International Journal of Life Sciences 10 (1) : 2016; 1 - 6

An Independent, Open Access, Peer Reviewed, Non-Profit Journal
International Journal of Life Sciences
ISSN 2091-0525
website: http://nepjol.info/index.php/IJLS/index

Founded 2007
International Journal of Life Sciences

Review Article

Effect of Drought Stress and its Mechanism in Plants

Amin Fathi[1], Davood Barari Tari[2]

[1]*Young Researchers and Elite Club, Ayatollah Amoli Branch, Islamic Azad University, Amol, Iran.*
[2]*Department of Agronomy, Ayatollah Amoli Branch Islamic Azad University, Amol, Iran.*

Article Information

***Key words:* Drought stress; mechanisms; crop; morphological characteristics**

ABSTRACT

Drought is the most important abiotic factor limiting growth, adversely affect growth and crop production. Stresses, resulting in the non-normal physiological processes that influence one or a combination of biological and environmental factors. Stress can damage which has occurred as a result of an abnormal metabolism and may reduce growth, plant death or the death of the plant develops. Production is limited by environmental stresses, according to different scholars estimates, only 10 percent of the world's arable land is free from Stress, in general, a major factor in the difference between yield and potential performance, environmental stresses. Drought and stress is the most common environmental stresses that almost 25 percent of agricultural lands for agricultural farm products in the world is limited. Drought risk to successful production of crops worldwide and occurs when a combination of physical and environmental factors causing stress in plants and thus reduce production.

INTRODUCTION

The crop growth and development are constantly influenced by environmental conditions such as stresses which are the most important yield reducing factors in the world (Dennis, 2000). Drought stress is considered as one of the crop performance limiting factors and a threat for successful crop production. Drought tolerance is important trait related to yield. To improve this trait, breeding requires fundamental changes in the set of relevant attributes, finally emerging as something named drought tolerance (Maleki et al, 2013). Drought, one of the most important environmental stresses that in many parts of the world, especially in warm and dry areas of crop yield are limited (Porudad and Beg, 2003). International Maize and Wheat Research Center researchers believe that the stiffness on wheat growth stages occur in three ways. In the first case, which is specific to the Mediterranean climate, the rainfall occurs during the winter and transplant only after the flowering stage drought are faced. The stiffness of about 6 million hectares of land occurs wheat (Kafi and Mahdavi Damghani 1999). The second type drought during the winter and the plants before flowering occurs after this period will not be encounter with drought. Van-Ginkel (1998) suggests that more than 3 million hectares of land under wheat cultivation of this type are affected by drought. The third type of wheat growth period occurs continuously in all of moisture stored in the soil and plant growth follows. Two to three million acres of wheat in the world of this type of drought is affected.

UNDERSTANDING DROUGHT BY PLANTS

Plant roots can sign (warning) to send the air to show that they are under water stress and tension we experience before he leaves, stomata are closed. The sign (warning), ABA hormone that is produced as a result of stress in the root tip (Pornajaf, 2005). In this respect, there is general agreement that the most important plant hormone abscisic acid is a major role in the life cycle of plants and many important physiological processes, morphological and plant adaptation to the environment, as well as reactions to adjust the tension (Kafi and Mahdavi

***Corresponding author Email address: amin_agronomist@yahoo.com**

DOI:dx.doi.org/10.3126/ijls.v10i1.14509

Damghani 1999). Strong evidence indicating that stomatal closure by ABA stress there. Stress reduction can be one of the major tasks of the ABA. ABA cis-trans, a hormone that is produced in the leaves. Synthesis rate of these hormones resulting in hormone concentrations in the leaves, thus increasing water stress(Mohsenzadeh et al, 2006). In case of lack of water in the root zone and reduce the pressure in the cells of this region, ABA synthesis in roots and aerial parts of the plant quickly spread (Ghodsi et al, 1998). Due to the fast reaction of stomatal guard cells during stress (stomatal closure at noon the weather is warm, low water absorption and transpiration rate increases) Many scientists believe that the ABA should take place in the near or inside the cells stomatal guard to be able to act quickly so the theory of trans to sis conversion (active form ABA) have raised. Then, ABA through stomatal closure down to the roots and shoots of various genes involved in the function of the genes related to known Absisic asid (Ghodsi et al, 1998). Scientists, accumulation materials such as carbohydrates and amino acids in plant cells that are called compatible solutes are known to play a role (Ourcut and Nilsson, 2000). Compatible soluble, low molecular weight compounds that interfere with cellular biochemical reactions normally do during osmotic stress, act as guards. In addition to the primary role in osmoregulation of these compounds may have an important role as protecting enzymes and membrane structure and eliminate active oxygen free radicals (Ourcut and Nilsson, 2000). Moisture reduction reactions such as protein degradation and accumulation of free amino acids in order to adjust the osmotic pressure of the cell followed (Bajji et al., 2001). In situations where moderate or severe stress, increases the concentration of proline, proline as a nitrogen storage tank or soluble cytoplasmic osmotic potential decrease in acts of plant stress tolerance assists (Ghodsi et al, 1998).

