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Ecophysiological Responses to Stresses in Plants: A General Approach

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Abstract: Stress (abiotic and biotic) factors reflect and specify the plant morphology and called as "*stress*" and have negative effect(s) on growth, development, quality, quantity and can reduce average plant productivity by 65 to 87%, depending on the plants and stage(s) and also give various permanent or temporary damage(s) according to length of exposed period, violence/density, developmental stage, age, etc. Researches have revealed that despite the advanced technology levels the fundamental basis of stress have not been understood comprehensively. Firstly taken response(s) has/have not yet fully understood and secondly any "*resistance*" or "*tolerance level of a variety/species*" because of their complex structure(s). But, this point is clear that with the help or assistance of "*multi-disciplinary*" approaches, it will be able to get promising result(s) in near future. This review focuses some of the ecophysiological responses of plants to biotic and abiotic stresses.

Key words: Ecophysiologic response(s), growth and development, phenology

INTRODUCTION

World population is expected to reach about (7.6-8.0) billion by the end of this century; lowness of the agricultural productivity is not increasing at a required rate to keep up with the global food demand, possible water shortages, depleting soil fertility and the various stresses are constitute of this handicap (Shanker and Venkateswarlu, 2011). As known, plants show wider physiological and ecophysiological response(s), functional diversity, growth rates, productivity, population and community dynamics at different scales (Ackerly *et al*., 2000). When they are subject to less ideal than sub-optimal growing conditions, considered being under stress and these stresses directly effect production and yield level. These environmental conditions such as water-logging, drought and high/low temperatures, excessive/extreme soil salinity, inadequate mineral content of soil, phytotoxic compounds (such as ozone, etc.), also cause damage to plant growth and productivity (Fig. 1, 2). Measuring the plant stress is very useful for many reasons. For example, the effect of different amounts of herbicides and pesticides on plant health and growth are very valuable and can be used to reduce of them.

Due to sessile organisms, plants are always open to low/high temperature, salinity, drought, flood, oxidative (stress), air pollution/heavy metal poisoning, etc. solely or combinations and their consequences (Fig. 1). In general, one may categorize stresses as biotic, those caused by biological agents, such as biotic and abiotic those brought about by the physical environments, such as too much or too little water, inadequate or excess minerals in the soil, heat, radiations etc. (Leung, 2008). Plants are unable to dislocate in its own environmental therefore they have to cope with various stresses with internal mechanism(s) for the "*tolerance*" and/or "*resistance*". Since, they have developed various adaptation (such as hairness, waxiness, thornyness) mechanisms to provide (resistance) or (tolerance) against them. So, carry out stress breeding programs in problem environments are very important (Blum and Jordan, 1985). But this is open that all of the above mentioned stress factors are responsible for shifting physiological and biochemical events from interms of the various anomalous growth regulators, promoters, transcription regulators, Ca^{+2} and Na^{+1} ions uptake and balance, etc. in any organism (Doubnerova and Ryslava, 2011). As a physically term, "*stress*" is an applied mechanical force to object in a unit area; but, as a biologically, it is varying response(s) depend(s) on the size of force (Chinnusamy *et al*., 2007). According to Ashraf and Harris (2004), an environmental factor that limits crop productivity or destroys obtained biomass is referred to as a "*stress*" or "*disturbance*". These responses appear at anywhere at any time and any stage of the plant's life cycle as water capacity osmotic/turgor pressure, ion capacity and balance, etc. Plant stress response(s) to

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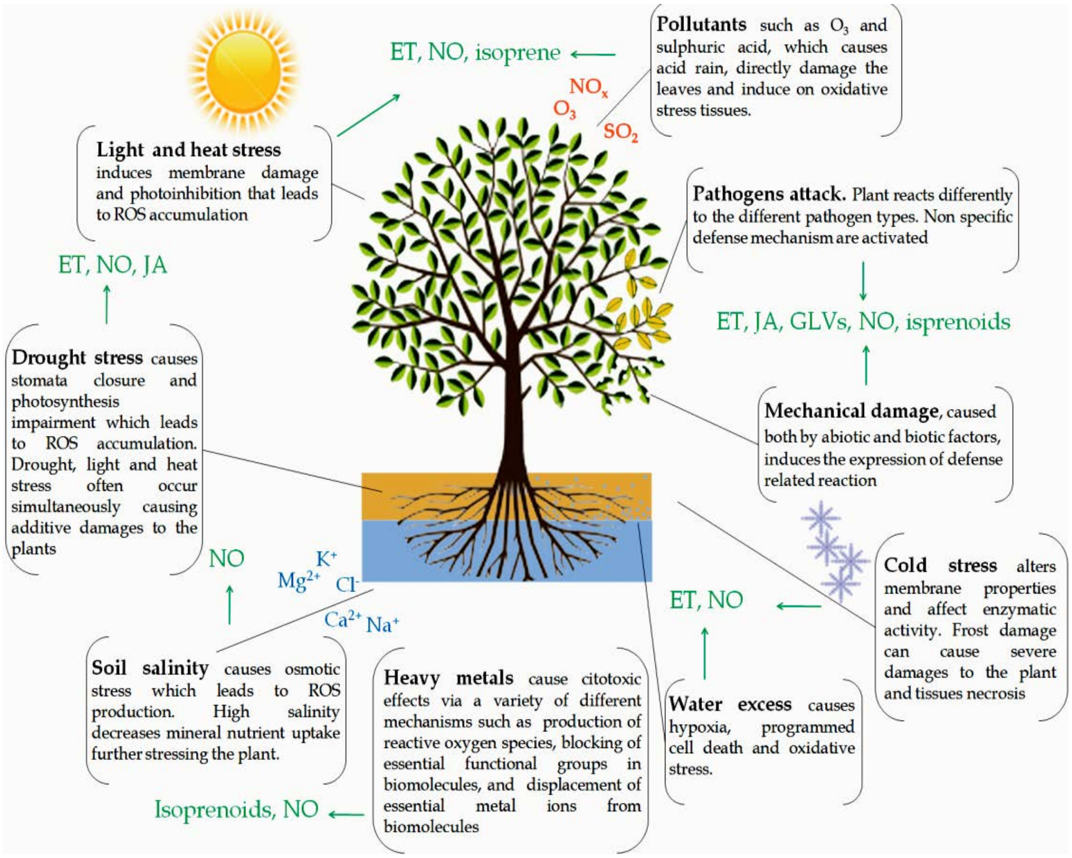

