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Regulation of Water Balance of the Plant from the Different Geo-Environmental Locations

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***Abstract*—**Under the drought stress condition, the plants would grow slower. Temperature is one of the most important abiotic factors which suppress the germination processes. However, the processes of transpiration are regulated directly by the cell water, which followed to an increase in volume of vacuoles. During stretching under the influence of water pressure, the cell goes into the state of turgor. In our experiments, lines of the semi-dental sweet maize of Armenian population from various zones of growth under mild and severe drought stress were tested. According to results, the value of the water balance of the plant cells may reflect the ability of plants to adapt to drought stress. It can be assumed that the turgor allows evaluating the number of received dissolved substance in cell.

***Keywords*—**Water balance, turgor, drought stress, Armenian population of maize.

I. Introduction

IT is known that the process by which the plant cells controls the formation and growth are the result of turgor. Plant growth requires concerted water uptake and irreversible cell wall expansion to enlarge cells because a drought results in water deficit stress [1]. It was caused tension and relaxation of cell walls as a consequence; the plant cells take various forms [2]. Since it is a system with an osmotic pectocellulose casing thus permeable to water and dissolved therein nutrients.

The increase amount of water in the cell leads to an increase in volume of vacuoles, and as a consequence, the juice of cell presses the cytoplasm to the cell membrane [3]. Stretching under the influence of internal pressure, the cell goes into the state of stress – turgor. Turgor pressure is a critical factor in regulating cells growth because the physical force needed to drive cell enlargement, which notably depends upon the extensibility of the cell wall [4], [5]. A low turgor pressure caused by water stress leads to a reduction or cessation of growth by decreasing cell extensibility and cell expansion [6].

Recently investigations have allowed progress towards understanding the fine cellular dynamics regulating growth of the plant cells. It was shown that the plant cell growth is achieved through a response to the mechanical stress (generated by the adherence to adjacent cells) mediated via katanin, a protein involved in microtubule severing [7], [8].

Obviously, determination of the turgor primarily is important in ecological studies. The drought stress generates physiological changes in higher plants, including loss of turgor, osmotic adjustment, and reduced leaf water potential [9], [10]. Therefore, the value of turgor may be one from the characteristics of environment for the plant species. During drought there is a decrease in water availability in the soil, which leads to a reduction in water potential. On this fact indicates the direction of water movement in soil and the displacement of the water to / from the plant cells.

It allows us to estimate the maximum capacity of the plant to absorb water from the soil and hold it. Reaction of a plant cell to change the osmotic potential is also caused by the concentration of solutes in the cell juice. Cell expansion can only occur when turgor pressure is greater than the wall cell yield threshold [1], [5]. Thus arising potential of pressure reflects physical strength with which water affects the environment.

The aim of the present work is study the issues of the environmental adaptation caused by a limited amount of water in the soil, for different maize lines based on identifying the mechanisms of the effect of water in the plant cells.

II. Materials and Methods

The objects of study were selected inbred lines of maize B73 (Iowa Stiff Stalk Synthetic, USA) as a control, and four lines of the semi-dental sweet maize of Armenian population which was harvested from two differed provinces of Armenia: Lory (Arm 1, Arm 2, Arm 3) and Armavir (Arm 4).

Maize plants were grown in a chamber with controlled climatic conditions (16 h day/8 h night, 25 °C/18 °C day/night [d/n], humidity: 20%, 300 $\mu E.m^{-2}$ s^{-1} PAR (Photosynthetically Active Radiation)) in laboratory of Molecular Plant Physiology and Biotechnology group at the University of Antwerp.

For control plants, we watered the pots daily to a Relative Soil Water Content (RSW) of 54%. For drought treatments water contents of 43% RSW (mild stress, no wilting), and 34% RSW (severe stress, leaves are wilting during the day), respectively was maintained. For kinematic analyses we harvest the fifth leaf during the steady-state growth on the third day of its appearance. The length of this leaf is measured daily. It was observed a significant difference in leaf elongation rate and in the final leaf length between the controls and the plants subjected to drought.

After a notable reduction of the growth rate of a fifth leaf for all samples was determined total water content. For that purpose, was cut the entire aboveground part of the plant, was weighed and placed in a thermostat until all moisture at + 70°C for 72 hours. Then the samples were weighed again.

Transpiration rate by the difference of wet and dry weight was determined.

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For measuring the osmotic potential of water the freshly cut leaf of corn plant was divided into segments by zones of growth under three conditions of water stress: control, mild and severe. The isolated segments separately were placed in PSYPRO device with a measuring chamber, which is equipped with a sensor C-52-CF to determine the potential of the water psychometric method.

After measurement of total water potential, the sample of freshly cut plant leaf was immediately frozen by placing in the liquid nitrogen at -80 °C. After complete freezing, when turgor was absent, the sample is again placed in the measuring chamber and measure the osmotic potential. The value of turgor was calculated as difference aqueous and osmotic potential.

