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Changes in crop physiology under drought stress: A review

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Abstract
In plants, usually the drought stress in considered as the lowering in the rate of respiration or decrease in the level of the photosynthesis. This review tells us the latest information about the drought stress and its effect on growth of plant with relation to the photosynthesis and water and the mechanism of adaptation. There are numerous ways of mechanism of adaptation that allows the plant to tolerate the drought stress condition. By this review we can proves the statement of different authors on the tolerance of drought stress and the slight changes in the environment conditions may lead to the fast flexibility of the cell metabolism is the first and main step in the avoidance of drought stress.

Keywords: Drought, photosynthesis, plant water relation, water deficit

Introduction

Plants are in the surrounding of several stresses of the environment, Out of which drought is one of the significant one. Drought Stress is the important reason for loss in production of various crops by 50% around the world [1]. In such conditions scarcity of water in plants tissue occurs. Several studies have been conducted with respect to different level of ecophysiological requirement and cell metabolism to check the water deficit occurred [2].

Every organism is related with the environment. Its affect can be inspected by the power and the time of the environmental factor and by the interaction between the factor and genetic abnormality. From these numerous factors the one factor is life system which is also called as ‘Stability Limit’. The range of these factors can be determined by the inherent plant capacity to withstand stresses also the intensity and time duration of the stress [3]. The capacity of the plant to accustom to a new climate or new condition is due to the presence of buffer properties to reduce the shock caused by the change in environment. Higher acclimation capacity means higher resistance to the drought wich is obbessed with the capacity of plant to maintain its physiology due to the variation in the environmental factor [4].

According to Levitt (1982) [5], stress is “any unfavorable circumstance that brings a change in the growth or development of the plant”. Stress can be brought by different factors. Change in physiological processes and functional activity (a shift in metabolism) of the plants named as a biological stress. Stress is “In stress, main rising demands made up to earlier destabilization of functions. It is followed by making it normal and then improving it. A modification to this concept was formulated by giving two new terms such as Eu-stress and Dis- stress [6]. Eu-stress is a positive stress for the development of the plant by activating or stimulating the stress. Dis-stress is the major stress that causes damage, and results in the reduction in growth level of the plant.

Effect on Plant Growth

Drought is multidimensional stress which effects the growth of plant at various stages [7]. The process of dehydration leads to the change in water relation, biochemicals and physiological process and cellular membrane of plant [8]. Drought is a complex process as it includes collection of stress which affects the plants at different levels of organization [9].

In dry environment high potential and efficient use water are important traits. The rate of growth and use of water is affected by the different biomass and by morphological and physiological properties. The response of water use efficiency when affected by physiological characters depends upon the water use and the growth of the plant. The allocation process that increases the growth depends upon the availability of the water. The roots get increased under the scarcity of water conditions [10].

Under favorable condition growth of plant, the higher leaf area ratio in plants is required, as higher leaf area ratio increases the rate of photosynthesis.

Interspecific variation in growth rate is due to differences in Leaf Area Ratio [11]. The major drawback of higher leaf area is that the rate of transpiration of the water is also higher even when the supply of water is less. Thus the leaf area ratio helps in growth but it is also associated with loss of higher water. There is a great contribution to growth and water use efficiency not only by biomass allocation but also by the differences in absorption and loss of water as well as carbon in different parts of the plant.

Ramos *et al.* (1999) [12] says that drought decreases the accumulation of fresh plant mass to a greater extent than dry biomass. Relatively lower influence of drought on dry biomass than on fresh mass results in the presence of disturbances in water relation to the plant body.

Changes in Plant Water Relation

Drought is the most significant barrier for the production of food. Relieving the plants from droughts is a difficult task. However, osmotic adjustment can prove beneficial in this [13]. In crop plants there were many mechanisms to survive from water deficit including escape, tolerance, and avoidance of tissue and cell dehydration [13]. Plants tolerate drought by maintaining sufficient cell turgor to allow metabolism to continue under increasing water deficits. Tolerance to stress involves at least two mechanisms, osmotic adjustment and changes in the elastic properties of tissues [14].

The functional component of drought resistance in several crop plants is Osmotic Adjustment [15]. To maintain cell turgor in many species Osmotic Adjustment is the important mechanism. It results in maintain metabolic activity of plant and hence increase the growth and productivity of the plant [16]. Osmotic Adjustment builds compounds which leads to dehydration of tissue and also lowers the osmotic potential of the cell in plants. Osmotic Adjustment also contributes in maintain Root and Shoot development in plants under the drought conditions [17].