Chlorophyll is one of the major chloroplast components for photosynthesis (Rahdari et al, 2012). The decrease in chlorophyll content under drought stress has been considered a typical symptom of pigment photo oxidation and chlorophyll degradation (Anjum et al, 2011). Decreased of chlorophyll content during drought stress depending on the duration and severity of drought level (Zhang and Kirkham, 1996). A decrease of total chlorophyll content with drought stress implies a lowered capacity for light harvesting. Since the production of reactive oxygen species is mainly driven by excess energy absorption in the photosynthetic apparatus, this might be avoided by degrading the absorbing pigments (Mafakheri et al, 2010). In relation to drought effect on chlorophyll a and b in leaf, we can express that drought is due to chloroplastic proteins hydrolysis, decreasing of leaf pigments and chlorophyll destruction as a primary stagein degradation of proteins (Synerri et al., 1993).

PHYSIOLOGICAL DROUGHT STRESS

In terms of of plant physiology, dryness causes of stress in plant growth, yield 50-30% reduction in drought stress due to low humidity in plant growth occurs as a result of the high evapotranspiration, temperature high intensity of sunlight(Ghodsi et al, 1998), high temperature caused by the drought stress of increased respiration, photosynthesis and enzyme activity in the plant. Drought in the sun, the light reaction of photosynthesis and continued production of free radicals of oxygen leading to plant death is light and oxidation. Absorb nutrients from the upper soil horizon, which is found in most foods, the drought reduced (Bagheri, 2009). The increase in drought conditions, accumulation of salts and ions in the upper layers of the soil around the root cause osmotic stress and ion toxicity. The first response to stress is a biophysical response. In fact, with increasing drought stress, cell wall wizened and loose, with a decrease in cell volume, pressure decreases and the potential for the development of the cell, depending on the potential pressure decreases and growth is reduced. These factors are the size and number of leaves in plants (Bagheri, 2009). Leaf mesophyll cells become dehydrated due to drought. The amount of abscisic acid had to be stored in the chloroplasts in the guard cells used and the construction of ABA in guard cells and mesophyll increased. With the increase of ABA, potassium and calcium out of the cell where it is guard cell. The result of this process stomatal closure, with the loss of water in the guard cell. Lack of water, the rate of photosynthesis in plants decreases. This is due to the decrease of photosynthetic enzymes. The shortage of water, causing discoloration and leaf trichomes and stomata on the leaf surface is increased. In conditions of severe water shortage, the roots will shrink and in the leaves induced deposition (Bagheri, 2009).

MOLECULAR RESPONSES TO DROUGHT

In drought conditions, reduced water potential and increased cell content of ABA, regulate the metabolism of cells. Increase substances such as proline, glycine and betaine can be one of the major molecular responses to drought stress is (Matysik et al, 2002). Accumulation of solutes in cells under stress conditions, in order to maintain cell volume against the loss of water, called the osmotic adaptation (Heidaiy and Moaveni, 2009). Drought stress induced free radicals cause lipid peroxidation and membrane deterioration in plants (Nair et al, 2008). Drought stress leads to an imbalance between antioxidant defenses and the amount of Reactive Oxygen Species (ROS) resulting in oxidative stress. ROS are necessary for intracellular signaling but at high concentration can cause damage at various levels of organization including chloroplasts (Smirnoff, 1993). ROS have the capacity to initiate lipid peroxidation and degrade proteins, lipids and nucleic acids (Hendry, 2005). Mechanism of retardation of lipid peroxidation consists of free radical scavenging enzymes such as catalase, peroxidase and superoxide dismutase (Fridovich et al., 2000). A number of enzymatic and non-enzymatic antioxidants are present inchloroplasts that serve to prevent ROS accumulation (Srivalli et al., 2003). Under water stress, the formation of ROS increased and the antioxidant system protects the cell by controlling the intracellular ROS concentration. One of the expected consequences of water stress induced cellular buildup of ROS is an increase in lipid peroxidation. The peroxidation of lipids in the cell membrane is one of the most damaging cellular responses observed in response to water stress (Thankamani et al., 2003).The amount of lipid per oxidation has also long been considered as one of the factors, which indicate the severity of stress experienced by a plant (Chowdhury and Chowdhury, 1985).