Fig. 1: Consequences of stresses and some plant ecophysiologic responses, ET: Ethylene, ROS: Reactive oxygen species, NO: Nitric oxide, JA: Jasmonic acid, GLVs: Green leaf volatile(s), O_3: Ozone (Blum and Jordan, 1985; Bohnert *et al*., 1995; Gutschick, 1999; Ackerly *et al*., 2000; Mittler, 2006; McSteen and Zhao, 2008; Wang and Frei, 2011; Shanker and Venkateswarlu, 2011; Kadioğlu *et al*., 2012)

stress factors (Fig. 1) have/has been widely studied up to now and was founded that environmental stresses trigger simultaneous up- and down-regulation of a large number of genes through a close control of genetic behavior (transcription) (Gençtan, 2012) and different chemical compounds. For example, order of the *Dicotyledoneae*, *Cactaceae*, *Chenopodiaceae* and *Aizoaceae* families are rich in the plants to the habitat tolerance adaptation (and also to harsh climates). In out of (22/12) plants "*habitat tolerance*" is being governed by "*Anthocyanin*" and, in (10) plants also, is being managed by "*Betalains*", "*Tertiary and Quaternary Amines*" and "*Sülfonilium*" or "*Polyol*" (Hanson *et al*., 1994) and related responsible genes. The C_4 and "*Crassulacean*" acid metabolism group plants (CAM) are common at the places where the water is scarcely. The most significant example of this is a "*Craterostigma panfagineum* Hochst plant".

This one is also known to be one of the most tolerant plants to excessive dryness conditions within the top (100) cultivated plants (Bohnert *et al*., 1995) in the world and it exploits from the carbohydrates' (CHs) under the stresses (Chinnusamy *et al*., 2007) in its stem. In the well-watered plants, convert of the "*2-Octulase*" to "*Sucrose*" is a common behavior in the many plants' leaves during the dryness conditions or loss of the water content (Doubnerova and Ryslava, 2011). Many findings showed that stress damages in the plants are influenced from environment or stress factors, growing practices, the agronomic-genetic adaptation mechanisms, etc. for internal and external parameters (Ulukan, 2008) of the ecophysiological responses. Biotic and abiotic stress cause changes in soil-plant-atmosphere relation and responsible for the yield reducing in several major plants (Ahmad and Prasad, 2012). Generally, plants are more sensitive to insect(s), disease(s), pest(s), weed(s) and

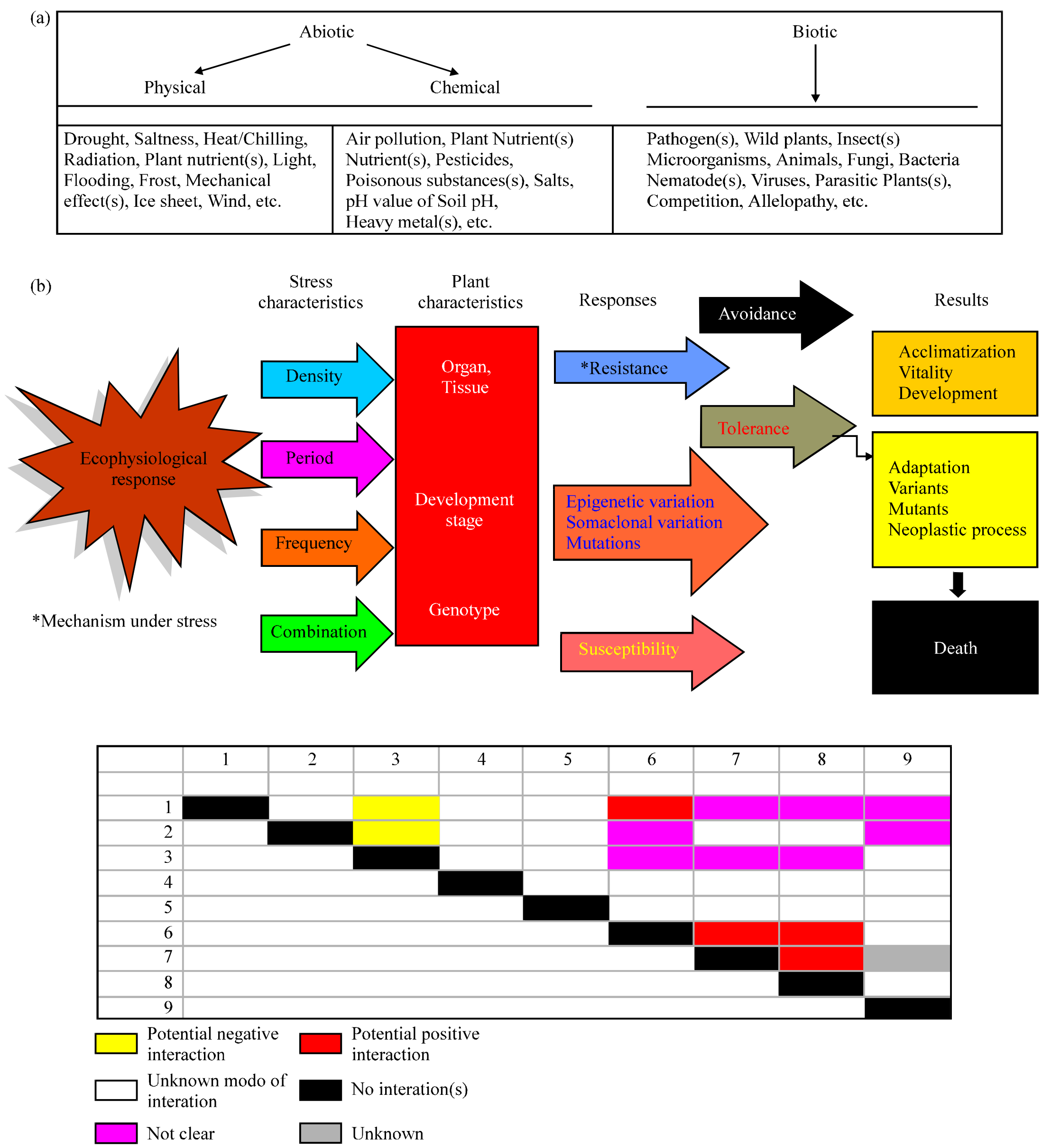

Fig. 2(a-b): (a) Some stress factors in plants and their interactions (Mittler, 2006; Ashraf and Foolad, 2007; Sunkar, 2010; Doubnerova and Ryslava, 2011) and (b) Some agriculturally important stresses and their combinations, 1: Drought, 2: Salinity, 3: Heat, 4: Chilling, 5: Freezing, 6: Ozone, 7: Pathogen, 8: UV, 9: Nutrient (Ackerly *et al*., 2000; Ashraf and Harris, 2004; Shanker and Venkateswarlu, 2011)

yield level(s) decreasing under stress conditions (Reddy *et al*., 2004). Similarly, due to complexity of the effected factors such as metabolism x factor(s), presence of the environmental, ecophysiological, origin, etc. to be able to determine the results successfully/properly is not easy and possible (Gregorio and Cabuslay, 2005). Particularly, it has not developed/released any/totally/partially "*tolerate*" or "*resistant*" plant species up to now to the salinity stress in rice (*Oryza sativa* L.), in common wheat (*Triticum aestivum* (L.) Em Thell) and in other cultivated plants (IRRI, 1998; CSSRI, 1999; Sunkar, 2010; Farooq *et al*., 2011; Witcombe *et al*., 2011). This is only possible either to use some preventive function(s) or use certain biochemical mechanism(s) (Chinnusamy *et al*., 2007). As known, stress factor(s) reduce(s) agricultural plant yield(s) approximately 65, 0% or more and plants usually affect adversely (Doubnerova and Ryslava, 2011), in a polygenic inheritance (Popelka *et al*., 2004) with poorly understood response(s) (Chinnusamy *et al*., 2007). When plants look suffer from/sick/appear to be under attack by insects, etc. the symptoms which are seen actually a sign that the plant is being (or may be) stressed by environmental factors and related ecophysiological responses (Fig. 1). In this study, ecophysiological responses to stresses of some cultivated plants' will be evaluated generally and possible result(s) will be mentioned.

