. *Journal of Animal and Plant Sciences.* 24(3): 874-885.

Hanin, M., Ebel, C., Ngom, M., Laplaze, L., & Masmoudi, K. (2016). New insights on plant salt tolerance mechanisms and their potential use for breeding. *Frontiers in plant science*,7: 1787.

Hasanuzzaman, M., Nahar, K. and Fujita, M., (2013). Plant response to salt stress and role of exogenous protectants to mitigate salt-induced damages. In *Ecophysiology and responses of plants under salt stress*, pp. 25-87. New York. Springer.

Hasegawa, P.M., Bressan, R.A., Zhu, J.K. and Bohnert, H.J., (2000). Plant cellular and molecular responses to high salinity. *Annual Review of Plant Biology.* 51(1): 463-499.

Harborne, J.B. (1989). Methods in plant biochemistry. In *General procedures and measurement of total phenolics,* ed. J.B. Harborne, pp. 10–11. London. Academic Press

Himabindu, Y., Chakradhar, T., Reddy, M. C., Kanygin, A., Redding, K. E., & Chandrasekhar, T. (2016). Salt-tolerant genes from halophytes are potential key players of salt tolerance in glycophytes. *Environmental and Experimental Botany*. 124: 39-63.

Hochmuth, G. J., & Hochmuth, B. C. (1991). Preliminary evaluation of production media systems for greenhouse tomatoes in Florida. In *Proceedings of the National Agricultural Plastics Congress (USA)*.

Houle, G., More, L., Reynolds, C. E. and Siége, J. (2001). The effect of salinity on different developmental stages of an endemic annual plant *Aster laurentianus* (Asteraceae). *American Journal of Botany.* 88: 62-67.

Horie, T., Karahara, I., & Katsuhara, M. (2012). Salinity tolerance mechanisms in glycophytes: an overview with the central focus

on rice plants. *Rice*, *5*(1), 11.

Hortensteiner, S., and Krautler, B. (2011). Chlorophyll breakdown in higher plants. *Biochimica et Biophysica Acta.* 1807: 977–988.

Hsiao, T.C., (1973). Plant responses to water stress. *Annual review of plant physiology.* 24(1): 519-570.

Imbamba, S. K. (1973). Leaf protein content of some Kenya vegetables. *East African Agricultural and Forestry Journal.* 38(3): 246-251.

Iqbal, N., Ashraf, M. Y., Javed, F., Martinez, V., & Ahmad, K. (2006). Nitrate reduction and nutrient accumulation in wheat grown in soil salinized with four different salts. *Journal of Plant Nutrition.* 29(3): 409-421.

Jaleel, C. A., Sankar, B., Sridharan, R., & Panneerselvam, R. (2008). Soil salinity alters growth, chlorophyll content, and secondary metabolite accumulation in *Catharanthus roseus*. *Turkish Journal Biology.* 32: 79- 83.

Jamil, M. and Rha, E.S., (2004). The Effect of Salinity (NaCl) on the Germination and Seedling of Sugar Beet (*Beta vulgaris L.*) and Cabbage (*Brassica oleracea L.*). *Plant Resources.* 7(3): 226-232.

Jamil, M., Bashir, S., Anwar, S., Bibi, S., Bangash, A., Ullah, F., & Rha, E. S. (2012). Effect of salinity on physiological and biochemical characteristics of different varieties of rice. *Pak. J. Bot*. (44): 7-13.

Jouyban, Z. (2012). The effects of salt stress on plant growth. *Technical Journal of Engineering and Applied Sciences*, *2*(1): 7-10.

Kader, M.A. and Jutzi, S.C., (2004). Effects of thermal and salt treatments during imbibition on germination and seedling growth of sorghum at 42/19°C. *Journal of Agronomy and Crop Science.* 190(1): 35-38.

Kandil, A.A., Sharief, A.E., Abido, W.A.E. and Ibrahim, M.M., (2012). Effect of salinity on seed germination and seedling characters of some forage sorghum cultivars. *International Journal of Agriculture Sciences.* 4 (7): 306-311.

Kennedy, B.F., De Filippis, L.F., (1999). Physiological and Oxidative Response to NaCl of the Salt Tolerant *Grevillea ilicifolia* and the Salt Sensitive *Grevillea arenaria*. *Journal of Plant Physiology.* 155: 746–754.

Kim MJ, Ciani S, Schachtman DP (2010). A peroxidase contributes to ROS production during *Arabidopsis* root response to potassium deficiency. *Molecular Plant.* 3:420–427.