WATER SCARCITY AND DROUGHT RESISTANCE

Yield of lack of water, depending on water availability and water use efficiency of the whole. The ability for water or plant water use efficiency is greater, will be more resistant to drought and adaptation of some plants, such as plants CAM and C4 is that their metabolic pathway, Allow them to exploitation of the dry environments, as well as the mechanisms of adaptation of plants that are activated in response to water stress (Kafi and Mahdavi Damghani, 1999).

A PRIMARY RESPONSE TO WATER DEFICIT REDUCED LEAF AREA

At the onset of water stress, inhibition of cell growth, leading to a reduction in leaf development. Lower leaf surface causes less water uptake from the soil and transpiration is reduced. Plenty of water to form effective for a longer period, the soil is kept. Restrictions on the leaf surface could be the first line of defense against water (Kafi and Mahdavi Damghani, 1999)

WATER DEFICIENCY STIMULATES LEAF ABSCISSION

If the plants, leaf water after the completion of the encounter, and the old leaves are falling. This regulation of leaves, long term change is important to improve the adaptability of the environment is facing a water shortage (Maleki et al. 2013). The process of shedding leaves during water stress, largely the result of increased synthesis and sensitivity to this hormone in plants (Kabiri, 2010).

STOMATAL ARE CLOSED DURING WATER STRESS IN RESPONSE TO ABSCISIC ACID

Abscisic acid to form a continuous and at low levels in leaf mesophyll cells produced and accumulates in the chloroplasts. When mesophyll with a mild wilting, two things happen: first, the amount of abscisic acid stored in mesophyll cells, which may be released to Pvplast transpiration stream, some of it to pass the guard cells. Second, the net production rates increased abscisic acid. Stomatal closure with redistribution of abscisic acid stored in the mesophyll chloroplasts into apoplast begins. Abscisic acid biosynthesis after stomatal closure started and it seems to exacerbate or prolong the effect of primary block is stored by abscisic acid (Matysik et al, 2002).

EFFECTS OF DROUGHT STRESS ON PLANT ACTIVITIES

The potentials of -10 to -15 more physiological phenomena such as leaf growth, stomatal conductance, photosynthetic rate and nitrogen metabolism decreases (Heidaiy and Moaveni, 2009). In the study of physiological phenomena of drought stress in plants, reported that the plant water status, often by measuring the water potential of tissues, specified by decreasing water potential decreases cell growth and protein synthesis. The flow of carbon dioxide and leaf transpiration decreases, but the accumulation of proline and abscisic acid stress increases (Heidaiy and Moaveni, 2009). Drought stress, photosynthesis by stomatal closure and transfer of carbon dioxide in chloroplasts and cell water potential decreased, affected. Drought stress, root and shoot growth is affected and may reduce the level of plants. Drought stress, crop yield reduces largely the following methods:1- The reduction of photo-synthetic active radiation absorbed by vegetation 2- reduce the efficiency of radiation 3- The reduction in harvest index. Corn dry matter, the reduction in water consumption will decline (Sajedi, 2008).

MECHANISMS OF RESISTANCE TO DROUGHT

Drought Resistance in fact, the ability of species or cultivars for growth and production in drought conditions. By a long dry period on the physiological and morphological effects on yield and ultimate effect on yield depends on many factors. This not only depends on the time of drought on the life cycle of plants and water holding capacity of the soil in the root zone It also depends on plant characteristics (Mohsenzadeh et al, 2006). To prevent water losses, crop should close the stomatal, reducing absorption or decreased sweating, or a combination of all three levels will reduce the amount of transpiration (Shekari, 2000). With increasing water shortages, crop species can clog your pores. This reduces transpiration and especially when the stomatal are completely blocked and cuticular resistance is much more true. Active and inactive motion and increased leaf wax cracking or effective in reducing the absorption of radiation. Active motion parallel to the incoming radiation leaves on the response to water shortages for several crops have been observed (Rahmani, 2006). Drought stress causes to mentose or waxy leaves of some plants are both of these characteristics are reflected by the increasing amount of leaves to reduce water loss (Leila, 2007). One of drought tolerance in crop plants through water conservation and sustaining water absorption. The important feature is that this requires one to have deep roots and branches and a low resistance to flow of water inside the plant (Zareian, 2004). Maintaining inflammation in the leaves while they are growing shortage of water can maintain the physiological activity. Maintaining inflammation in conditions of reduced leaf water potential can be fully or partially by setting the osmotic conditions, increase or decrease the size of the cell elasticity acquired (Shekari, 2000).