SEVERAL ABIOTIC STRESSES WITH THEIR ECOPHYSIOLOGICAL RESPONSES

Water/Drought stress: When the water lossing occurred in the plant, first of all, its turgor pressure suddenly drops. Stresses have negative effects on cell growth, causes separation of membrane proteins and decreases the chlorophyll content and losses of germination capability (Jaleel *et al*., 2009). Genetic mechanism of the water or drought stress have not been known properly and clearly in the plant (Gutschick, 1999), but, it is widely thinking that "*escape*" or "*tolerance*" is "*dominant*" in this regard (Sunkar, 2010; Witcombe *et al*., 2011). Reduction of the leaf morphology (size reducing, rolling), weakness in grain shapes and insufficient size development in different parts of the plant such as stem, leave, ear, head, etc. (in cereals), severe plant height reducings (in potatoes (*Solanum tuberosa* L.), in soybean (*Glycine max* Merr.), in okra (*Abelmoschus esculentus* (L.) Moench), in cowpea (*Vigna unguiculata* (L.) Walp.), in parsley (*Petroselinum crispum* (Mill.) Nyman and AW Hill), in sunflower (*Helianthus annuus* L.), in citrus (*Citrus* spp.) are typical symptoms (Wu *et al*., 2008, Kadıoğlu *et al*., 2011). The water shortage effects and brings important limitations for all the type of agricultural production(s) (especially in legume production (Dita *et al*., 2006)).

Similarly, hairy root (*Radix fibriosa*) trait is another important and useful pecularity for the plants when the water amount is limited or inadequate and when they under this stress, they excrete various plant hormones. Generally; these compounds are brassinosteroids (BLs), Auxin(s), Gibberellin(s) that promote(s) the growth and keep the balance between organism and water stress tolerance (Ehsanpour and Razavizadeh, 2005), ethylene and abscisic acid (ABA) suppress the growth (McSteen and Zhao, 2008), tolerance against to the osmotic pressure (Chinnusamy *et al*., 2007) and closing the stomata during transpiration (Blum and Jordan, 1985). By doing this, ABA prevents the water lossing, slows down the development of apical organ(s), allows increase of the water usage by roots and to give more chance to find out water in the soil. As known, water drought/waterlogging caused water stress induced not only shows several ecophysiological and biochemical responses associated with general reduction in size but also exhibits characteristic modifications in structure; particularly in the leaves (Gençtan, 2012). This type stress reduces number of grain at pre-anthesis stage and largeness (especially for Q gene) of numerous morphological and domestication-related traits such as plant height, flowering time, leaf morphology, structural deformation(s) at spike in wheat (*Triticum* spp.) (Farooq *et al*., 2011), pod number and relevant yield components per unit area decreases in soybean (*Glycine max* Merril), 100-seed weight reduces in sunflower (*Helianthus annuus* L.), yield level per plant decreases in corn (*Zea mays* L.), damage(s) between the grain filling and anthesis stage in beans (*Phaseolus vulgaris* L.), in chickpea (*Cicer arietinum* L.) and in parsley (*Petrosellinum* spp.) (Webber *et al*., 2008). Under these circumstances, nearly all cultivated plants were developed important protective and resistancy mechanism(s) against to this stress in both top-soil and sub-soil horizons.

Especially, at the pre-drought and/or after rains, rapid maturation and water loss reduction are important topics that-to be able to avoid from the negative effect(s) of this phenomena-nearly all plants under these threat(s) have developed "*a deep and radicilous root system*" with the main aim of to save or keep the water availability for their development during vegetation period. *Protective and xerophytic structures* such as hairness, acanthaceous, waxiness, etc. in plants have an important place in terms of the (stress) resistance strategy (Shepherd and Griffiths, 2006). Under this stress, the plants excrete ABA, amino acid(s), proline and prolamins, quaternar amino acids, glycine betaine, mannitol, sorbitol, raffinose, trelose, H_2O_2, ascorbat, α-tocopherols, etc. compounds (Hussain *et al*., 2011). Similarly, brief exposure of the plants to high temperatures during the grain set and filling stage; senescence can accelerate, grain formation processes slow down and (finally) yield level reduce (Porporato *et al*., 2003). The amount of photosynthetic pigments in the plants and reducing the photosynthetic efficiency in the leaves under the drought stress are decreased of the yield level and imbalances happens between available CO_2 and turgor pressure (Mittler, 2006). It was found that there are a close correlation between "drought resistance" and "dehydrated accumulation" in the wheat (*Triticum* spp.) and the poplar (*Populus* spp.) (Yordanov *et al*., 2000). Severe drought period negatively effects to protein structure(s)' and accelerates the moisture lossing from the plant and environment, blocks the transmission to vascular bundles, oil and enzyme activities in cell walls in the leaves.

This reduction was recorded as (3-12) times faster than in birdsfoot trefoil (*Lotus corniculatus* L.) (Yordanov *et al*., 2000), the (starch/sucrose) ratio was decreased in bean (*Vicia faba* L.) and it happens that CO_2 imbalance as the form of *sucrose* in sugar beet (*Saccharum* spp.) leaves (Mittler, 2006). The plants intake of O_2, CO_2 and water vapor from air by their leaves. If stomata close, transpiration immediately interrupts, finally stops. This process happens much more faster in drought resistant plants and this formation is an important barrier for the water and gas losses (Mittler, 2006). But, the early closure of stomata is the mostly related to "the soil dryness" (Porporato *et al*., 2003). It was understood that this is a helper mechanism for the water balance, depending the transpiration rate in the leaf of plant (Aina *et al*., 2007). Similarly, coating of the leaf surface by cuticle or a wax layer (Shepherd and Griffiths, 2006), prevents the water loss and reduces CO_2 intake (Yordanov *et al*., 2000). Many cultivars are tolerant to indicated stress factors (especially wilds (Massarelli *et al*., 2006) and it was discovered that some nitrogenous chemical compound(s) (NCC) such as proline, polyamines, sucrose, dehydrated, etc., accumulate(s) under the stress conditions and was found that many genes responsible from these processes (Hussain *et al*., 2011). Waterlogged soils adversely effect the growth of plants not adapted to wet land conditions, also salinity effects the growth and water content of some plants (Gaber, 2003). So, the strategies for surviving and growth of the plants under water stress, divide into two main groups as "*The morphologics*" and "*The physiologics*". The morphologics are: Descending deeper root system than those of the morphological forms as narrowing of the leaf and stem surface; curling or rolling of the leaves, hairness in stem; increase in thickness of a the cuticle/wax layer, deeply embeding of the stomata, the leaf shedding, to do photosynthesis of stem or other parts (Farooq *et al*., 2011), The physiologics are: stomatal originated, photosynthetic regulations, osmotic adjustments, protective solutions in the leaves, protein level increasing at the cell membranes and storage organs, oil, carbohydrates (Zhu *et al*., 1997; Chinnusamy *et al*., 2007).

