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Determination of Root Structures and Element Contents of Two Pumpkins (*Cucurbita pepo* L.) Genotypes Under Drought Stress

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ABSTRACT

This study evaluated the effects of two different pumpkin genotypes (C-26 and C-27) on root growth parameters and some nutrition element concentrations under drought stress conditions. The research was carried out in five replications. Both genotypes are negatively affected by drought stress. However, it was determined that the C-26 genotype showed a more significant decrease in root growth rates than C-27 (48%). However, while was an increase in root fresh and dry weights in the C-26 genotype, there were decreases in the C-27 genotype compared to the control. A proportionally more significant decrease in Ca, Mg, and Na contents in the C-26 genotype was observed with drought stress. In the amount of K, the C-27 genotype showed a significant decrease compared to C-26. Having information about the contents of plant nutrients in drought conditions in plants with economic potential such as zucchini can help control plants' growth and development under these conditions.

Kuraklık Stresine Maruz Bırakılan İki Kabak (*Cucurbita pepo* L.) Genotiplerinin Kök Büyüme ve Element İçeriklerin Belirlenmesi

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ÖZ

Bu çalışmada, iki farklı kabak genotipinin (C-26 ve C-27) kuraklık stresi koşullarında kök büyüme parametreleri ve bazı besin elementi konsantrasyonları üzerindeki etkileri değerlendirilmiştir. Araştırma beş tekerrürlü olarak gerçekleştirilmiştir. Her iki genotip de kuraklık stresinden olumsuz etkilenmiştir. Ancak C-26 genotipinin kök büyüme oranlarında C-27'ye göre daha belirgin bir (48%) düşüş gösterdiği tespit edilmiştir. Ancak, C-26 genotipinde kök yaş ve kuru ağırlıklarında artış olurken, C-27 genotipinde kontrole göre düşüşler olmuştur. Kuraklık stresi ile C-26 genotipinde Ca, Mg ve Na içeriklerinde önemli bir azalma olduğu görülmüştür. K miktarında, C-27 genotipi, C-26'ya göre daha fazla bir düşüş göstermiştir. Kabak gibi ekonomik potansiyele sahip bitkilerde kuraklık koşullarında bitki besin elementlerinin içerikleri hakkında bilgi sahibi olunması, bu koşullar altında bitkilerin büyüme ve gelişmesini kontrol etmeye yardımcı olabilir.

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1. Introduction

Different plant genotypes that regulate the performance and distribution depend on how these methods are regulated and the water uptake and nutrients. Drought, one of the most important abiotic stresses and leading to a negative impact on environmental factors, is an important limiting factor in crop yields and sustainable agricultural lands worldwide (Kusvuran and Dasgan, 2017). At the beginning of these factors, the human factor increases the greenhouse gas concentration in the atmosphere, causing the Earth's average surface temperature to warm up. As a result, the average temperature will likely increase by 1.4–5.8◦C by the end of this century (Heinemann *et al*., 2017). These increases in surface temperature will indirectly increase precipitation amounts but will not benefit from precipitation due to increases in drought frequency, intensity, and duration (Sallam *et al*., 2019). Therefore, the plant's response to drought stress primarily depends on the severity and duration of the stress and the plant's growth parameters. Under stress conditions, certain physiological and biochemical processes may be disrupted in the plant, such as photosynthetic parameters, photosynthesis rates and proteins, amino acids and other organic compounds.

Environmental factors such as drought can cause nutrient deficiencies even in previously fertilized farmland, as the physicochemical properties of the soil can result in reduced mobility and absorption of nutrients. Plant nutrients are chemical elements required for plant growth and reproduction, mainly obtained from the soil in inorganic ions. Except for K and Ca, all macronutrients are associated with important organic compounds such as amino acids and proteins (N and S), nucleic acids (N and P), phospholipids (P), and chlorophyll (Mg). Drought can also have a substantial effect on plant nutrient uptake.

For example, a recent study (He and Dijkstra, 2014), showed that drought stress reduces nitrogen (N) and phosphorus (P) concentrations in plant tissue, and many other studies have reported that drought reduces nutrient uptake from the soil (Cramer *et al*., 2009; Sardans and Peñuelas, 2012). Reductions in nutrient uptake during drought can occur for various reasons, including reduced nutrient supply through mineralization and reduced mass flow by nutrient diffusion in the soil (Fierer and Schimel, 2002; Sanaullah *et al*., 2012).

This study aimed to reveal the changes in root growth and some nutrition elements of the drought caused by polietilen glikol (PEG) applications under hydroponic conditions of pumpkin genotypes, which are known to have different responses to drought (Turkmen, 2016).

