DROUGHT STRESS DUE TO CLIMATE CHANGE AND EFFECTS ON PLANTS

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Abstract: The Climate comes first in the most important factors which effect of the life and the distribution of life forms on earth. For this reason, life plains of natural and cultural plants is formed by the effect of climatic factors. The observations of the World Meteorological Organization and lots of works show a global climate change. No doubt, the effects of this change is seen in Turkey. The effect of climate factors on agricultural production cannot be ignored. Plants encounter many stress factors which affect their growth and development throughout their lifecycles because of their nature. These stress conditions which can be originated by biotic and abiotic factors can adversely affect the quantity and quality of the product with leading to physiological and biochemical damage to crops. Drought stress, one of the most common environmental limitations affecting growth and productivity of plants, causes many mechanical, metabolic and photosynthetic changes in plants. This situation makes cultivation of plants tolerant to high stress more crucial. Therefore, current studies are mostly focused on the explaining the tolerance mechanisms of highly drought resistant plants and protecting and transforming of the plant genetic sources. In this paper, drought effects on the plants are explained by referring important researches done in the recent years.

***Keywords*:** Climate change, drought stress, mechanical, metabolic and photosynthetic changes.

INTRODUCTION

Increasing temperatures due to climate change, changes in precipitation regime and record-increasing natural disasters due to meteorological changes every year, which we are beginning to feel more nowadays, negatively affect the vital activities of human beings. It is inevitable that crop production is also affected by climate changes. Climate change and associated meteorological disasters cause serious crop losses in crop production. Atmospheric evaporation losses are expected to increase as a result of drought events that are expected to increase due to climate change (Teuling, 2013). Increased temperatures due to climate change and irregularities in the precipitation regime cause drought to occur more and more every year.

In addition, drought stress has become increasingly important in plant breeding every day due to the declining nature and quantity of water resources around the world, leading to changes in the normal physiological functions of plants with economical preserve. This is especially important in the cultivation of crop plants, which require large amounts of water for their development and often cause water loss to yield deficiencies. Drought, which causes very serious decreases in crop production, causes serious economic losses all over the world Therefore, WMO provides guidance and scientific information to strengthen national services responsible for addressing drought risks to agriculture.

Plants encounter many stress factors during their lives. According to Levitt, stress factors are divided into biotic and abiotic (Levitt, 1980). Biotic factors; Infection of microorganisms (fungi, bacteria and viruses), and attack factors of harmful animals (Figure 1).

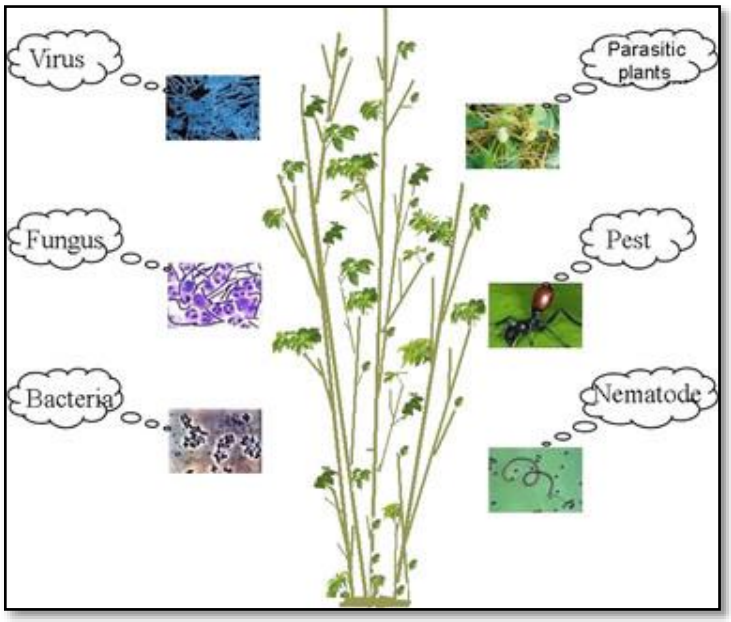

Figure 1: Biotic stress factors

Abiotic factors are environmental factors such as drought, water, radiation, chemicals, magnetic and electrical fields (Lichtenhaler, 1996). Climate and soil factors are at the top of the abiotic factors that plants have to cope with (Figure 2). Each of these factors affects the distribution of plant species and the genetic makeup of the population in different ways. Their effects are not independent of each other and they have a common effect on the plant. For example, it is possible to balance the resistance of the plant against high temperature stress, in part with the amount of available water in the soil (Burke, 1990). Climate factors include unpredictable properties such as the amount of precipitation or the number of days below zero, as well as predictable properties such as photoperiod. Soil properties vary very slowly over time according to climate characteristics.