Salt stress: According to statistics, there are approximately 397 mil ha under salinity; 5,762.9 mil ha under the drought (Ashraf and Foolad, 2007), 434 mil ha are also under alkalinity in the world (FAO, 2011). Alkaline soils are usually categorized by low availability of plant nutrients, high concentrations of HCO_3^{-1}, CO_3^{-2} and high pH, bicarbonate (HCO_3^{-1}) and carbonate (CO_3^{-2}) are principal contributors to the alkalinity, whereas hydroxide, borate, ammonia, organic bases, phosphates and silicates are considered minor contributors, hence plant/crop growth is mainly inhibited by the HCO_3^{-1} and CO_3^{-2} ions rather than OH^{-1} in the alkaline soils. At the regions, where the air temperature is quite high but precipitation amount is low, either water losses by evaporation or the salt significantly accumulate at the different soil layers as a white thin layer (especially at the surface) and limits the agricultural production. Particularly, chlorides (NaCl, $CaCl_2$ and $MgCl_2$), sulfates (Na_2SO_4 and $MgSO_4$), nitrates ($NaNO_3$ and KNO_3), carbonates and bicarbonates (Na_2CO_3 and $NaHCO_3$) are the main reason of soil salinity and several essential micro nutrients such as (Fe), (Zn) and (Mn) become less available to plants under the alkaline stress conditions (Shanker and Venkateswarlu, 2011). Under the salt stress, increasing amount and density of dissolved salt at the plant root zone, hampers of the water uptake, on account of ion concentration increasing, finally it poisons the plant (Zhu, 2001). High salinity affects the plants in different ways such as water stress, ion toxicity, nutritional disorders, oxidative stress, alteration of metabolic processes, membrane disorganization, reduction of cell division and expansion, genotoxicity (Shanker and Venkateswarlu, 2011).

When the plant under excessive salt stress, its height and root growth, bud formation, root, stem and shoot length, fresh dry weight and the leaf area are decreased; emerged plant number reduces, chlorophyll content decreases and yield level falls, flavor and color of the fruits degenerate, ion balance of the cells breaks down and "*oxidative*" stress happens, all the leaves remain small, the root system, bud(s), the leaf edge(s) have yellow spots (necrosis) (especially they appear at the growth points), water amount and enzyme(s) activity(ies) decrease(s), protein synthesis slows down, cell membrane permeability decreases, whole organelles (firstly chloroplasts) are damaged (Zhu *et al*., 1997; Chinnusamy *et al*., 2007); if plant(s) remain(s) under the long-termed salt stress; ion toxicity and lack of water appear, CHs deficiency and related symptom(s) are seen in the leaves (Zhu, 2001). Under the saline conditions, plants allow using and taking of development of K^{+1} or Ca^{+2} instead of Na^{+1} and highness of the (K/Na) or (Ca/Na) ratios increase Studies have shown that all cereals are more durable than the legumes to the salt stress (Lopez *et al*., 2009; Sunkar, 2010).

Heat stress: One of the major environmental factors that affecting plant growth and productivity is (esp. high temperature) and field grown plants are often subjected to fluctuating temperature that has a profound effect on the plant metabolism (Saleh *et al.*, 2007). Temperature is a "*melter*" or "*dissolver*" character and has a double effect on plants: low and high. At the same time, it easily breaks the bonds of molecules, caused the structure of cell membranes convert into softening but when the temperature turns into low degrees, it makes the cell membranes hard. It was recorded a shortening effect on the grain filling period (Murchie *et al.*, 2009), beyond the plant reproduction biology, ecophysiology, growing techniques, etc. in temperate zones. Depending on the growing period, its violence, metabolic activity regulates the growth and development, with the geographical limitations, almost all plants are produced ABA, α-tocopherol, cytokinin, salicylic acid, etc. (Munne-Bosch, 2005; Kotak *et al.*, 2007).

It was determined that all cultivars normally develop between (15-45)°C; but, out of this range, depending on the environmental conditions, ecophysiological responses, quality and quantity, all components are urgently and negatively affected (Wang and Feri, 2011). Whereas, high temperature accelerates and encourages the development and growing, causes the reduction of enzyme activity and digests the proteins, provokes the cell structure and changes their functions; but, its genetical pathway and mechanism(s) is/are still unknown and a mysterious.

However, it was discovered that there are some of special proteins (such as heat shock proteins - HSPs-, etc. (Burke *et al.*, 1976)) which produced and play important role in the plants life (Chinnusamy *et al.*, 2007). Similarly, seeds and dormant buds can earn an "endogenous tolerance to desiccation" and "cryogenic temperature stresses" against to very low heat (temperature) stress (Volk, 2010). According to researches, in the wheat and other cool season cereals, during the reproductive and grain filling stages, due to performing of pollination, partially heading and seed setting events, should not to be "*heat* (temperature) *stress*". The optimum temperature degree varies (12-22)°C for the wheat at anthesis and the grain filling stages and if exposures to temperatures out of above, heat stress can easily and significantly reduce of the grain yield (Farooq *et al.*, 2011). And this finding is being added that during the acclimation period to *heat* (temperature) *stress* are reversible, but if the stress conditions(s) is/are too great, irreversible changes happen(s) and these formations may be cause to the plant death (Saleh *et al.*, 2007).

Cold stress: Cold treatments cause instant or abrupt changes in the structure of cellular lipids and cytoplasm; from them, ice crystals formed in hydrated cells and an undesirable plasma membrane change(s) happens with the temperature dropping. This extracellular ice formation trigers or invokes "a desiccation stress" (Volk, 2010). In general, (0-15)°C degrees are optimum, but it should be under 15°C for the tropical and semi-tropical zone plants for not to be under cold stress. It's damage mainly depends on the plant density and norm, ecophysiological responses, age, available water's viscosity, duration, ecological condition(s), time, etc.