III. Results and Discussion

At the initial stage of the experiments the speed of growth rate of plants by changing the length of its fifth leaf is determined. Here the main parameter is leaf elongation rate (LER) as indicator of plant growth. This value is measured on a daily basis, at the same time and was calculated as LER during the stationary growth of the plant within three days after the appearance. The results are shown in Fig. 1.

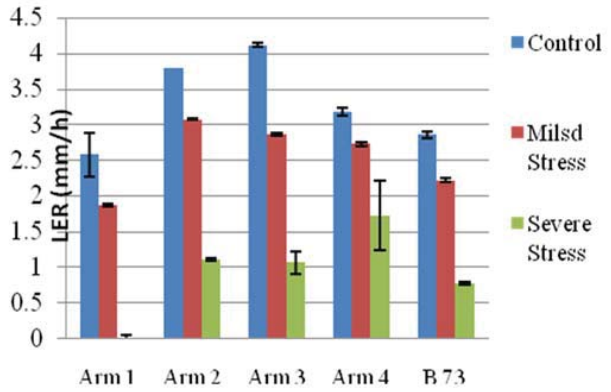

Fig. 1 The effect of mild (43% RSW, no visible signs of wilting) and severe drought (34% RSW, mild wilting visible) on leaf elongation rate (LER) during first 3 days after its emergence

Obtained results of the Armenian samples differ by the growth rate which compared to the control B73 sample. They can be divided into two groups: fast-growing (Arm 2 and Arm 3), and slow-growing (Arm 1 and Arm 4). LER plants from the first group exceed the value compared to the B73 on average by 38%. The samples from the second group have minor changes. Later, LER was calculated for the plants under mild and severe drought stress. Mild stress caused a slowdown of growth of the Armenian samples when compared with the B73, albeit LER was more an average of 15%.

During severe drought, we observed reducing growth rates in all samples, although in comparison with the control plants LER value decreased on average by 4%. A completely different situation is observed in case of the sample Arm 4. The simulated drought speed of its growth has averaged 37%.

Analysis of the results indicates that the drought is cause of changes in morphological parameters of plants; definitely slowing their growth. It is known that drought leads to water scarcity in plant cells, which is defined as an imbalance between the availability of water in the soil, and its evaporation from the surface of the plant [11]. Then, the value of transpiration rate for estimating the amount of absorbed water by the above-ground parts of plants was determined. Our experimental results are presented in Table I, according to which irrespective of modeled drought, the speed of absorption of moisture above-ground part of plant for all the samples was the same. In the case of mild drought stress, it was 86% and by severe drought stress - 76%. It is obvious that abiotic stress - drought soil, reduces the total moisture content in the above-ground parts of the plant as a whole by 39% in mild drought and by 77% in severe drought. After removal of moisture from the samples by their placement in a drying oven was marked reducing the both values on 28% in mild drought and 57% in severe drought are respectively. The drought produces physiological changes in the cells of the higher plants, adjusting the osmotic potential of leaf cells during of limiting the access of water.

TABLE I
The Values for the Transpiration Coefficient of Maize Leaves Under Control and the Effect of Mild (43% RSW, No Visible Signs of Wilting) and Severe Drought (34% RSW, Mild Wilting Visible)

Plant sample	Control	Mild Stress	Severe Stress
Arm1	31.4±1.75	12.98±1.71	4.93±2.18
Arm 2	50.83±1.54	30.54±1.22	9.29±0.70
Arm 3	49.93±0.70	26.79±1.65	9.22±2.40
Arm 4	45.63±1.39	28.01±1.15	9.96±0.77
B 73	34.38±0.63	23.05±0.17	8.86±0.43

The growth of plant is due to the absorption of water, regulating the elasticity of the cell walls [12]. So, plants, which were exposed to drought stress, show morphological changes which are the result of deformation of the cell wall [13]. It is carried out by decrease in the thickness of the dry cell walls by preventing adaptation of the hydraulic system during stress [14]. Proceeding from this, in further investigations, were determined values of osmotic and water potentials of freshly cut 5th-leaf of maize at the same experiment of drought stress (Fig. 2). In the control condition (without drought stress), Armenian samples had water potential, which was higher in case for sample B73 in 2.7 times. After a deep freeze (according to the experiment protocol), the value of the osmotic potential of Armenian samples almost coincides with value of control sample, except for the samples Arm1 and Arm 4 (Fig. 2).

Under mild drought stress, the osmotic potential of the Armenian sample again was close to the value for sample of B73, in addition to samples Arm1 and Arm 4 (Fig. 2 (b)). During severe drought stress samples Arm 1 and Arm 2 had very low level of water potential according value of the turgor (Fig. 2 (c)).