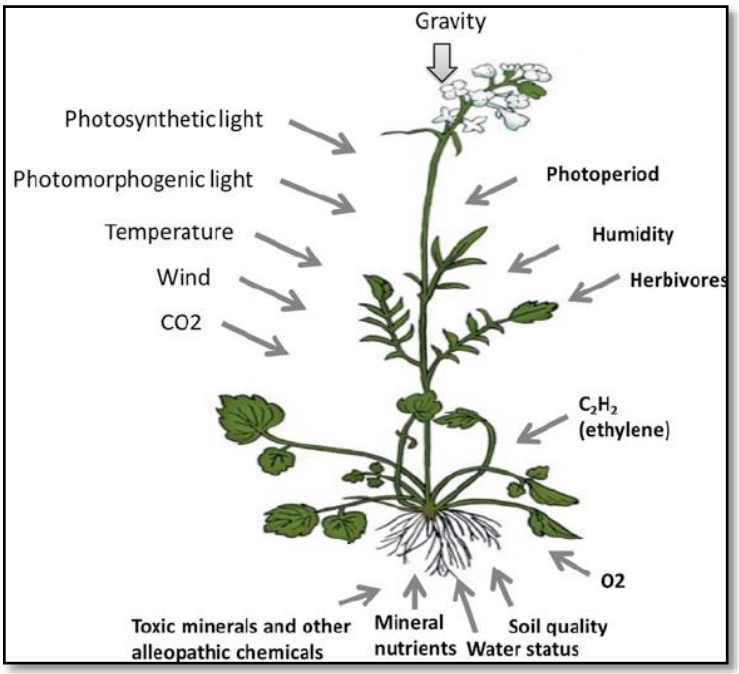

Figure 2: Abiotic stress factors

Drought stress, which is a natural stress factor, has the highest percentage with 26% part when the usable areas on the earth are classified in view of stress factors. It is followed by mineral stress with 20% part, cold and freezing stress with 15% part. The other stress get 29% part whereas only 10% area is not exposed any stress factors (Blum, 1986) (Figure 3). Therefore drought stress is one of the most widespread environmental stresses, which affects growing and productivity; it causes mechanical, metabolic and photosynthetic changes on plants.