Despite the fact that cold climate plants easily adapt to low temperatures; but, due to be not cold climate plants, citrus fruits, cotton (*Gossypium* spp.), rice, sugar cane (*Saccharum officinarum* L.), soybean, potato (*Solanum* spp.) are known as (very) sensitive plants to the cold. When they under the cold stress; there is enough water in the soil but can not take it due to the its viscosity hence availability, root cell membranes have lost or reduced their permeability/ies, stomatal aperture have been turned into the fully or partially, but, if stress continues first of all the leaves in the plants turn yellow and finally plants go to die (Taulavuori *et al.*, 2005). Die of the tropical plants (such as in banana (*Musa* spp.), below 13°C within (1,0-1,5) hours is one of the most dramatic examples of this stress (Chinnusamy *et al.*, 2007). But, if the temperature falls not sharply, step-wise or gradually, a progressive reduction of the cell water happens in the plants, so they do not easily damage or invulnerable from the frost and that time, they have become a "*cold tolerance*" (Thakur *et al.*, 2010).

Freezing stress: It arises when the below 0°C, but main reason of this stress is "cell water freezing". At that temperature, nearly whole metabolic events slow down and all vital functions come to stop point in the cells. The cell water goes to intracellular apertures and begins to freeze, osmotic pressure balance disorders, organism loss of its water (Zhu *et al.*, 1997). If the freezing stress has just started, does not freeze all the water content of cells and does not give heavy damages; but if it continues, whole water content freezes and ice crystals occur. Afterwards, crystals tear and blast membranes and cause the plant death (Sunkar, 2010). But, due to unknown reasons (for now), the ice crystal formations do not to be happen in some plants because they carry some "*sugar molecule(s)*" and these chemicals increasing the producing of "*antifreeze*" or "*water freezing retarder*" compounds such as simple sugars, glycol, proline, etc. (Chinnusamy *et al.*, 2007).

Light stress: Basically reason of this stress is "*day light*". The light plays a critical role in regulating plant growth and development through the modulation of expression levels of light-responsive genes that regulate developmental and seed germination, seedlings photomorphogenesis, chloroplast development and orientation, photodinesis, stem growth, pigment biosynthesis, flowering and senescence (Shanker and Venkateswarlu, 2011). From them, "*photosynthesis*" is the most sensitive physiological process and has many important ecophysiological responses to elevated temperature (Farooq *et al.*, 2011). Photosynthetic activity and metabolic functions of the plant are very affected from this when the density or norm is low. Therefore, behaviors of shadow and sun light (plenty light) plants are different from each other and another light traits (such as wavelength, density, etc.) are effective.

The plants utilize the light as their primary source of energy converting light to usable chemical energy through "photosynthesis" and is an essential prerequisite for chlorophyll biosynthesis and chloroplast development; events that do not take place in darkness (Shanker and Venkateswarlu, 2011). Amount of chlorophyll in the plants grown under the sun light (plenty light) is less than the plants grown under the shadow plants and, when they placed to shadow, firstly, they expand and thinner their leafs and reduce the production of CHs production in these organs. But this time, respiration process slows down and less amount of nutrient(s) go(es) to the roots. However, in them (grown under the sun light-plenty light), the leaves are thicker (esp. under extreme lights), photosynthesis rate increases, respiration ratio accelerates and the leaves are covered with a waxy/ cuticle layer(s).

If the shadow plants put under the sun light (plenty light), their photosynthetic activities accelerate, but, due to oxygen radicals not to be removed from the leaves (for example H_2O_2), other free radicals can be easily react with each other and emerges some "*toxic compounds*" and finally caused the death (Kotak *et al.*, 2007). Elevated UV radiation has pleiotropic effects on the plant development, morphology and ecophysiology. Generally, morphological consequences of the UV supplemented white-light treatment in the plants are growth reducing, leaves thickening and covering the wax/cuticular layers (Saleh *et al.*, 2007). The rice plant showed a significant decrease in total biomass with increased (UV-B) radiation; chlorophyll (a) and (b) contents of the bean leaves dropped after the (UV-B) stress (Saleh *et al.*, 2007) and (UV-A, B) rays break the proteins' disulfide bonds of the DNAs in organisms.

Flooding and submergence stress: Due to overflow of rivers or excessive rain, "*water*" does not enter to the soil, so the O_2 infiltration to the soil is impossible or to stop, than, cultivated plants do not respirate and go to die. But, the rice is usually thought of as being highly tolerant of flooded conditions (Visser *et al.*, 2003). The rice is a unique plant that only cultivates under the Water in the world due to special root structure can take dissolved 0_2 in the water. The plants under flooding and submergence stress growth adversely affected and end product of photosynthesis' amount (yield level) decreases. O_2 level run off in these soils between (1,0-2,0) hours; then, anaerobic respiration begins. In the cell, (Fe), (Mn), (H_2S), sulfides, lactic acid, butyric acid(s) activated and they reach to toxic level; protein synthesis decreases, mitochondria damages; division and elongation of the cells slow down, ion transmission negatively affects; stomata closes, the leaves lose their turgor pressure than the plant(s) die(s) (Sunkar, 2010).

Disease stress: Disease factor(s) enter(s) from the leaves, stomata and scratch(es) that caused to "*infection*". If the plant is susceptible and pathogeneity level is high, when the other conditions (disease triangle factors, etc.) are optimum can be cause "epidemy/ies" at the level of local, national or international scale(s). It was reported that there is 0 to 80% dry matter losses occurs each year due to the rust (*Puccinia* spp.) diseases in wheat (*Triticum* spp.) production (Ulukan, 1998). When the pathogen entering, biochemically based measurement(s) against to disease pathogens are secretion of some chemicals such as tannins, alkaloids, etc. (Liu and Ekramoddoullah, 2006) and symptoms are: pustules, chlorosis, necrosis, wilting and crusting in stem and leaves, rot in the root sytem and fruits (= a disease product).

Allelopathy: It was used first time by Molish in 1937 (Türküsay and Onoğur, 1998). Especially, when allelopathic plants entered the stress, conditions (particularly under water/Drought stress), they secret and release the allelopathic enzymes such as cinnamic acid, hydroxycinnamic acid (ferulic), salicylic acid, terpene(s), phenol(s) and phenolic(s), amines, coumarine(s), juglone, leptospermone, etc. by various parts' (roots, stem, leave, seed, fruit, etc.). Main reason of this behaviour's of them is inhibit the growth and development, surviving, light, etc. to the next plant seeds.