Khan, M. S. Y., Bano, S., Javed, K., & Mueed, M. A. (2006). A comprehensive review on the chemistry and pharmacology of Corchorus species-A source of cardiac glycosides, triterpenoids, ionones, flavonoids, coumarins, steroids and some other compounds. *Journal of scientific and industrial research.* 65(4): 283.

Khan, M. A. and Gul, B. (2002). Some ecophysiological aspects of seed germination in halophytes In: *Halophyte Utilization and Regional Sustainable Development of Agriculture*.. X. Liu and M. Liu (eds.), pp. 56-68. Beijing. Metereological Press.

Khan, M. A. and Gul, B. (2006). Halophyte seed germination. In: *Eco-physiology of High Salinity Tolerant Plants*, M.A. Khan and D.J. Weber (eds), pp. 11-30. New York. Springer.

Khan, M. A. and Gulzar, S. (2003). Germination responses of *Sporobolus ioclados*: A saline desert grass. *Journal of Arid Environments.* 55: 453-464.

Khan, M. A. and Qaiser, M. (2006). Halophytes of Pakistan: Distribution, Ecology, and Economic Importance. In: *Sabkha Ecosystems*. M.A. Khan, H. Barth, G.C. Kust and B. Boer (eds.), pp. 129-153. Netherlands. Springer.

Khan, M. A., Ahmed, M. Z. and Hameed, A. (2006). Effect of sea salt and L-ascorbic acid on the seed germination of halophytes. *Journal of Arid Environment.* 65: 535-540.

Khan, M. A., Gul, B. and Weber, D. J. (2002). Effect of temperature, and salinity on the germination of *Sarcobatus vermiculatus*. *Plant Biology*.45: 133-135.

Khan, M.A., Gul, B. and Weber, D.J., (2000). Germination responses of *Salicornia rubra* to temperature and salinity. *Journal of Arid Environments.* 45(3): 207-214.

Khavari-Nejad, R.A., and Mostofi, Y., (1998). Effects of NaCl on photosynthetic pigments, saccharides, and chloroplast ultrastructure in leaves of tomato cultivars. *Photosynthetica*.35:151–154.

Koyro, H. W. (2006). Effect of salinity on growth, photosynthesis, water relations and solute composition of the potential cash crop halophyte *Plantago coronopus* (L.). *Environmental and*

Experimental Botany. 56(2):136-146.

Krishnamurthy, L., Rachid Serraj, C., Tom Hash, Abdullah, J., Dakheel, J., Belum, V. and Reddy, S. (2007). Screening sorghum genotypes for salinity tolerant biomass production. *Biochemical and Life Science.* 156 (1-2): 15-24.

Kurban, H., Saneoka, H., Nehira, K., Adilla, R., Premachandra, G. S. and Fujita, K. (1999). Effect of salinity on growth, photosynthesis and mineral composition in leguminous plant *Alhagi pseudoalhagi* (Bieb.). *Soil Science and Plant Nutrition.* 45:851-862.

Kusvuran, S. (2012). Effects of drought and salt stresses on growth, stomatal conductance, leaf water and osmotic potentials of melon genotypes (Cucumis melo L.). *African Journal of Agricultural Research*. *7*(5): 775-781.

Kuvykin IV, Ptushenko VV, Vershubskii AV, Tikhonov AN (2011). Regulation of electron transport in C3 plant chloroplasts in situ and in silico: Short-term effects of atmospheric CO_2 and O_2. *Biochimica et Biophysica Acta.* 1807:336–347.

Lauchli, A., & Grattan, S. R. (2007). Plant growth and development under salinity stress. In*: Advances in molecular breeding toward drought and salt tolerant crops Jenks*, M. A., Paul, M. H. & Jain, S. M. (ed.), pp 1–32. New York. Springer.

Lazof, D. B., & Bernstein, N. (1998). The NaCl induced inhibition of shoot growth: the case for disturbed nutrition with special consideration of calcium. *Advances in Botanical Research.* 29:113-189.

Lichtenthaler, H. K., & Buschmann, C. (2001). Chlorophylls and carotenoids: Measurement and characterization by UV-VIS spectroscopy. In: Lichtenthaler HK editor. *Current protocols in food analytical chemistry* (pp. F4.3.1−F4.3.8). New York: Wiley.