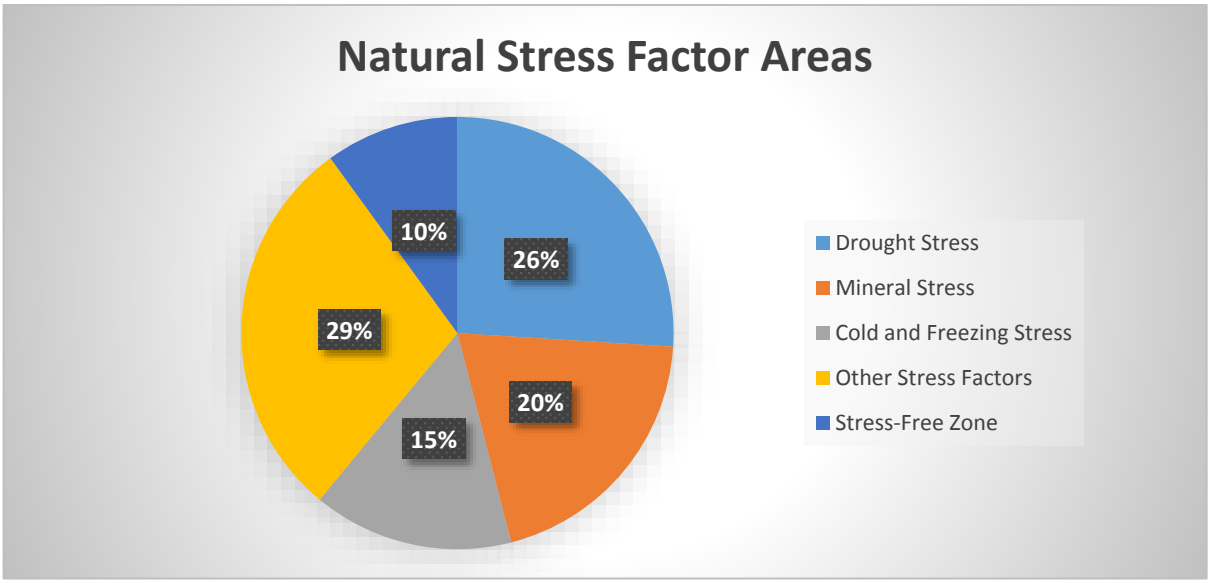

Figure 3: Natural stress factor areas.

DROUGHT STRESS

In the most general sense, drought can be defined as a meteorological phenomenon: a period without rain long enough to cause significant reduction in soil moisture content and plant growth. The period of time without rainfall actually needed to produce a drought depends mainly on the water holding capacity of the soil and rate of evapotranspiration by plants (Jones, 1992). There are significant differences in terms of physiological and metabolic changes between plant species and varieties, even their organs, in terms of their effect on drought stress (Belkhodja, 1994) (Figure 4). The degree of drought induced by different genotypes depends on the metabolic changes that the genotype develops under stress, that is, the physiological and biochemical reactions (Kayabaşı, 2011).

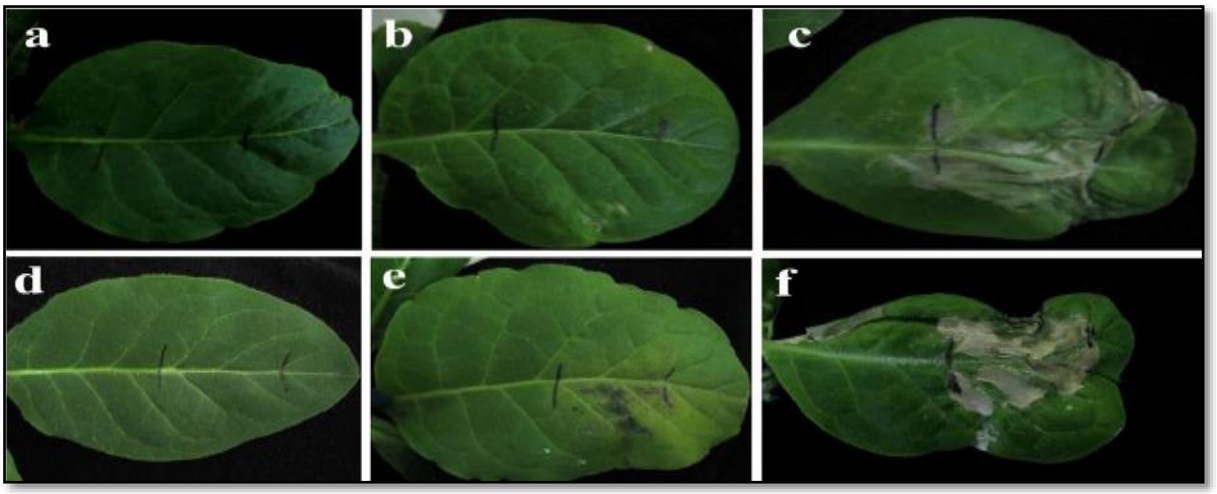

Figure 4: Grades affected by drought in different plants

Drought, which is the stress factor with the greatest effect on plant yield and quality, has recently caused yield losses in different plants and parts of Turkey. Loss of up to 30% in agricultural production has been determined that in regions with drought in 2007, 2008, 2012 and 2014. When the yield values of wheat, barley and oat were examined in the last 10 years period, there was a yield loss of 15% in wheat, 22% in barley and 12% in oat in 2014 (TUIK, 2017) (Figure 5).