DROUGHT STRESS IN GERMINATION STAGE

Germination and vigor to determine the number of green plants per unit area, has an important role in the production. One of the most important stages during plant growth is often influenced by environmental stresses including drought placed (Leila, 2007). Water absorption is the first stage of germination. Both live and dead seeds absorb water and swell. The amount of water absorbed depends on the chemical composition of the seed. Proteins, mucilage and pectin are more hydrophilic colloid and absorbs more water than starch (Rahmani, 2006). Grains such as corn, soybeans, almost a third of a second seed weight and seed weight to absorb water. Usually much lower than field capacity soil moisture is favorable for germination. The wilting point moisture farm to reduce the germination rate is slower. If the water level is less than desirable, if not completely water absorption and germination declines or stops (Leila, 2007). Water is the main factor stimulating germination and access to water by osmotic and matric potential (suction) is reduced. Water potential environment impact on the rate of water absorption and thus, germination plant. Drought stress can affect germination rate reduction, however, sensitive to drought stress during different stages of germination and root out what is different (Zareian, 2004). With increasing severity of drought, the percentage and rate of germination, root and shoot length was reduced in millet. Drought has affected many aspects of plant growth and delaying germination addition, the growth of shoot and reduce the production of dry matter (Shekari, 2000).

DROUGHT STRESS IN VEGETATIVE STAGE

Drought stress in vegetative stage less important than in reproductive stage of tension and the impact on yield and yield components, However, since the stress at this stage of development of leaf, stem development, photo-synthesis, leaf, and the accumulation of great importance is the impact in plant (Kabiri, 2010). Plants in most arid regions of the world, more or less exposed to stress. Water shortages, with the disappearance of inflammatory cells, disrupted physiological processes, leaf growth, photosynthesis, stomatal closure, changes in metabolism, drying and dying plants (Rahmani, 2006). The main possible causes of dry weight in vegetative stage of stress, can be a real photosynthesis, leaf area

Figure 1. Effect of drought stress on the vegetative growth of rice cv Ir64

index and stimulate plant's reproductive stages (Diallo et al., 2001). The first and foremost effect of drought is impaired germination and poor stand establishment (Harris et al., 2002). Drought stress has been reported to severely reduce germination and seedling stand (Kaya et al., 2006). In a study on pea, drought stress impaired the germination and early seedling growth of five cultivars tested (Okcu et al., 2005). Moreover,in alfalfa (Medicago sativa), germination potential, hypocotylnlength, and shoot and root fresh and dry weights were reduced by polyethylene glycol-induced water deficit, while the root length was increased (Zeid and Shedeed, 2006). However, in rice, drought stress during the vegetative stage greatly reduced the plant growth and development (Fig. 1; Tripathy et al. 2000. Manikavelu et al., 2006.Farooq et al. 2009).