In the nature, there are many allelopathic plants (maple family (*Aceraceae*), the beech family (*Fagaceae*), the walnut family (*Juglandaceae*), Eastern red cedar (*Juniperus virginiana*), Norway spruce (*Picea abies*), Virginia pine (*Pinus virginiana*), American arborvitae (*Thuja orientalis*), Canadian hemlock (*Tsuga canadiensis*), boxelder/ashleaf maple (*Acer negundo*), Japanese maple (*Acer palmatum*), sugar maple (*Acer saccharum*), serviceberry (*Amelanchier* spp.) and birch (*Betula* spp.), Indian bean (*Catalpa* spp.), eastern redbud (*Cercis canadensis*), fringetree/old man's beard (*Chionanthus virginicus*), American beech (*Fagus grandifolia*), European beech (*Fagus sylvatica*), American ash (*Fraxinus americanus*), stonecrop (*Sedum* spp.), mullein (*Verbascum* spp.), speedwell (*Veronica* spp.), daphne species (*Daphne* spp.), berberis species (*Berberis* spp.), white and red oaks (*Quercus alba* and *Quercus rubra*) (Roy *et al*., 2011).

In addition to this, there are the non-native, invasive weed tree/tree of heaven (*Ailanthus altissima*), corncockle (*Agrostemma githago)*, goosegrass (*Eluisine indica*), wild garlic (*Allium vineale)*, limpo grass (*Hemartia altissima)*, red-rooted pigweed (*Amaranthus retroflexus)*, prickly amarth (*Amarantus spinosus)*, annual ryegrrass (*Lolium multiflorum*), prickly lettuce (*Lactuca scariola*), common ragweed (*Ambrosia artemisiifolia*), scentless chamomile (*Matricaria inodora*), cuman ragweed (*Ambrosia psilostachya*), meadowgrass/ bluegrass/tussock/speargrass (*Poa* spp.), buffalo weed (*Ambrosia trifida)*, common knotgrass (*Polygonum aviculare*), mugwort/common wormwood (*Artemisia vulgaris*), poppy (*Papaver orientale*), common wild oat (*Avena fatua*), redshank (*Polygonum persicaria)*, cruciferous vegetables/mustard (*Brassica* sp.), common purslane/verdolaga/moss rose (*Portulaca oleracea*), camelina (*Camelina alyssum*), prickly saltwort/prickly glasswort (*Salsola kali*), bermuda grass/dubo (*Cynodon dactylon)*, green foxtail/green bristlegrass (*Setaria viridis*), green spurge/leafy spurge (*Euphorbia esula)*, giant foxtail/Chinese foxtail (*Setaria faberi*) and common chickweed (*Stellaria media*) in the nature (Bezuidenhout, 2012; Anonymous, 2012).

Oxidative stress: As a basically, it results from conditions promoting the formation of active oxygen species that damage or kill cells. Most of the abiotic stresses induce in plants an oxidative damage of the cell structure and consequently a loss in the cellular activities (Shanker and Venkateswarlu, 2011). Oxidative stress is known to be generated by a number of environmental factors such as air pollution, oxidant herbicides, heavy metals, drought, heat and cold stress, wounding, the UV light and dense (high) light that. Oxidative stress from environmental sources and developmental transitions such as seed maturation involves the formation of reactive oxygen species (ROS) in plant cells-They (ROS) play an important role in endonuclease activation in the plant cell and consequently DNA damage- (Grene, 2002). Especially, from them ozone (O_3) gas is one of the most important factors of this stress.

This gas locates in the upper layers of the atmosphere and, protects the world influence of (UV-A, B) rays, but at the same time, is also very dangerous because of they are very reactive oxidant (Iglesias *et al*., 2006). O_3 has been considered to be the most harmful agent to plants and reduce the photosynthesis and speed up the senescence. including light, temperature, water, mineral deficiency, toxic metals, air pollutants, such as O_3, SO_2, CO_2 and NO and furthermore, plants after reacting with oxygen can exhibit a broad range of physiological responses including changes in gene expression (Patra and Panda, 1998). Reactive oxygen species (ROS), which is cell damaging or killing, can be distinguished or characterized by formation in the cells. Important deleterious effects under saline conditions might be due to ROS which cause oxidative stress as one of the most general stress types (Shanker and Venkateswarlu, 2011).

Obtained findings were showed that O_3 could be broke of the cycle of glucolysis and pentose phosphate cycle in Aleppo pine (*Pinus halepensis*), sugar maple (*Acer saccharum*), silver birch (*Betula pendula*), Norway spruce (*Picea abies*), [poplar (*Populus* sp.) x White poplar (*Populus alba*)] and European beech/common beech (*Fagus sylvatica*) genotypes; plays an important role in the *RUBISCO* enzyme formation (Doubnerova and Ryslava, 2011) and, it is reported that oxidative stress is being increased with the aging in plants before anthesis (Munne-Bosch and Alegre, 2002); decreased rates of photosynthesis, leaf injury, reduced growth of shoots and roots; accelerated flowering and reducing yield. On the other hand, alters ion transport, increasing membrane permeability, inhibiting H^+-pump activity, collapsing the membran potential and activity, increasing Ca^{+2} uptake from apoplasm and oxidative damage(s) can be mentioned as ozone damages.

Air pollution and heavy metal stresses: The main sources are soil and water originated toxic substances. They can identified as industrial, home and agricultural wastes, fossil fuels, SO_2, N_2O, NO, NO_2, O_3 and H_2S gases. Researches reported that various pollutant effects' could be change on the same plant (Rudorff *et al*., 1996). Another one is heavy metal stress. They contain some toxic elements such as Zn, Pb, Ni, Co, Cr, Cu, Mn, Cd, Se, Sb, As and Al and starts over their specific/lethal dose(s). It is interesting that the heavy metals have biological importance in the plant development and growth, where they play key roles affecting cellular processes such as homeostasis and photosynthesis (Despres and Goloubinffi, 2007) and inhibit the root development and cell division. Particularly, Al^{+3} could be easily react with in the plant cell wall, nucleus, etc. at the acid soils (Doubnerova and Ryslava, 2011). In general, damages arisen during the "*electron transferring*" stage in the photosynthesis; block the vital enzyme(s) processing in the organism to a certain extent, inconvenience(s) emerge(s) in the meeting of energy requirement(s) and reduce(s) the quality components (Volk, 2010).

DISCUSSION

Today, due to knowledge limitations on the stresses, to better understand of plants ecophysiological responses' are very important and basic. Particularly, to be able to do this evaluation in the light of increasing interesting(s) for the stressors or stress factor(s) like salinity, drought, flooding, heavy metal, temperature extremes, high-light intensities, (UV-A, B) radiation, herbicides, ozone, etc. are very valuable particularly at the problem areas (Hasanuzzaman *et al*., 2010). Likewise, (esp. in abiotic stresses) the stresses are an integral part of "*climate change*," with their complex structure and have unpredictable impacts under the any environmental conditions and this point is verified by Ahmad and Prasad (2012). Changes in processes regulates by GSH (*Glutathionine*) concentration and/or redox status are considered to be important in the adaptive mechanisms of plants exposed to stressful environmental conditions and increase in protein turnover in plants may also be a non-specific response which is known to be induced by a variety of stresses including metals, temperature and air pollutants (Jordan, 1996). If stress topic examine as genetically, it is obvious that hundreds of genes respond to any specific stress and their products may or may not have a role in adaptation to stress; but, its the ecophysiological role of most of them are yet unknown (Munne-Bosch and Alegre, 2002).