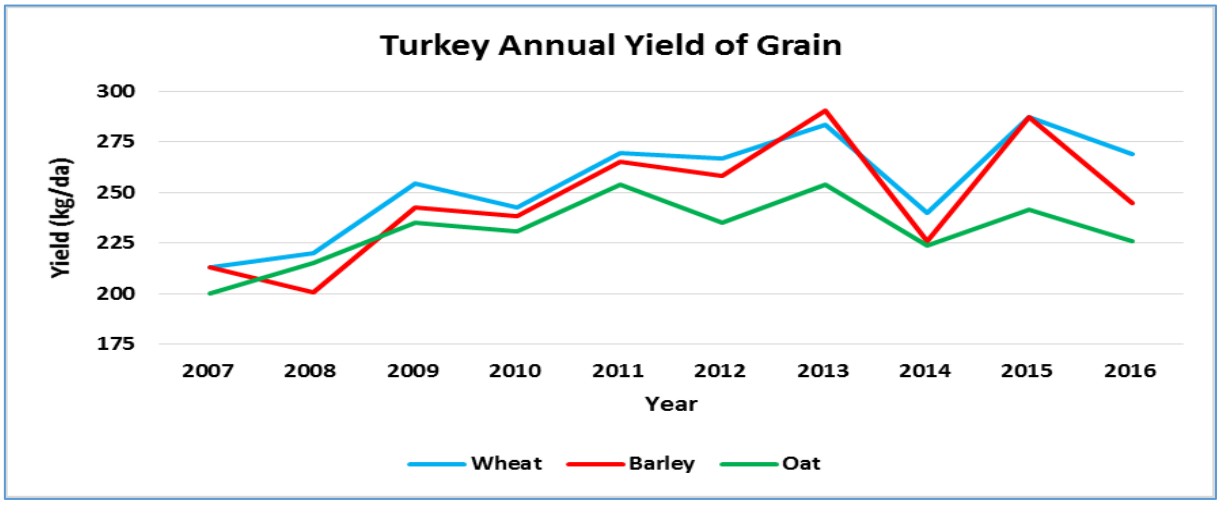

Figure 5: Turkey annual yield of grain.

Drought could be considered as water deficit and desiccation separately. Water deficit can be defined to be a moderate loss of water which leads to stomatal closure and limitation of gas exchange. In plants which are exposed to mild water deficits that relative water content (RWC) remains approximately 70%, carbon dioxide uptake is limited because of stomatal closure. Desiccation can be defined to be as an excessive loss of water which can potentially lead to entirely disruption of metabolism and cell structure and eventually to the cessation of enzyme-catalyzed reactions. As a general rule, most vegetative tissues of desiccation-sensitive vascular plants, cannot recover if dried to a RWC below 30% (Smirnoff, 1993).

THE EFFECTS OF DROUGHT STRESS ON PLANTS

MECHANICAL EFFECT

When water is lost in significant quantities from plant cells, the immediate stress experienced as turgor is lost by the plant, is mechanical (Levitt, 1980). The structure of the plasma membrane, Liquid-crystalline phase is consequence of the aqueous environment of the cell (Figure 6). As water leaves the cell, the structure of the membrane alters. Membranes pass into the Gel phase, which is a compact appearance. In this new construction, there is less mobility in the membrane than in the Liquid-crystalline phase. Due to water loss, the volume in the cell also decreases. Plasma membrane under tension may rupture (McKersie, 1994). This may result in the release of the hydrolytic enzymes located on the membranes and thus the autolysis of the cytoplasm (Salisbury, 1992). This harm usually permanently disrupts normal cellular metabolism.