Li, Z., Ji, C., & Liu, J. (2007). Leaf area calculating based on digital image. In *International Conference on Computer and Computing Technologies in Agriculture,* pp. 1427-1433. Springer, US.

Lim, J. H., Park, K. J., Kim, B. K., Jeong, J. W., & Kim, H. J. (2012). Effect of salinity stress on phenolic compounds and carotenoids in buckwheat (*Fagopyrum esculentum* M.) sprout. *Food Chemistry.* 135 (3): 1065-1070.

Lisar, S. Y., Motafakkerazad, R., Hossain, M. M., & Rahman, I. M. (2012). Water stress in plants: causes, effects and responses.

In *Water stress*. *InTech*. Pp 1-14.

Liu, L.-P., Zang, X. Y., Yuan, Q. Y., & Cai, Q. S. (2006). Mitigating effect of exogenous sucrose on root growth of buckwheat (Fagopyrum esculentum Moench) seedlings under salt stress. *Plant Physiology Communications.* 42(5): 847–850.

Liu, X., Qiao, H., Li, W., Tadano, T. and Khan, M. A. (2006). Comparative effect of NaCl and Seawater on seed germination of *Suaeda salsa* and *Atriplex centralasiatica*. *Biosaline agriculture and salinity tolerance in plants.* 1: 45-53

Longstreth, D.J. and Nobel, P.S., (1979). Salinity effects on leaf anatomy consequences for photosynthesis. *Plant Physiology.*63(4): 700-703.

Loreto, F., Harley, P.C., Di Marco, G. and Sharkey, T.D., (1992). Estimation of mesophyll conductance to CO_2 flux by three different methods. *Plant physiology.* 98(4):1437-1443.

Maathuis, F. J., Ahmad, I., & Patishtan, J. (2014). Regulation of Na+ fluxes in plants. *Frontiers in plant science*,*5*: pp 467.

Machado, R. M. A., & Serralheiro, R. P. (2017). Soil Salinity: Effect on Vegetable Crop Growth. Management Practices to Prevent and Mitigate Soil Salinization. *Horticulturae*. *3*(2): pp 30.

Manchanda, G. and Garg, N. (2008) Salinity and its effects on the functional biology of legumes. *Acta Physiologiae Plantarum.* 30:595-618.

Magbol, A., Al Saeedi, A. and Al Dosari, M. (1996). Sea water Utilization and coastal desert greening. In: First international technical seminar for salicornia, phonex, Arizona USA.

Maroco, J.P., Pereira, J.S., Chaves, M.M., (1997). Stomatal responses to leaf-to-air vapour pressure deficit in sahelian species. *Australian Journal of Plant Physiology.* 24: 381–387.

Meiri, A. and Poljakoff-Mayber, A., (1967). The effect of chloride salinity on growth of bean leaves in thickness and in area*. Israel Journal of Botany.* 16: 115-123.

Meloni, D. A., Oliva, M. A., Ruiz, H. A., & Martinez, C. A. (2001). Contribution of proline and inorganic solutes to osmotic adjustment in cotton under salt stress. *Journal of Plant Nutrition.*24 (3): 599-612.

Memon, S. A., Hou, X., & Wang, L. J. (2010). Morphologicval analaysisi of salt stress of Pak Choi. *Journal of Environmental, Agricultural & Food Chemistry.* 9(1): 248–254.

Mguis, K., Albouchi, A. and Brahim, N.B., (2014). Germination responses of *Corchorus olitorius L*. to salinity and temperature. *African Journal of Agricultural Research.* 9(1): 65-73.

Mignolet-Spruyt, L., Xu, E., Idänheimo, N., Hoeberichts, F. A., Mühlenbock, P., Brosché, M., ... & Kangasjärvi, J. (2016). Spreading the news: subcellular and organellar reactive oxygen species production and signalling. *Journal of experimental botany*. *67*(13): 3831-3844.

Miladinova, K., Ivanova, K., Georgieva, T., Geneva, M., & Markovska, Y. (2013). The salinity effect on morphology and pigments content in three paulownia clones grown *ex vitro. Bulgarian Journal of Agricultural Science.* 19(2): 52-56.

Mitsuya, S., Takeoka, Y., Miyake, H., (2000). Effects of sodium chloride on foliar ultrastructure of sweet potato (Ipomoea batatas Lam.) plantlets grown under light and dark conditions *in vitro*. *Journal of Plant Physiology.* 157: 661–667.