A variety of reports states that metabolic process in plants is sensitive than absolute water potential [18]. The relationship between turgor pressure and olume of cell is result of change in elasticity is due to the drought conditions [19], Maury *et al.*, 2000 [20] found this relationship in Sunflower Crop, whereas Zlatev, 2005 [21] found this relationship in Common Bean Crop. Under Drought condition the data of leaf water potential is a useful indicator in many species of the plant for maintaining its functional activity [22].

Variability in proline metabolism is found in various crops, but it is not properly known that Imino Acid plays an important role in susceptibility or tolerance nature from drought in the plants [23]. Navari-Izzo *et al.*, 1990 [24] states that at given water status level the different species of plants shows difference in metabolic activity of the plant. The relationship of turgor and proline accumulation as a sensor for drought injury in the plant is given by Irigoyen *et al.*, (1992) [25].

Effects on Photosynthesis

The alteration in carbon and nitrogen assimilation is associated with a progressive suspension of photosynthesis due to the drought and water deficit in plants [26]. Stomatal and Non Stomatal limitations results as decreased photosynthetic rate [27].

Major importance in drought tolerance is to maintain the functionality of the photosynthetic machinery under the water stress. Reacting to the shortage of water the plant rapidly closes the stomata in order to keep away the water loss through transpiration [28]. The decreased rate of photosynthesis in plants is caused by the decrease in the concentration of internal carbon dioxide which results in limitation of photosynthesis at a place of ribulose-1, 5-bisphospate Rubisco [29].

In contempt of Photosystem II in drought electron transport is prevented under the water shortage condition. In some cases, it is found that due to the drought conditions in Photosystem II the oxygen evolving complex gets damaged and photosystem reaction centre gets associated with the D1 protein [28]. During drought conditions the capacity of exchange of gases decreases which leads to increase in Carbon dioxide compensation point which results in the change in the curve of photosynthesis of Carbon dioxide. While comparing with normal plant drought stressed plant shows decrease in the slope of plateue of these curves [21]. Von Caemmerer and Farquhar 1981 [30] states that the maximum carboxylation efficiency of Rubisco is defined as the first slope of Carbon dioxide curve. Whereas the capacity of the leaves to regenerate RuBP is reflected by rate of photosynthesis at Ci and had a connection with electron transport activity. Reduction in Rubisco carboxylation activity and RuBP regeneration capacity is lead by the drought is indicated by lowering of the initial slope [31]. The photosynthetic rate of the plant decreases due to the stomatal and non stomatal factors. During the stress drought tolerance species controls the function which results in the carbon fixation and the water efficiency of the plant is improved [32].

Barker and Horton in 1987 [33] suggested two methods which showed the change of fluorescence under unsuitable conditions for the growth of the plant. The first method shows the minimum increase in the level of fluorescence from the leaves placed in dark conditions. This is occurred due to the not proper oxidation of plastoquinone acceptor. Whereas, the second method is responsible for the quenching variation in fluorescence level or also known as maximum increase in the level of the fluorescence from the leaves which are placed in the dark condition. Quenching denotes the great effect on the reaction centre. Decrease in the fluorescence level is related with the decrease in the water splitting enzyme activity around or within Photosystem II [34]. As a result of quenching of fluorescence level the increase in non radiative energy would be seen by Gilmore and Bjorkman in 1995 [35].

The photo inhibition is occurred due to the continuous decrease in transport of quantum yield of electron. Droughted plant indicates the greater decrease in the proportion of energy driven by the photosynthetic pathway. In 1999 Vassie and Manlov [36] conducted an experiment to show a significant decrease in transportation of quantum yield of electron and photochemical quenching can be treated by the treatment of cadmium in plants and also by increasing the non photochemical quenching in plants.

Conclusion

By this literature we can conclude that drought causes the enlargement of stomatal limitation. The large increase of stomatal limitation leads to decrease in all photosynthetic parameter of the plant. Closure of stomata results in depressed Carbon Dioxide assimilation. Drought affects the photosynthesis rate in all aspects. The plants which have maintained Fv/Fm and are less affected, with lower increase in non photochemical quenching considered to be tolerant towards the drought stress.

Future Thrust

Continuous research in the field of drought stress management in crops is pivotal, Advanced research in plant Breeding and plant genetics to develop the drought tolerant rootstock or cultivar is required. It is advisable to develop various techniques to overcome the drought stress in the plants and to increase the rate of photosynthesis for the better growth and development so that we get maximum yield under the drought stress condition.

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