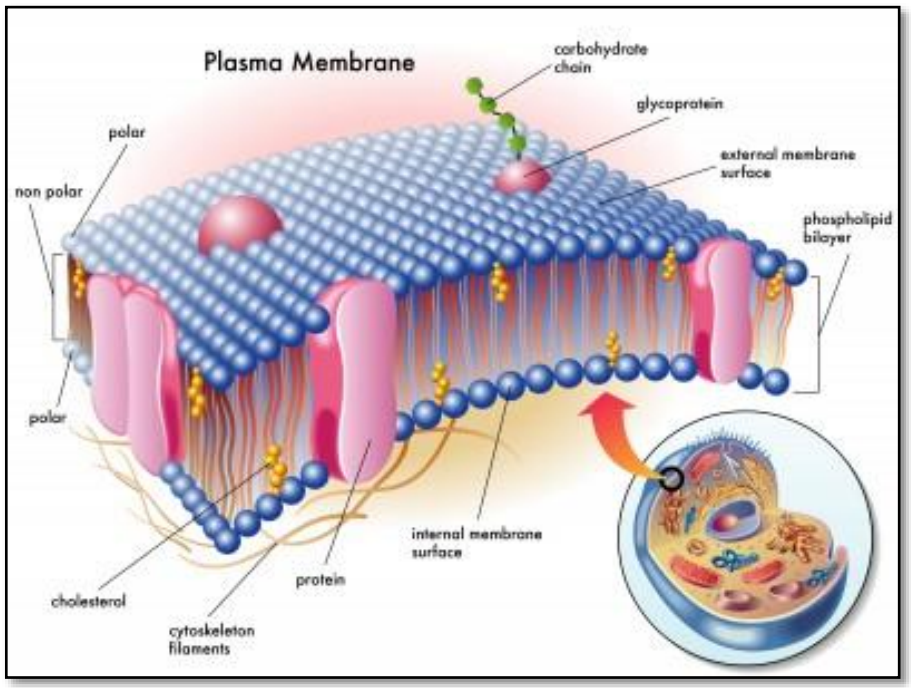

Figure 6: Structure of plasma membrane

METABOLIC EFFECT

When water is lost from cells, because of its functional characteristics of filling the most part of the cell volume, being a transport medium, playing the role as a solvent for the cellular reactions and processes, regulation in the cell and metabolism disrupts. Ion accumulation which is originating from the water loss of the cell, can damage the cell, disrupt membranes and cause protein denaturation. As a result of water loss; the interactions of amino acids in the structure of proteins with water disrupt (Campbell, 1991). Another damage to plant cells during drought stress is the degradation of nucleic acids such as DNA and RNA (Figure 7). According to Kessler, in foliage exposed to drought stress, enzymes shift from bound-state to free-state and cause destruction of nucleic acids (Kessler, 1961).

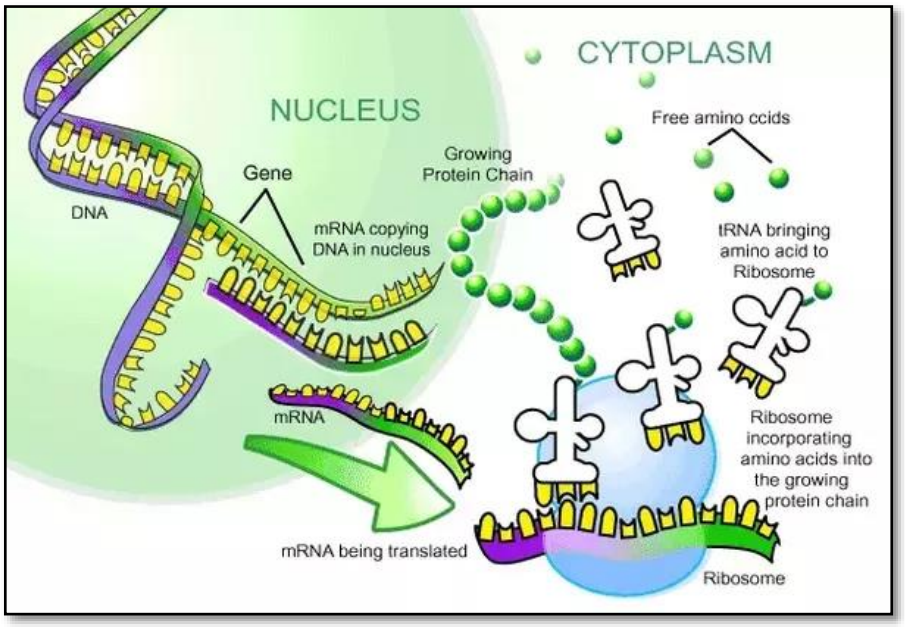

Figure 7: Structure of amino acids degraded by water loss

PHOTOSYNTHETIC EFFECT

During drought, photosynthesis decreases due mainly to two reasons; stomatal limitations that occur due to stomatal closure upon moderate water deficit conditions and other limitations that generally occurs upon longer and more severe water stresses (Figure 8). One of the earliest responses against drought is stomatal closure that limits CO2 diffusion towards chloroplasts (Lima, 2002). During drought two main reasons to cause plants to close their stomata are hydrolic signals (leaf water potential, cell turgor) and chemical signals (Abscisic acid; ABA). Abscisic acid (ABA), synthesized in the roots can also be transport via transpiration stream, induces stomatal closure under drought stress conditions (Teiz, 1998).