Mittova, V., Tal, M., Volokita, M., & Guy, M. (2003). Up-regulation of the leaf mitochondrial and peroxisomal antioxidative systems in response to salt-induced oxidative stress in the wild salt-tolerant tomato species *Lycopersicon pennellii*. *Plant, cell and environment*. 26(6): 845-856.

Mohammad, M., Shibli, R., Ajlouni, M., & Nimri, L. (1998). Tomato root and shoot responses to salt stress under different levels of phosphorus nutrition. *Journal of plant nutrition.* 21(8): 1667-1680.

Mohammadizad, H. A., Khazaei, I., Ghafari, M., Sinehsar, M. F. F., & Barzegar, R. (2013). Effect of salt and drought stresses on seed germination and early seedling growth of nepeta persica. *International Journal of Farming and Allied Sciences*. *2*(21): 895-899.

Molazem, D., Qurbanov, E. M., & Dunyamaliyev, S. A. (2010). Role of proline, Na and chlorophyll content in salt tolerance of corn (*Zea mays* L.). *American-Eurasian Journal of Agricultural and Environmental Science.* 9 (3): 319-324.

Momani, K., El-Hasan, T., Auaydeh, S. and Al-Nawayseh, K., (2009). Heavy metals distribution in the Dead Sea black mud,

Jordan. *The Jordan Journal of Earth and Environmental Sciences*. 2(2): 81-88.

Munns, M. (2009). Strategies for Crop Improvement in saline soils. In: *Salinity and water stress* (pp. 99-110). Netherlands. Springer.

Munns, R. (1993). Physiological processes limiting plant growth insaline soil: some dogmas and hypotheses. *Plant, Cell and Environment.* 16: 15–24.

Munns, R. (2002). Comparative physiology of salt and water stress. *Plant, Cell and Environment.* 25: 239–250.

Munns, R. and James, R. A. (2003). Screening methods for salinity tolerance: a case study with tetraploid wheat. *Plant and Soil.* 253: 201–218

Munns, R. and Tester, M., (2008). Mechanisms of salinity tolerance*. Annual Review of Plant Biology.* 59: 651-681.

Moucheshi AS, Pakniyat H, Pirasteh-Anosheh H, Azooz MM. (2014). Role of ROS signaling molecule in plants. In: Ahmad P (ed) Oxidative damage to plants. *Elsevier*, The Netherland. Pp 585–620.

Naczk, M., & Shahidi, F. (2004). Extraction and analysis of phenolics in food. *Journal of Chromatography A.* 1054(1): 95-111.

Naczk, M., & Shahidi, F. (2006). Phenolics in cereals, fruits and vegetables: Occurrence, extraction and analysis. *Journal of Pharmaceutical and Biomedical Analysis.* 41(5): 1523-1542.

Narawatthana, S. (2013). *The regulation of leaf thickness in rice* (*Oryza sativa L.).* PhD thesis, University of Sheffield.

Negi, J., Hashimoto-Sugimoto, M., Kusumi, K., & Iba, K. (2013). New approaches to the biology of stomatal guard cells. *Plant and Cell Physiology*. *55*(2): 241-250.

Negrão, S., Schmöckel, S. M., & Tester, M. (2017). Evaluating physiological responses of plants to salinity stress. *Annals of botany*. 119(1): 1-11.

Nissenbaum, A. (1977). Minor and trace elements in Dead Sea water. Chemical Geology. 19(1), 99-111.

Noctor G, Mhamdi A, Chaouch S, Han Y, Neukermans J, Marquez-Garcia B, Queval G, Foyer CH (2012) Glutathione in plants: an integrated overview. *Plant Cell Environment*. 35:454–484

Noe, G. B. and Zedler, J. B. (2000). Differential effects of four abiotic factors on the germination of salt marsh annuals. *American Journal of Botany.* 87: 1679-1692.

Oboh, G.,Radatz, H. &Henle, T. (2009) „Characterization of the antioxidant properties of hydrophilic and lipophilic extracts of Jute (Corchorus olitorius) leaf. *International Journal of Food Sciences and Nutrition.* 60: 124-134.

Ogunrinde, A.T. and Fasinmirin, J.T., (2012). Soil Moisture Distribution Pattern and Yield of Jute Mallow (*Corchorus olitorius*) under Three Different Soil Fertility Management. *COLERM Proceedings.* 2: 372-380.