2. Material and Methods

Two pumpkin genotypes, C-26 (Drought tolerance) and C-27 (Drought sensitive) were grown in controlled hydroponic growth conditions where photoperiod, light intensity, temperature, and humidity were set to 16/8 hrs day/night, 14000 lux/day, 21±1 °C, and 45-55%, respectively. The pumpkin seeds were sterilized with 5% sodium hypochlorite for 10 min and thoroughly rinsed 3 times with sterile deionized water (dI-H_2O). After germination, both pumpkin genotypes were placed in the computer-controlled research hydroponic system. After surface sterilization, seeds were imbibed for 2 h, put on humid filter papers in petri plates, and then kept at 4°C overnight. Germinated seeds were floated on nylon net in 0.5 mM $CaCl_2$ solution at 25°C under dark and the seedlings were transferred to 1/5 Hoagland solution (pH 6.0) in a continuously aerated growth room. When the plants reached the first three-leaf stage, 1/5 Hoagland solution containing PEG 6000 was applied to pumpkin genotypes.

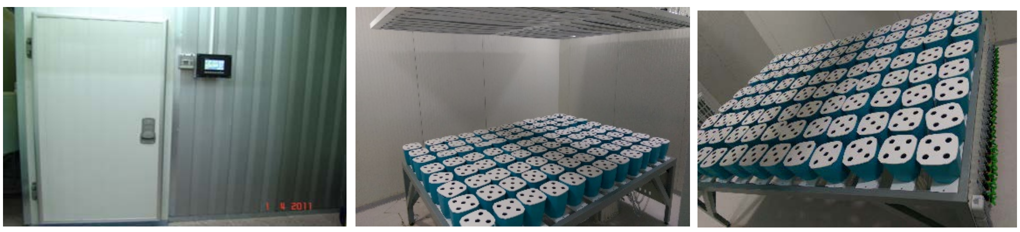

Photo 2.1 *Growth stages of plants and growing conditions*

In order to determine the drought dose to be used in this study, 5%, 6%, and 15% PEG applications pre-treatment on pumpkin genotypes, and after it was determined that (look at the growth parameter) the most appropriate dose was 6% (photo 2.2).

Photo 2.2 *PEG applications at different concentrations*

In the study, drought stress groups (6% PEG 6000) were formed with the control group (Hoagland solution group). This study, which will investigate the effects of pumpkin genotypes on osmotic stress tolerance, was established as five replications and prepared as a total of 20 pots (photo 2.3).

Photo 2.3 *Experimental Plans*

The following studies were carried out on the samples of the harvested zucchini genotypes in order to achieve the goals stated in the drought conditions;

• Measurement of growth parameters

• Analysis of Na, K, Ca and Mg in plants

Roots and shoots of harvested pumpkin genotypes were separated at 0 day, and the 10th day and root length and fresh weight were measured. After drying the samples at 70 0C for 72 hrs, root dry weights were measured.

Na, K, Ca, and Mg contents were determined by ICP-AES device (Inductively Coupled Plasma Atomic Emission Spectrometer)-(Varian-Vista, axiel) (Burt, 2004).

3. Results and Discussion

Global warming, which occurs as a result of anthropogenic increases in greenhouse gases worldwide, is expected to increase in evapotranspiration rates together with a decrease in precipitation in many parts of the world in the coming years, resulting in increased drought. In addition to affecting plant root growth and development, drought also negatively affects plant root Ca, Mg, Na, and K concentration (%) (Bista *et al*., 2018).

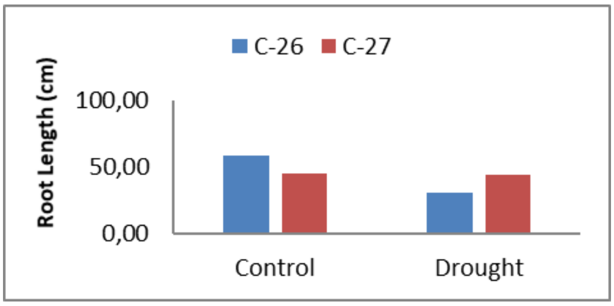

Figure 1. *Effects of exogenous PEG on plants root length*

Plant growth is one of the most fundamental processes in vegetables of economic value and is significantly affected by environmental variables, including the water stress factor. Therefore, the plant growth rate has always been an essential indicator of plant vitality and plant response to environmental stress (Dobbertin, 2005). In general, drought stress showed an inhibitory effect on the growth rate of plants (Skirycz and Inzé, 2010; Zlatev and Lidon, 2012). In this study, no significant change was observed in the C-27 genotype with the application of drought in root length, while a 48% decrease was observed in the C-26 compared to the control. However, in root fresh and dry weights, while the C-26 genotype increased compared to the control, decreases were detected in the C-27 genotype (Figure 1-2).