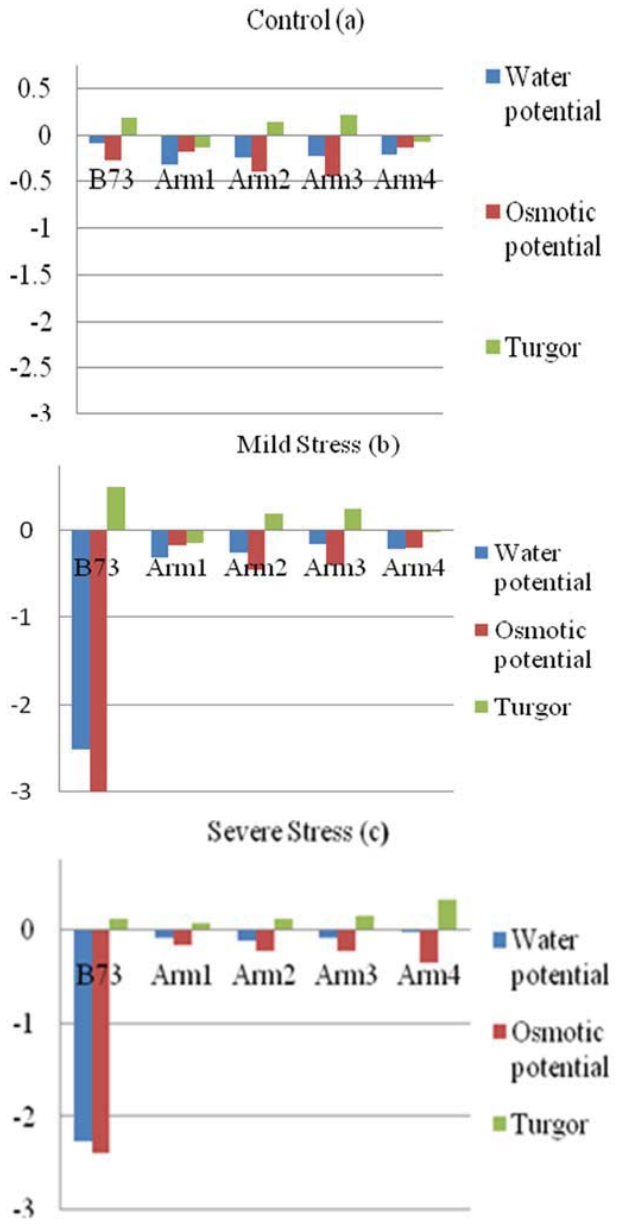

Fig. 2 (a)-(c) The values of turgor, osmotic and water potentials freshly cut 5-leaf of maize in control, and in effects of mild (43% RSW, no visible signs of wilting) and severe drought (34% RSW, mild wilting visible)

IV. Conclusion

Comparison with the water consumption plant with dry matter accumulation is due to some extent to the degree of opening of the stomata. Plants was under drought stress are becoming more resistant to dehydration. However, if exposed drought stress, growth and productivity to adult plant wilting its decline. During rearranged conformation of proteins, enzymes, and they become less sensitive to water loss. However, new cells and organs, meristems arise from undergoing dehydration, characterized by relatively large resistance.

The drought stress depending on intensity is the result in both loosening and tightening in the plant cell walls. Changes in the cell wall in response to drought have been quite well investigated [2], [12], [13]. The force acts on the internal cell walls of plant cells by counteracting the pressure of the cell resulting in a condition of tensile stress [11], [14].

The temperature of transpiring leaf is below air temperature. Usually reduce plant temperature through transpiration and thus avoid overheating. Water deficit was occurred when a lack of water, increases the adverse effects of high temperatures. Drought has a devastating effect on the organisms that cause damage to the membranes and proteins. Various proteins denature enzymes at different temperatures. However, even some of the partial denaturation of thermo labile enzymes leads to violation of consistency exchange processes. Accumulating soluble nitrogen compounds and other toxic intermediate metabolites is resulting in cell death. High temperature inhibits photosynthesis and respiration. Reduced energy conjugation processes.

Drought resistance is achieved near adaptive metabolic changes, including an increase in cytoplasmic viscosity increase in the content of osmotic active substances, organic acids, ammonia binding. Resistance to high temperatures, plants are able to synthesize more heat resistant protein enzymes. At the organism level, heat resistance is associated with devices aimed at illumination reduction by rolling leaves or reduces their size.

The value of turgor as residual between both potentials the water and the osmotic was calculated. It means that the turgor, as the most important parameter, controls the expansion of the plant cells.

The adjustment of cell wall under abiotic stress is an important phenomenon in the plant adaptation. It determined by difference in concentrations of dissolved substances in water between the inside and outside of cells. Overall, the architecture of the plant cell walls is affected of the drought stress differs depending on the power of stress. During of growth the plant cell walls expand due to the turgor and whenever the concentration of dissolved substances increases in the plant cells, the pressure increases the turgor. Thus, the turgor allows evaluating the number of received dissolved substance in plant cells and the transpiration regulates by water and will be adjusted directly by the availability of water in cells.

Obtained results allow us to determine the value of turgor as residual between both potentials the water and the osmotic. It means that the turgor, as the most important parameter, controls the expansion of the plant cells.

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