Okçu, G., Kaya, M.D. and Atak, M., (2005). Effects of salt and drought stresses on germination and seedling growth of pea (*Pisum sativum L.*). *Turkish Journal of Agriculture and Forestry.* 29(4): 237-242.

Okusanya, O. T. (1979). Quantitative analysis of the effects of photoperiod, temperature, salinity and soil types on the germination and growth of Corchorus olitorius. *Oikos*, 444-450.

Oladiran, J.A., (1986). Effect of stage of harvesting and seed treatment on germination, seedling emergence and growth in *Corchorus olitorius* 'Oniyaya'.*Scientia Horticulturae.* 28(3): 227-233.

Oyedele, D.J., Asonugho, C. &Awotoye, O.O. (2006). Heavy metals in Soil and Accumulated by Edible Vegetable after phosphate fertilizer application"*Electron. Journal of Environmental and Agricultural Food Chemistry.* 5(4):1446-1453.

Özdemir, F., Bor, M., Demiral, T. and Türkan, İ., (2004). Effects of 24-epibrassinolide on seed germination, seedling growth, lipid peroxidation, proline content and antioxidative system of rice (*Oryza sativa L.*) under salinity stress. *Plant Growth Regulation.* 42(3): 203-211.

Pallardy, S. (2008) Physiology of woody plants.Burlington Academic Press.Pang, C. H., & Wang, B. S. (2008). Oxidative stress and salt tolerance in plants. In *Progress in botany,* pp 231-245.Berlin Heidelberg. Springer.

Panuccio, M.R., Jacobsen, S.E., Akhtar, S.S. and Muscolo, A., (2014). Effect of saline water on seed germination and early seedling growth of the halophyte quinoa. *AoB Plants.* 6: 47.

Parida, A. K., & Das, A. B. (2005). Salt tolerance and salinity effects on plants: a review. *Ecotoxicology and Environmental Safety.* 60(3): 324-349.

Parida, A.K., Das, A.B., Mittra, B., (2004). Effects of salt on growth, ion accumulation, photosynthesis and leaf anatomy of the mangrove, Bruguiera parviflora. *Trees – Structure and Function.* 18:167–174.

Paul, D., (2013). Osmotic stress adaptations in rhizobacteria. *Journal of basic microbiology.*53(2): 101-110.

Pedranzani, H., Sierra-de-Grado, R., Vigliocco, A., Miersch, O., & Abdala, G. (2007). Cold and water stresses produce changes in endogenous jasmonates in two populations of *Pinus pinaster* Ait. *Plant Growth Regulation.* 52: 111–116.

Perez, T., Moreno, C. Seffino, G. L. Grunber, A. Bravo, S. and Zenoff, A. (1998). Salinityeffects on the early development stages of *Panicum coloratum*: Cultivar differences. *Grass and Forage Science.* 53(3): 270-278.

Petridis, A., Therios, I., Samouris, G., & Tananaki, C. (2012). Salinity-induced changes in phenolic compounds in leaves and roots of four olive cultivars (*Olea europaea* L.) and their relationship to antioxidant activity. *Environmental and Experimental Botany.* 79: 37-43.

Pinheiro, H. A., Silva, J. V., Endres, L., Ferreira, V. M., Camara, C. A., Cabral, F. F. (2008). Leaf gas exchange, chloroplastic pigments and dry matter accumulation in castor bean (*Ricinus communis* L) seedlings subjected to salt stress conditions. *Industrial Crops and Products.* 27(3): 385-392.

Pitman, M. G. and Lauchli, A. (2002). Global impact of salinity and agricultural ecosystems. In: Salinity: environment plants molecules Läuchli A, Lüttge U, eds (pp3–20). Netherlands, Springer.

Piwowarczyk, B., Tokarz, K., & Kamińska, I. (2016). Responses of grass pea seedlings to salinity stress in in vitro culture conditions. *Plant Cell, Tissue and Organ Culture (PCTOC)*.124(2): 227-240.

Podsędek, A. (2007). Natural antioxidants and antioxidant capacity of Brassica vegetables: A review. *LWT-Food Science and Technology.* 40(1): 1-11.

Pospíšil P. (2009). Production of reactive oxygen species by photosystem II. *Biochimica et Biophysica Acta.* 1787:1151–

1160.

Prior, R. L., & Cao, G. (2000). Analysis of botanicals and dietary supplements for antioxidant capacity: a review. *Journal of AOAC International.* 83(4): 950-956.

Radulovich, R., Rodríguez, M. J., & Mata, R. (2017). Growing halophytes floating at sea. *Aquaculture Reports*. 8: 1-7.