Figure 1. Effect of drought stress on the vegetative growth of rice cv IR64. Both the plants were grown under well-watered conditions up to 20 days following emergence. One pot was submitted to progressive soil drying (drought stress). The afternoon before the drought, all pots were fully watered (to saturation). After draining overnight, the pots were enclosed around the stem to prevent direct soil evaporation A small tube was inserted for re-watering pots. The decrease in soil moisture was controlled by partial re-watering of the stressed pots to avoid a quicker imposition of stress and to homogenize the development of drought stress. A well-watered control pot was maintained at the initial target weight by adding the daily water loss back to the pot. This figure shows the plants 20 days after imposition of drought stress (farooq et al, 2009). In general it can be said that the stress conditions in the organs of plants are growing faster than other organs are damaged. Therefore stress at vegetative stage of forage plants compared to grain crops is more strongly influenced (emam and Zavareh, 2004). Water Deficit induced degradation of photosynthetic pigments, reducing the amount of chlorophyll and photosynthetic system will be destroyed. Significant reduction in chlorophyll content and chlorophyll synthesis may be due to factors for which the structure is destroyed. This means that dehydration increases in chlorophyll catabolism. Similar reports on the reduction of Water Deficit on chlorophyll in plants is the olive and wheat (logini et al., 1999). Stress at vegetative stage of rape leads to reduced stomatal conductance, net photosynthesis and thus the yield (Kerepesi and Galiba, 2000). Water deficit of the main factors limiting maize production in arid and semi-arid regions are considered. Vegetative growth stages of corn, short-term water stress can speed up the growth of leaves and leaf area index and the next steps to reduce light use efficiency (Sarvar and Ali, 1999). Final grain size is determined by two factors: the rate and duration of grain filling. Sensitivity to drought stress during grain filling, grain filling rate is over. So severe moisture stress, further reducing the duration of grain filling, grain size affects the (Maleki et al., 2013). Most grain crops are sensitive to lack of moisture during the growth phase, because at this time the number of grains in weight and shape(Maleki et al. 2013).

Therefore, the stress at each stage of the growth may lead to a reduction in yield. Crops such as millet, foxtail, sorghum and cowpea are also grown in the arid and semi-arid areas affected by drought stress at the reproductive stage are (emam and Zavareh, 2004). Possible causes more stress influence the reproductive stage are: remobilization of nitrogen and carbohydrates from leaf to leaf with increasing age, Degradation of chlorophyll and light harvesting complexes (Momeni, 2010), an increase in stomatal resistance decreased with increasing leaf age and Rabyskv and rehabilitation activities RUBP stated (Cabuslay et al., 2002). The drought is the major threat to agricultural production. At any stage of plant development from germination to maturity, plant, water is very essential. Thus the degree of unbalance of water to produce adverse effects on the crop and apply.

REFERENCES

Anjum S, Xie X, Wang L, Saleem M, Man C, Lei W, 2011. Morphological, physiological and biochemical

Bagheri, A., 2009, Effects of drought stress on chlorophyll, proline and rates of photosynthesis and respiration and activity of superoxide dismutase and peroxidase in millet (Panicum milenaceum L.). National conference on water scarcity and drought management in agriculture. Islamic Azad University Arsanjan, p.16.

Bajji, M., Lutts, S., & Kinet, J.-M. (2001). Water deficit effects on solute contribution to osmotic adjustment as a function of leaf ageing in three durum wheat (Triticum durum Desf.) cultivars performing differently in arid conditions. Plant Science, 160(4), 669-681.

Bradford, K.J. 1994. Water stress and the water relation of seed development, a critical review. Crop Science. 34: 1-11.

Cabuslay, G.S., Ito, O., and Alejar, A.A., 2002. Physiological evaluation of responses of rice (Oriza sativa L.) to water deficit. Plant Science. 163: 815-827.

Campose, H., coopet, M., Habben, J.E., and Schussler, J.R., 2004. Improving drought tolerance in maize: A view from Industry. Field Crops Reserch. 89: 1-16.

Chowdhury RS, Chowdhury, MA, 1985. Hydrogen peroxide metabolism as an index of water stress tolerance in jute. Physiol. Plant, 65, 503-507.

De, R., and Kar, R.K., 1995. Seed germination and seedling growth of mung bean (Vigna radiate) under water stress induced by PEG 6000. Seed science and Technoligy. 23: 301-308.

Dennis, B. E., Bruening, W. P. (2000). Potential of early maturing soybean cultivars in late .plantings. Agron. J. 92:532 -537.

Diallo, A.T., Samb, P.I., and Roy- Macauley, H., 2001. Water status and stomatal behavior of cowpea, Vigna unguiculata L. Walp, plants inoculated with two Glomus species at low soil moisture levels. European Journal Soil Biology. 37: 187-196.

Emam, a., Zavareh, M., 2004. Drought Tolerance in Plants (analysis of the physiological and molecular biology) (Translation). University Publishing Centre. Page 75.

Fridovich Lu, Rao, S, 2000. Oxygen radicals, hydrogen peroxide and oxygen toxicity. Free Radical in Biology, 1, 239-277.

Ghodsi, M., M. Nuzeri and A. Zarea-Fizabady. 1998. The reaction of new cultivars and Alite lines on spring wheat into drought stress, Collection of abstract articles of 5 th Iranian agronomy and plant breeding conference, Karaj, Iran. 252p.