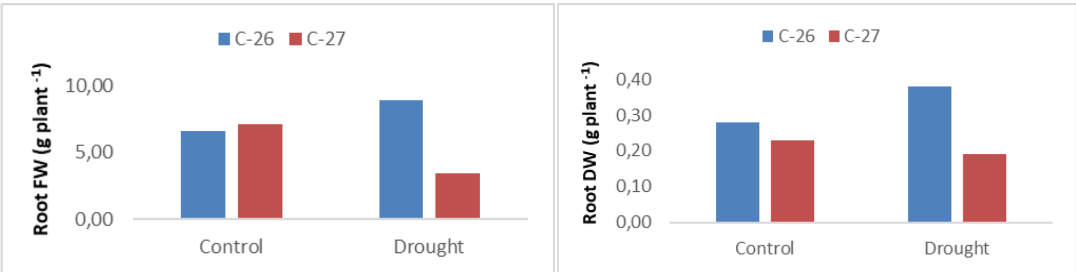

Figure 2. *Effects of exogenous PEG on plants flesh and dry (FW-DW) weight*

In the study, drought stress significantly reduced Na concentration by 44-51% and K concentration by 39-48% in drought-sensitive and sensitive squash seedlings. Although excessive Na accumulation in the plant under stress conditions (especially salinity) is known to have a toxic effect, as the plant adapts to stress conditions, Na can be split into vacuoles, and partitioned Na can be used for osmotic adjustment to reduce water potential and increase drought resistance. Furthermore, as can be seen from Hofmeister's cation sequence, Sodium has lower substitution power than K^+ and higher affinity with anionic groups as carboxyl groups of proteins (Vrbka *et al*., 2006). Therefore, it often disrupts the positive roles of K^+ in living cells. Due to high frequency, similar valence electron in the outer shell, similar hydrated ion radius, and lack of high-performance discriminative antiporters (Maathuis and Amtmann, 1999), Na^+ interferes with K^+ uptake and translocation. It can also increase plant performance by being involved in osmotic regulation in the vacuole (Mengel and Kirkby, 2001). This role of Na^+ is even more important in drought conditions where total nutrient uptake is reduced and in water deficit conditions where Na^+ toxicity is not an issue. Most studies emphasize the necessity of reducing Na^+ under stress conditions in order to maintain a high K^+/Na^+ ratio in the intracellular space. (Maathuis and Amtmann, 1999). Although changing the K^+/Na^+ ratio under drought stress is not the main concern, increasing this ratio may facilitate plant survival and growth under this condition. Six sorghum cultivars under drought stress caused to decrease the content of these monovalent cations in both root and shoot, while increased sodium content in roots of drought-tolerant cultivars and potassium content remained constant (Achakzai, 2011). Plants that can absorb more K^+ in the intracellular space and maintain a higher K^+/Na^+ ratio can improve the adverse effects of drought on water relations and organic and inorganic solute accumulation in different organs (Nandwal *et al*., 1998).

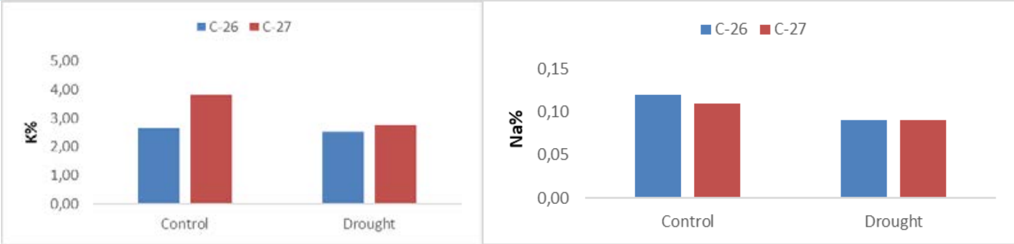

Figure 3. *Effects of exogenous PEG on K and Na content*

K^+ content in the roots of pumpkin seedlings showed a positive correlation with root growth parameters (Figure 3). Some studies have suggested that the K^+ content in roots and shoots is independent and shoot K^+ content is related to transpiration. In contrast, variations in root K^+ content are not related to leaf transpiration rate (Fayyaz *et al*., 2013). Therefore, plants with high K^+ can absorb more water under drought stress (El-Hadi *et al*., 1997). In general, K^+ uptake increases in the early stages of drought stress and may decrease with higher drought stress.