Rao, M. S., Jindal, P. C., & Dalal, M. A. (1991). *In vitro* effects of NaCl on leaf damage and chlorophyll content of grapes (*Vitis vinifera* L.). *Current Agriculture.* 15: 35-40.

Rao, S., and Jabeen, F. T. Z. (2013). Optimization of Protocols for Callus Induction, Regeneration and Acclimatization of Sugarcane (*Saccharum officinarum* L.) Cultivar CO-86032. *Current Trends in Biotechnology and Pharmacy. 7*(4):861

Ratnakar, A. and Rai, A., (2013). Effect of sodium chloride salinity on seed germination and early seedling growth of *Trigonella foenum-graecum l*. Var. Peb. Octa *Journal of Environmental Research.*1(4):304-309.

Redondo-Gómez, S., Mateos-Naranjo, E., Wharmby, C., Luque, C.J., Castillo, J.M., Luque, T., Mohamed, M.F., Davy, A.J. and Figueroa, M.E., (2007). Bracteoles affect germination and seedling establishment in a Mediterranean population of Atriplex portulacoides. *Aquatic botany.* 86(1): 93-96.

Richter, H. and Wagner, S.B., (1983). Water stress resistance of photosynthesis: some aspects of osmotic relations. In *Effects of Stress on Photosynthesis (*pp 45-53). Netherlands. Springer.

Romero-Aranda, R., Soria, T., & Cuartero, J. (2001). Tomato plant-water uptake and plant-water relationships under saline growth conditions. *Plant Science.* 160(2): 265-272.

Rosimah Nulit, Lecturer of the Faculty of Science, Universiti Putra Malaysia, pers. Comm. 20 August 2010.

Roychoudhury, A., and Ghosh, S. (2013). Physiological and biochemical responses of mungbean (Vigna radiata L. Wilczek) to varying concentrations of cadmium chloride or sodium chloride. *UNnique Journal of Pharmaceutical and Biological Sciences*. *1*(3): 11-21.

Ryu, H., & Cho, Y. G. (2015). Plant hormones in salt stress tolerance. *Journal of Plant Biology*. *58*(3): 147-155.

Sabir, F., Sangwan, R. S., Kumar, R., & Sangwan, N. S. (2012). Salt stress-induced responses in growth and metabolism in callus cultures and differentiating *in vitro* shoots of indian ginseng (*Withania somnifera* Dunal). *Journal Plant Growth Regulation*. 31 (4), 537-548.

Sadeghian, S. Y. and Yavari, N. (2004). Effect of water deficit stress on germination and early seedling growth in sugar beet. *Journal of Agronomy and Crop Science*. 190, 138-144.

Sakamoto, A. and Murata, N. (2002). The role of glycine betaine in the protection of plants from stress: Clues from transgenic plants. *Plant, Cell and Environment. 25*, 163-171.

Santos, C. V. (2004). Regulation of chlorophyll biosynthesis and degradation by salt stress in sunflower leaves. *Scientia Horticulturae*. 103(1), 93-99.

Schippers, R., Maundu, P., Imbuni, M., & Obiero, H. (2002). *How to grow and Use Jew's mallow*. Horticultural Development Services, Baarn, The Netherlands.

Schletz, R., (2008). Stomata densities of developing and mature leaves of Geraniums. *ESSAI.* 6(1): 126-132.

Schwabe, K. A., Iddo, K. and knap K. C. (2006). Drain water management for salinity mitigation in irrigated agriculture. *American Journal of Agricultural Economics.* 88: 133-140.

Schulze, E. D. (1986). Carbon dioxide and water vapor exchange in response to drought in the atmosphere and in the soil. *Annual Review of Plant Physiology.* 37(1): 247-274.

Sepehr, M. F., & Ghorbanli, M. (2006). Physiological responses of *Zea mays* seedlings to interactions between cadmium and salinity. *Journal of Integrative Plant Biology.* 48(7): 807- 813.

Shabala, S. (2013). Learning from halophytes: physiological basis and strategies to improve abiotic stress tolerance in crops. *Annals of Botany*. 112(7): 1209-1221.

Shahbaz, M., Ashraf, M., Al-Qurainy, F., & Harris, P. J. C. (2012). Salt tolerance in selected vegetable crops. *Critical Reviews in Plant Sciences.* 31: 303–320.