Stress studies in the plants have some difficulties that they can be mentioned like this and they have to solve: First, their action or pathway mechanism(s) is/are very complex; second, they give generally unexpected results due to interactions with internal and external factors and stress(es); third, as a disadvantage, our knowledge on stress-associated metabolism factors are rather limited (for the time being) and usually, this limitation(s) play(s) a major gap or key role for the agricultural production(s) (Anonymous, 2012). But this is a strongly possibity that with the aid and collaboration of special technical techniques and tools such as DNA technology, proteome analysis, photo-acoustic spectroscopy, etc. (Roy *et al*., 2011) and other biological science(s), important promising result(s) will be realized and they can be able to put into practice in near future.

REFERENCES

Ackerly, D.D., S.A Dudley, S.E. Sultan, J. Schmitt and S.J. Coleman *et al*., 2000. The evolution of plant ecophysiology traits: Recent advances and future directions. Bioscience, 11: 979-995.

Ahmad, P. and M.N.V. Prasad, 2012. Abiotic Stress Responses in Plants. Springer Verlag, USA., Pages: 473.

Aina, O.O., A.G.O. Dixon and E.A. Akinrinde, 2007. Effect of soil moisture stress on growth and yield of cassava in Nigeria. Pak. J. Biol. Sci., 10: 3085-3090.

Anonymous, 2012. Plant stress: An overview by Jozef Bujarsky. Bios 761-Plant Stress Seminar. http://www.pdf-txt.com/pdf/plant-stress-Accessed 27.12.2012.

Ashraf, M. and M.R. Foolad, 2007. Roles of glycine betaine and proline in improving plant abiotic stress resistance. Environ. Exp. Bot., 59: 206-216.

Ashraf, M. and P.J.C. Harris, 2004. Potential biochemical indicators of salinity tolerance in plants. Plant Sci., 166: 3-16.

Bezuidenhout, S.R., 2012. Allelopathy as a possible cause for crop yield reductions. http://agriculture.kzntl.gov.za/portal/AgricPublications/TechnicalInformation/Allelopathy/tabid/184/Default.aspx.

Blum, A. and W.R. Jordan, 1985. Breeding crop varieties for stress environments. Crit. Rev. Plant Sci., 3: 199-238.

Bohnert, H.J., D.E. Nelson and R.G. Jensen, 1995. Adaptations to environmental stresses.The Plant Cell., 7: 1099-1111.

Burke, J.M., L.V. Gusta, H.A. Quamme, C.J. Weiser and P.H. Li, 1976. Freezing and injury in plants. Annu. Rev. Plant Physiol., 27: 507-528.

Chinnusamy, V., J. Zhu and J.K. Zhu, 2007. Cold stress regulation of gene expression in plants. Trends Plant Sci., 12: 444-451.

CSSRI, 1999. Central Soil Salinity Research Institute, Karnal, Indian annual report. pp: 41-52.

Despres, B. and I. Goloubinffi, 2007. Plant responses to stress: Role of molecular chaperones. Encycl. Plant Crop Sci., 330: 1002-1005.

Dita, A.M., N. Rispail, E. Prats, D. Rubiales and K.B. Singh, 2006. Biotechnology approaches to overcome biotic and abiotic stress constraints in legumes. Euphytica, 147: 1-24.

Doubnerova, V. and H. Ryslava, 2011. What can enzymes of C_4 photosynthesis do for C_3 plants under stress?. Plant Sci., 180: 575-583.

Ehsanpour, A.A. and R. Razavizadeh, 2005. Effect of UV-A radiation on drought tolerance of alfalfa (*Medicago sativa*) callus. Pak. J. Biol. Sci., 8: 1221-1224.

FAO, 2011. Land and plant nutrition management service. Food and Agriculture Organization, Rome, Italy.

Farooq, M., H. Bramley, J.A. Palta and K.H.M. Siddique, 2011. Heat stress in wheat during reproductive and grain-filling phases. Crit. Rev. Plant Sci., 30: 491-507.

Gaber, A.M., 2003. Response of water stressed *Vigna sinensis* plants to application of IAA and/or oxalic acid. Pak. J. Biol. Sci., 6: 514-524.

Gençtan, T., 2012. Tarımsal Ekoloji. [Agricultural Ecology]. University of Namık Kemal Publishing, Tekirdağ, Türkiye, 6/3, Pg: 353.

Gregorio, G.B. and G. Cabuslay, 2005. Breeding for abiotic stress tolerance in rice. In: Abiotic Stresses, Plant Resistance Through Breeding and Molecular Approaches, Ashraf, M. and P.J.C. Harris (Eds.). Food Products Press/The Haworth Press Inc., New York, USA., pp: 513-544.

Grene, R., 2002. Oxidative Stress and acclimation mechanisms in plants. In: The *Arabidopsis* Book, Somerville, C.R. and E.M. Meyerowitz (Eds.). American Society of Plant Biologists, Rockville, MD., USA., pp: 1-20.

Gutschick, V., 1999. Research reviews: biotic and abiotic consequences of differences in leaf structure. New Phytol., 143: 3-18.

Hanson, A.D., B. Rathinasabapthi, D. Rlvoal, M. Burnet, M.O. Dillon and D.A. Gage, 1994. Osmoprotective compounds in the *Plumbaginaceae*: A natural experiment in metabolic engineering of stress tolerance. Proc. Natl. Acad. Sci. USA., 91: 306-310.

Hasanuzzaman, M., M.A. Hossain and M. Fujita, 2010. Physiological and biochemical mechanisms of nitric oxide induced abiotic stress tolerance in plants. Am. J. Plant Physiol., 5: 295-324.

Hussain, S.S., M. Ali, M. Ahmad and K.H.M. Siddique, 2011. Polyamines, natural and engineered abiotic and biotic stress tolerance in plants. Biotechnol. Adv., 29: 300-311.

IRRI, 1998. Programme report for 1997. International Rice Research Institute, The Philippines. Pg 175.

Iglesias, J.D., A. Calatayud, E. Barreno, E. Primo-Millo and M. Talon, 2006. Responses of citrus plants to ozone: Leaf biochemistry, antioxidant mechanisms and lipid peroxidation. Plant Physiol. Biochem., 44: 125-131.

Jaleel, C.A., M. Paramasivam, A. Wahid, M. Farooq, H.J. Al-Juburi, F. Somasundaram and R. Panneerselvam, 2009. Drought stress in plants: A review on morphological characteristics and pigment compositions. Int. J. Agric. Biol., 11: 100-105.

Jordan, B.R., 1996. The effects of ultraviolet-B radiation on plants: A molecular perspective. Adv. Bot. Res., 22: 97-162.