Harris D., Tripathi R.S., Joshi A. (2002) On-farm seed priming to improve crop establishment and yield in dry direct-seeded rice, in: Pandey S., Mortimer M., Wade L., Tuong T.P., Lopes K., Hardy B. (Eds.), Direct seeding: Research Strategies and Opportunities, International Research Institute, Manila, Philippines, pp. 231–240.

Heidaiy, Y and Moaveni, p. 2009. Study of Drought stress on accumulation and proline among aba in different genotypes forage corn .Research journal of biological sciences.4:1121-1124.

Hendry GA, 2005. Oxygen free radical process and seed longevity. Seed Sci. J., 3: 141-147.

Kabiri, R. 2010. Effect of salicylic acid to reduce the oxidative stress caused by drought in the hydroponic cultivation of Nigella sativa (Nigella sativa). MA thesis. Kerman University SHahid Bahonar.

Kafi, M. Damghany Mahdavi , A. 1999. Mechanisms of resistance of plants to environmental stresses (Translation). University of Mashhad.

Kaya .M.D., Okçub G., Ataka M., Çıkılıc Y., Kolsarıcıa Ö. (2006) Seed treatments to overcome salt and drought stress during germination in sunflower (Helianthus annuus L.), Eur. J. Agron. 24, 291–295.