Shannon, M. C., and Grieve, C. M. (1998). Tolerance of vegetable crops to salinity. *Scientia Horticulturae.* 78(1-4): 5-38.

Shannon, M. C., Grieve, C. M. and Francois, L. E. (1994). Whole-plant response to salinity. In *Plant-Environment Interactions*, Ed. R.E.

Wilkinson, Marcel Dekker (pp 199- 244). New York.

Shannon, M. (1984). Breeding, selection, and the genetics of salt tolerance. In *Salinity Tolerance in Plant Strategies for Crop Improvement.* R. Staples and G. H. Toenniessen, Eds. (pp. 23 I-254). New York. Wiley-Interscience.

Sharma, P., Jha, A. B., Dubey, R. S., & Pessarakli, M. (2012). Reactive oxygen species, oxidative damage, and antioxidative defense mechanism in plants under stressful conditions. *Journal of botany*. 10.1155/2012/217037.

Shibli, R. A., Kushad, M., Yousef, G. G., & Lila, M. A. (2007). Physiological and biochemical responses of tomato microshoots to induced salinity stress with associated ethylene accumulation. *Plant Growth Regulation.*51(2): 159-169.

Shrivastava, P.,and Kumar, R., (2015). Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. *Saudi journal of biological sciences.* 22(2): 123-131.

Sharma, P. K., & Hall, D. O. (1991). Interaction of salt stress and photoinhibition on photosynthesis in barley and sorghum. *Journal of Plant Physiology.* 138(5): 614-619.

Siddiqi, E. H., Ashraf, M., Hussain, M., & Jamil, A. (2009). Assessment of intercultivar variation for salt tolerance in safflower (*Carthamus tinctorius* L.) using gas exchange characteristics as selection criteria. *Pakistan Journal of Botany.* 41(5): 2251-2559.

Siler, B., Misic, D., Filipovic, B., Popovic, Z., Cvetic, T., & Mijovc, A. (2007). Effects of salinity on *in vitro* growth and photosynthesis of common centaury (*Centaurium erythraea* Rafn.). *Archives of Biological Sciences.* 59(2): 129-134.

Smirnoff, N. (1993). The Rote of Active Oxygen in the Response of Plants to Water Deficit and Desiccation. *New Phytologist.* 1 (25):27-58.

Sotiropoulos, T. E. (2007). Effect of NaCl and CaCl2 on growth and contents of minerals, chlorophyll, proline and sugars in the apple rootstock M 4 cultured *in vitro*. *Biologia Plantarum.* 51(1): 177-180.

Stefanov, M., Yotsova, E., Rashkov, G., Ivanova, K., Markovska, Y., & Apostolova, E. L. (2016). Effects of salinity on the photosynthetic apparatus of two Paulownia lines. *Plant*

Physiology and Biochemistry. 101: 54-59.

Stepien, P., Johnson, G.N., (2009). Contrasting Responses of Photosynthesis to Salt Stress in the Glycophyte Arabidopsis and the Halophyte Thellungiella: Role of the Plastid Terminal Oxidase as an Alternative Electron Sink. *Plant Physiology.* 149: 1154–1165.

Taamalli, W., Abaza, L., Ben Youssef, N., Daoud Ben Miled, D. and Zarrouk, M. (2004). Dégradation des lipides dans les semences de tournesol (Helianthus annuus L.) au cours de la croissance post germinative en conditions de stress salin. *La Rivista Italiana Delle Sostanze Grasse. 2*: 90-97.

Taneenah, A., Nulit, R., Yusof, U. K., & Janaydeh, M. (2015). Tolerance of Molokhia (Corchorus olitorius L.) seed with dead sea water, sea water, and NaCl: germination and anatomical approach. *Advances in Environmental Biology*. *9*(27): 106-116.

Tantawy, A. S., Abdel-Mawgoud, A. M. R., El-Nemr, M. A., & Chamoun, Y. G. (2009). Alleviation of salinity effects on tomato plants by application of amino acids and growth regulators. *European Journal Scientific Research.* 30: 484–494.

Tausz, M., Šircelj, H., & Grill, D. (2004). The glutathione system as a stress marker in plant ecophysiology: is a stress-response concept valid?. *Journal of Experimental Botany.* 55(404): 1955-1962.

Trchounian, A., Petrosyan, M., & Sahakyan, N. (2016). Plant Cell Redox Homeostasis and Reactive Oxygen Species. In *Redox State as a Central Regulator of Plant-Cell Stress Responses*. Pp. 25-50.