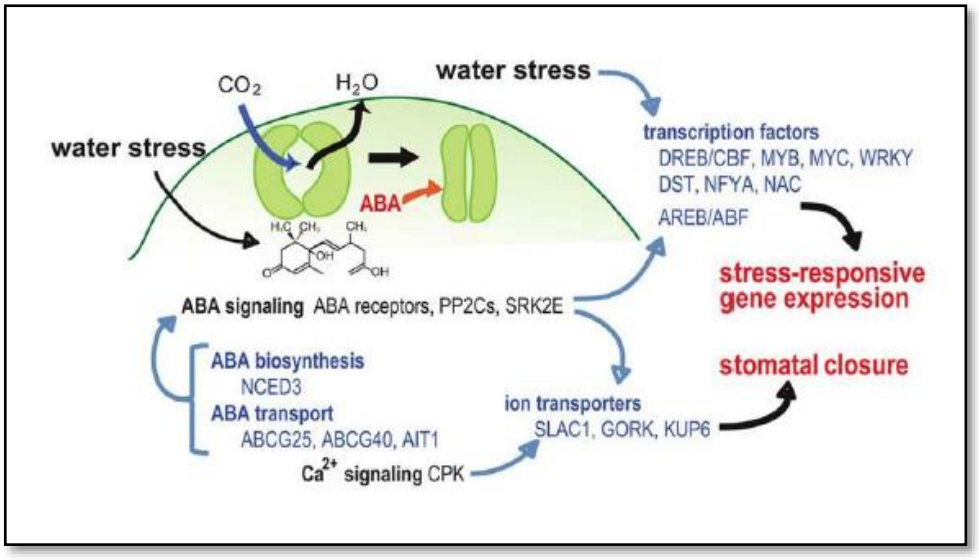

Figure 8: Closure of stomata by the effect of abscisic acid (ABA) in the plant exposed to the stress

It has been found that photosynthetic electron transport and photophosphorylation capacities decrease in chloroplasts of plants which are exposed to severe water deficit reduce (Smirnoff, 1993). Photosystems in chloroplasts, particularly PSII, are affected by drought stress (He, 1995). Other limitation of photosynthesis may

be related to the oxidative damage to chloroplast lipids, pigments or proteins (Tambussi, 2000). Photosynthetic capacity in plants varies depending on the content of water within the cell.

CONCLUSIONS AND RECOMMENDATIONS

Drought, which is generally defined as the rainfall values below the average of underground and surface water values, is in the first place of the natural disasters in the world. Human activities like burning of fossil fuel, destroying forests, industrial activities cause increase of the "greenhouse gases" such as carbon dioxide, methane, ozone. As a result of the greenhouse effect created by these gases, there is also an increase in temperature on the surface of the earth. This phenomenon is called global warming resulted in changes in the climate and according to the research results in South Europe including Turkey will be under the influence of dry and hot climate in the middle of this century. Drought stress, which is mostly an oxidative damage at cellular level, mechanically, metabolically and photosensitically affects the plant and reduces yield and quality in arid and semi-arid regions.

Drought, which may cause reduction in feeding capacity of the natural resources and as a result of that millions of people may die due to starvation, is the major threat for all biologic life. For this reason, research works on determination the plant species tolerant to drought, determining the tolerance mechanisms, conservation and transformation of the gene resources of the plants resistant to drought will play an important role in preventing the drought particularly caused by global warming, to become a major problem for all organisms in the future.

The mechanisms of plants that can survive in restricted water conditions and which show relatively low decreases in yields have become a field of interest. By examining these mechanisms, stress resistant genotypes have begun to be determined. It is important to change the production and irrigation methods depending on the physiological water requirements of the drought and the plants. The development of new varieties using biotechnological methods and drought tolerance and high water use efficiency characteristics can also provide important contributions to the provision of food for future years.

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