Kerepesi, H., and Galiba, G., 2000. Osmotic and salt stress Induced alteration in soluble carbohydrate content in wheat seedling. Crop Science, 40: 482-487.
Kochaki, A. 1994. agriculture in arid regions. Press Jahad, Ferdowsi University of Mashhad. Iran.
Kramer, P.J. 1969.Plant and soil water relationshio: a modern synthesis. Mc Graw – Hill, New York. 18: 281-295.
Leila, R. 2007. Response of Tunisian autochthonous peral millet to drought stress induced by polyethylene glycol 6000. African Journal of Biotechnology. 6: 1102-1105.
Loggini, B., Scartazza, A., Brugnoli, E., and Navari –Izzo, F., 1999. Antioxidative defense system pigment composition and photosynthetic effiency in two wheat cultivars subjected to Drought. Plant Physiology. 119: 1091-1100.
Lowler, D.W. 1979. Effect of water and heat stress on carbon metabolism of planta with C3 and C4 photosynthesis. Stress physiology in crop plants. PP. 326-303.
M. Farooq, A. Wahid, N. Kobayashi D. Fujita S.M.A. Basra. Plant drought stress:e_ects,mechanisms and management. Agronomy for Sustainable Development, Springer Verlag (Germany), 2009, 29 (1), pp.185-212.
Mafakheri A, Siosemardeh A, Bahramnejad B, Struik PC, Sohrabi Y, 2010. Effect of drought stress on yield, proline and chlorophyll content in three Chickpea cultivars. J. Australian Crop Sci., 4(8): 580-585.
Maleki. A., Naderi , R., Naseri , A., Fathi ,A ., Bahamin . S and R . Maleki . 2013 . Physiological Performance of Soybean Cultivars under Drought Stress. Bull. Env. Pharmacol. Life Sci., Vol 2 (6): 38-44.
Manikavelu A., Nadarajan N., Ganesh S.K., Gnanamalar R.P., Babu R.C. (2006) Drought tolerance in rice: morphological and molecular genetic consideration, Plant Growth Regul. 50, 121–138.
Matysik J, Alia B, halu B, Mohanty P (2002) Molecular mechanisms of quenching of reactive oxygen species by proline under stress in plants. Current Sci 82: 525-532
Mohsenzadeh S, Malboobi MA, Razavi K, Farrahi-Ashtiani (2006) Physiological and molecular responses of Aeluropus lagopoides (poaceae) to water stress. Environ Exp Bot 56: 314-322.
Momeni, S. 2010. Effect of seed priming with salicylic acid and polyethylene glycol in combination with salicylic acid spraying plants with drought resistance of maize (Zea mays L.). Master Thesis Seed Science and Technology University of Birjand.
Nair A, Abraham TK, Jaya DS, 2008. Studies on the changes in lipid peroxidation and antioxidants in drought stress induced Cowpea (*Vigna unguiculata* L.) varieties. J. of Environmental. Biol., 29(5): 689-691.
Okcu G., Kaya M.D., Atak M. (2005) Effects of salt and drought stresses on germination and seedling growth of pea (Pisum sativum L.), Turk. J. Agr. For. 29, 237–242.
Ourcut, D. and Nilsen, E. T. 2000. Salinity and drought stress. In Physiology of plants under Stress. KA/PP: 177-235.Terlestkaya, N. 2000. Water stress. American Society of Plant Biologist.
Pook-pakdi, A., Thira virojana, K., Saeradee, I., and Chaikaew, S. 1990.Response of New soybean accession to water stress during reproductive phase. Kastsart Journal Natural sciences. 24: 3, 378-387.(ABSTRACTS).
Porudad, S.S., and Beg, A., 2003. Safflower: Asuitable oil seed for dryland areas of Iran. In: proceeding of 7thinternational conference on development of drylands. Sep. 14-17. Tehran, Iran.
Pour Najaf, M. 2005. Effect of supplemental irrigation and nitrogen fertilizer and inoculation with Rhizobium bacteria on yield and quality of chickpea cultivars under rainfed conditions. Soil Master Thesis. Zanjan University.
Rahdari P, Hoseini SM, Tavakoli S, 2012. The studying effect of drought stress on germination, proline, sugar, lipid, protein and chlorophyll content in Purslane (*Portulaca oleraceae* L.) leaves. J. of Medicinal Plants. Res., Vol. 6(9): 1539-1547.
Rahmani, n. 2006. Effect of irrigation and nitrogen application on the quantity and quality of medicinal plant Marigold (Calendula Officinalis L.). Master Thesis Agronomy, University of Takestan Branch.
responses of plants to drought stress. J. African. Agri. Res., Vol. 6(9): 2026-2032.
Sajedi, N. and Sajedi. AS., 2008, Effect of drought stress on physiological characteristics of maize mycorrhiza and zinc. Journal of Crop Science. Volume 11, No. 3, p. 202 to 222.
Sarmadneya, Gh. 1992. The importance of environmental stresses on agriculture. Key articles Congress of Agronomy. College of Agriculture, Karaj.
Sarvar,A.K.M.G., and Ali, M.A., 1999. Effect of water stress on the growth features of different maize (Zea mays L.) cultivars. Pakistan Journal of Botany. 31(2): 455-654.
SHekari, F. 2000. Effect of drought stress on phenology, water relations, growth, yield and quality canola, doctorate thesis in the field of Agriculture, University of Tabriz, p. 180.
Smirnoff N, 1993. The role of Reactive Oxygen in the response of plants to water deficit and desiccation. J. New Phytol., 125: 27-30.
Sobardo, M.A. 1990. Drought responses of tropical corn, Leaf area and yield components in the field. Maydica. 35(3): 221-226.
Srivalli B, Chinnusami V, Renu KC, 2003. Antioxidant defense in response to abiotic stresses in plants. J. Plant Biol., 30, 121-139.
Synerri CLM, Pizino C, Navariizzo F, 1993. Chemical changes and O2 production in thylakoid membrane under water stress. Plant Physiol., 87: 211-216.
Thankamani CK, Chempakam B, Ashokan P, 2003. Water stress induced changes in enzymatic activities and lipid peroxidation in black pepper (*Piper nigrum*). J. Medicinal Aromatic Plant Sci., 25, 646.
Tripathy J.N., Zhang J., Robin S., Nguyen T.T., Nguyen H.T. (2000) QTLs for cell-membrane stability mapped in rice (Oryza sativa L.) under drought stress, Theor. Appl. Genet. 100, 1197–1202.
Van-Ginkel, M.F., Trethowan, R.M., and Cukadar, B., 1998. A guide to the CIMMYT bread wheat program.WPSR. No. 5, CIMMYT, Mexico.
Zainali, a., Soltani, A., And galeshi, s., 2001. Germination response to salt stress components in canola. Iranian Journal of Agricultural Sciences. 463-457: 36.
Zare'ian, J. 2004. Effects of drought on the different stages of growth, and growth traits, varieties of winter canola, MS Thesis Agronomy, Faculty of Agriculture, Islamic Azad University of Khorasgan.
Zeid I.M., Shedeed Z.A. (2006) Response of alfalfa to putrescine treatment under drought stress, Biol. Plant. 50, 635–640.
Zhang J, Kirkham MB, 1996. Antioxidant response to drought in Sunflower and Sorghum seedlings. New Phytol., 132: 361-373.