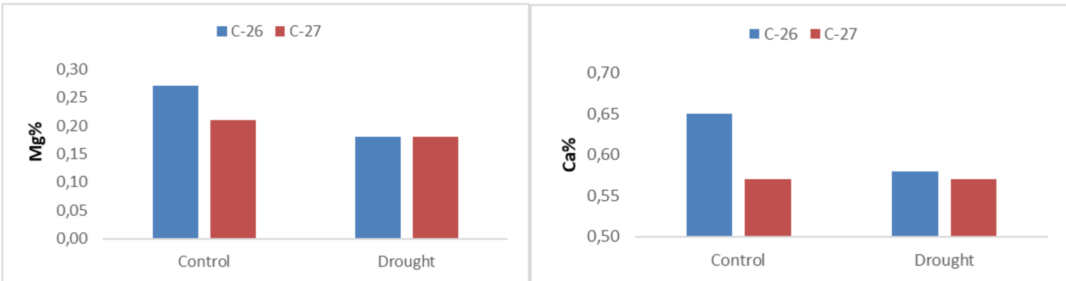

Figure 4. *Effects of exogenous PEG on plants Mg and Ca content*

Crops need several essential nutrients to achieve their growth potential, and the reduced availability of such nutrients affects their development and crop production. Drought interrupts the supply of essential trace elements in the soil, resulting in an imbalance or reduction in nutrients in plants (Hu and Schmidhalter, 2005). This may be the result of poor root growth or poor mobility of elements in the soil. The reduced availability of nutrients in a drought-stressed plant may result from impaired absorption of nutrients, excretory mechanisms, and decreased transpiration flow. In our current study, although decreases in Mg contents were observed in both genotypes under drought conditions, the highest decrease was detected in the C-26 genotype (Figure 4). Although the magnesium concentration caused a decrease in both genotypes under drought stress, the highest decrease was detected in the C-26 genotype. The increase in drought stress decreased the plant root Mg concentration. A previous study found that the Mg concentration in tomato plants (*Lycopersicon esculentum* Mill.) decreased under drought stress. (Nahar and Gretzmacher, 2002). In drought conditions, K increased the relative moisture content of the leaves in *Carthamus tinctorius*; however, magnesium has been reported to reduce this (Vafaie *et al*., 2013). The use of Mg has a significant effect on the chlorophyll content of leaves and has a negative effect on the amount of Ca in safe flow (Vafaie *et al*., 2013). Although there was a decrease in the C-26 genotype for Ca concentration compared to the control under drought conditions, no change was observed in the C-27 genotype. When drought stress was applied to the C-26 genotype, the Ca concentration decreased and reached a lower level than the control plants. Bharambe and Joshi (1993) found that the absorption of N, P, K, Ca, and Mg by sorghum was negatively affected by drought. Ca concentrations in tomatoes differed by culture, and drought decreased Ca content (Nahar and Gretzmacher, 2002). Ca ions are important secondary messengers that stimulate essential physiological functions in cells in response to drought stress and are required in almost all stages of plant growth and development. In this direction, it is seen that the C-27 genotype increases the survival possibility of the plant under drought stress conditions by keeping the Ca concentration under control conditions. Ca also plays an essential role in regulating the growth of polar cells and tissues and in the plant's adaptation to stress. This element influences abscisic acid (ABA)-induced stomatal closure and adaptation of plants to drought stress (Song *et al*., 2008). In addition to these, Tadayyon, Nikneshan, and Pessarakli (2018), in their study, found that potassium (K), magnesium (Mg), calcium (Ca), sodium (Na), iron (Fe), copper (Cu) and zinc (Zn) contents were measured and found to be significantly affected in many castor oil plants under drought stress.

4. Conclusion

The growth and element contents of the two different pumpkin plants analysed showed significant differences under drought conditions. Among the essential nutrients measured, the Drought stress Ca, Mg, and Na contents decreased more in C-26 compared to C-27. On the other hand, it was determined that K decreased more in C-27 genotype compared to C-26. The fact that the amount of Ca in the C-27 genotype did not change in drought conditions compared to the control is a piece of evidence that the plant's survival potential and resistance to stress increase. Knowing the changes in essential plant nutrients under drought conditions of this plant with economic value may be essential for plant growth and growth potential in arid lands.

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