Tsegay, B. A., & Gebreslassie, B. (2014). The effect of salinity (NaCl) on germination and early seedling growth of Lathyrus sativus and Pisum sativum var. abyssinicum. *African Journal of Plant Science*. *8*(5): 225-231.

Tulio, A.Z., Ose, K., Chachin, K. and Ueda, Y., (2002). Effects of storage temperatures on the postharvest quality of jute leaves (*Corchorus olitorius L.*). *Postharvest biology and technology.* 26(3): 329-338.

Uddin, M. K., & Juraimi, A. S. (2013). Salinity tolerance turfgrass: history and prospects. *The Scientific World Journal*. 6-11.

Ungar, I. A. (1996). Effect of salinity on seed germination, growth and ion accumulation of *Atriplex patula* (Chenopodiaceae). *American Journal of Botany.* 83: 604–607.

Vaidyanathan, H., Sivakumar, P., Chakrabarty, R., & Thomas, G. (2003). Scavenging of reactive oxygen species in NaCl-stressed rice (*Oryza sativa* L.) differential response in salt-tolerant and sensitive varieties. *Plant Science.* 165(6): 1411-1418.

Weatherley, P., (1950). Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. *New Phytologist.* 81-97.

Wellburn, A. R. (1994). The spectral determination of chlorophylls *a* and *b*, as well as total carotenoids, using various solvents with spectrophotometers of different resolution. *Journal of plant physiology.* 144(3): 307-313.

Werner, A., and Stelzer, R., (1990). Physiological responses of the mangrove Rhizophora mangle grown in the absence and presence of NaCl. *Plant, Cell and Environment.* 13(3): 243-255.

Wu, G. Q., Jiao, Q., & Shui, Q. Z. (2015). Effect of salinity on seed germination, seedling growth, and inorganic and organic solutes accumulation in sunflower (Helianthus annuus L.). *Plant Soil Environ*. 61: 220-226.

Yan, N., Marschner, P., Cao, W., Zuo, C., & Qin, W. (2015). Influence of salinity and water content on soil microorganisms. *International Soil and Water Conservation Research*. *3*(4): 316-323.

Yari, L., Daryaei, F., & Sadeghi, H. (2015). Evaluation of seed size and NaCl stress on germination and early seedling growth of sunflower (Helianthus annuus L.). *International Journal of Agronomy and Agricultural Research*. *7*(3): 60-65.

Yin, Y., Adachi, Y., Ye, W., Hayashi, M., Nakamura, Y., Kinoshita, T., Mori, I.C. and Murata, Y., (2013). Difference in abscisic acid perception mechanisms between closure induction and opening inhibition of stomata. *Plant physiology.* 163(2): 600- 610.

Yokoi, S., Bressan, R. A., & Hasegawa, P. M. (2002a). Salt stress tolerance of plants. *JIRCAS Working Report.* 1: 25-33.

Yuan, G., Wang, X., Guo, R., & Wang, Q. (2010). Effect of salt stress on phenolic compounds, glucosinolates, myrosinase and antioxidant activity in radish sprouts. *Food Chemistry.* 121(4): 1014-1019.

Zakaria, ZA, Sulaiman MR, Jais AM, *et al*. (2006) The antinociceptive activity of *Muntingia calabura*aqueous extract and the involvement of L-arginine/nitric oxide/cyclic

guanosine monophosphate pathway in its observed activity in mice. *Fundam. Clin. Pharmacol.,* 20: 365–372.

Zapata, P. J., Pretel, M. T., Amorós, A., & Botella, M. Á. (2003). Changes in ethylene evolution and polyamine profiles of seedlings of nine cultivars of Lactuca sativa L. in response to salt stress during germination. *Plant Science.* 164(4): 557- 563.

Zeinali, H., Hezarjaribi, E. and Ahmadi. M. R. (2002). Evaluation of genetic correlation of seed oil with some important agronomic traits in soybean through path analysis. Iran. *Journal of Agriculture Science.*33(4): 699-705.

Zhang, L., Ma, H., Chen, T., Pen, J., Yu, S. and Zhao, X., (2014). Morphological and Physiological Responses of Cotton (*Gossypium hirsutum L.*) Plants to Salinity. *PLOS One.* 9(11): 1-14.

Zhang, J. L., & Shi, H. (2013). Physiological and molecular mechanisms of plant salt tolerance. *Photosynthesis research*. *115*(1): 1-22.