Kadioğlu, A., R. Terzi, N. Saruhan and A. Sahlam, 2012. Current advances in the investigation of leaf rolling caused by biotic and abiotic stress factors. Plant Sci., 182: 42-48.

Kotak, S., J. Larkindale, U. Lee, P. Von Koskull-Döring, E. Vierling and K.D. Scharf, 2007. Complexity of the heat stress response in plants. Curr. Opin. Plant Biol., 10: 310-316.

Leung, H., 2008. Stressed genomics-bringing relief to rice fields. Curr. Opin. Plant Biol., 11: 201-208.

Liu, J.J. and A.K.M. Ekramoddoullah, 2006. The family 10 of plant pathogenesis-related proteins: Their structure, regulation and function in response to biotic and abiotic stresses. Physiol. Mol. Plant Pathol., 68: 3-13.

Lopez, M., N.A. Tejera and C. Lluch, 2009. Validamycin an improves the response of *Medicago truncatula* plants to salt stress by inducing trehalose accumulation in the root nodules. J. Plant Physiol., 166: 1218-1222.

Massarelli, I., R. Cioffi, G. Batelli, M. De Palma, A. Costa, S. Grillo and A. Leone, 2006. Functional screening of plant stress-related cDNAs by random over-expression in *Escherichia coli*. Plant Sci., 170: 880-888.

McSteen, P. and Y. Zhao, 2008. Plant hormones and signaling: Common themes and new developments. Dev. Cell, 14: 467-473.

Mittler, R., 2006. Abiotic stress, the field environment and stress combination. Trends Plant Sci., 11: 15-19.

Munne-Bosch, S. and L. Alegre, 2002. Plant aging increases oxidative stress in chloroplasts. Planta, 214: 608-615.

Munne-Bosch, S., 2005. The role of α-tocopherol in plant stress tolerance. J. Plant Physiol., 162: 743-748.

Murchie, E., M. Pinto and P. Horton, 2009. Agriculture and the new challenges for photosynthesis research. New Phytol., 181: 532-552.

Patra, J. and B.B. Panda, 1998. A comparison of biochemical responses to oxidative and metal stress in seedlings of barley, (*Hordeum vulgare*) L. Environ. Pollut., 101: 99-105.

Popelka, J.C., N. Terryn and T.H.V. Higgins, 2004. Gene technology for grain legumes, can it contribute to the food challenge in developing countries?. Plant Sci., 167: 195-206.

Porporato, A., F. Laita, I. Ridolfi, K. Caylor and I. Rodriguez-Iturbe, 2003. Soil moisture and plant stress dynamics along the Kalahari precipitation gradient. J. Geophy. Res., Vol. 108. 10.1029/2002JD002448

Reddy, A.R., K.V. Chaitanya and M. Vivekanandan, 2004. Drought-induced responses of photosynthesis and antioxidant metabolism in higher plants. J. Plant Physiol., 161: 1189-1202.

Roy, J.S., J.E. Tucker and M. Tester, 2011. Genetic analysis of abiotic stress tolerance in crops. Curr. Opin. Plant Biol., 14: 232-239.

Rudorff, B.F., C.L. Mulchi, E.H. Lee, R. Rowland and R. Pausch, 1996. Effects of enhanced O_3 and CO_2 enrichment on plant characteristics in wheat and corn. Environ. Pollut., 94: 53-60.

Saleh, A.A.H., D.Z. Abdel-Kader and A.M. El Elish, 2007. Role of heat shock and salicylic acid in antioxidant homeostasis in Mungbean (*Vigna radiata* L.) plant subjected to heat stress. Am. J. Plant Physiol., 2: 344-355.

Shanker, A.K. and B. Venkateswarlu, 2011. Abiotic Stress in Plants-Mechanisms and Adaptations. InTech Publisher, Janeza Tridne Rijeka, Croatia, ISBN: 9789533073941, Pages: 428.

Shepherd, T. and D.W. Griffiths, 2006. The effects of stress on plant cuticular waxes. New Phytol., 171: 469-499.

Sunkar, R., 2010. MicroRNAs with macro-effects on plant stress responses. Semin. Cell Dev. Biol., 21: 805-811.

Taulavuori, K., M.N.V. Prasad, E. Taulavuori and K. Laine, 2005. Metal stress consequences on frost hardiness of plants at northern high latitudes: A review and hypothesis. Environ. Pollut., 135: 209-220.

Thakur, P., S. Kumar, J.A. Malik, J.D. Berger and H. Nayyar, 2010. Cold stress effects on reproductive development in grain crops: An overview. Environ. Exp. Bot., 67: 429-443.

Türküsay, H. and E. Onoğur, 1998. Bazı bitki ekstraktlarının *in vitro* antifungal etkileri üzerine araştirmalar [Studies on antifungal effects of some plant extracts *in vitro*]. Turk. J. Agric. For., 22: 267-271.

Ulukan, H., 1998. Relationship between rust (*Puccinia* spp.) resistance and morphological traits in some wheat (*Triticum* spp.) species. Ph.D. Thesis, Faculty of Agriculture, Natural and Applied School, University of Ankara, Ankara, Türkey.

Ulukan, H., 2008. Agronomic adaptation of some field crops: A general approach. J. Agron. Crop Sci., 194: 169-179.

Visser, E.J.W., L.A.C.J. Voesenek, B.B. Vartapetian and M.B. Jackson, 2003. Flooding and plant growth. Ann. Bot., 91: 107-109.

Volk, M.G., 2010. Application of functional genomics and proteomics to plant cryopreservation. Curr. Genom., 11: 24-29.

Wang, Y. and M. Frei, 2011. Stressed food-the impact of abiotic environmental stresses on crop quality. Agric. Ecosyst. Environ., 141: 271-286.

Webber, M., J. Barnett, B. Finlayson and M. Wang, 2008. Pricing China's irrigation water, Working Paper, School Anthrop. Geog. Environ. Studies, The University of Melbourne, Victoria, Australia, 4: 617-625.

Witcombe, J.R., P.A. Hollington, C.J. Howarth, S. Reader and K.A. Steele, 2011. Breeding for abiotic stresses for sustainable agriculture. Phil. Trans. R. Soc. B, 363: 703-716.

Wu, Q.S., X.R. Xia and Y.N. Zou, 2008. Improved soil structure and citrus growth after inoculation with three arbuscular mycorrhizal fungi under drought stress. Eur. J. Soil Biol., 44: 122-128.

Yordanov, I., V. Velikova and T. Tsonev, 2000. Plant responses to drought, acclimation and stress tolerance. Photosynthesis, 38: 171-186.

Zhu, J.K., 2001. Plant salt tolerance. Trends Plant Sci., 6: 66-71.

Zhu, J.K., P.M. Hasegawa, R.A. Bressan and H.J. Bohnert, 1997. Molecular aspects of osmotic stress in plants. Crit. Rev. Plant Sci., 16: 253-277.