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Impact of ascorbic acid on seed yield and its components in sweet corn (*Zea mays* L.) under drought stress

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Abstract

The present study aimed at evaluating the impact of drought stress combined with foliar application of ascorbic acid on grain yield and its components in sweet corn. The experiment was conducted as split plot design based on randomized complete block design with three replications at Agricultural Research Station of Ardabil in the 2016 growing season. The main plots were four levels of drought stress as irrigation after 70 (as control), 100, 130 and 160 mm evaporation from the class A pan, and the sub-plots were four levels of ascorbic acid (0 as control, 150, 200 and 250 ppm). The results revealed that drought stress significantly decreased the ear length, number of kernels per ear, number of kernel rows per ear, number of kernels per row, dry weight of husks, 300-kernel weight and grain yield. Although foliar application of ascorbic acid at some concentrations had positive effect on all traits of sweet corn, except dry weight of husks and ear length, but more results are needed to recommend its usefulness under drought stress conditions of this experiment.

Keywords: Ascorbic Acid; Drought Stress; Dry weight; Sweet corn.

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Introduction

Drought stress is regarded as the main growth-restricting factor for plants, especially in arid and semiarid areas where plants are often exposed to periods of water deficit stress which is one of the main reasons for the crop loss in the world (Anjum *et al*. 2017). Drought responses in plants are complex, and it is well documented that drought stress damages multiple physiological and metabolic processes (Witt *et al*. 2012). Drought stress reduces grain yield in the corn plant. However, the yield reduction depends on the stress intensity, duration, and incidence at the crop stage (Talaat *et al*. 2015). Drought occurring two weeks before and during silking phase decreases seed setting and kernel size, which causes yield losses of about 20-50% (Moharramnejad *et al*. 2019; Zarabi *et al*. 2011).

To alleviate deleterious effects of drought and to improve the growth of stressed plants in relation to varying physiological and biochemical characteristics, different strategies have been adopted. The exogenous use of chemicals as foliar spray or pre-sowing seed treatment is regarded as the most appreciable strategy. These compounds are absorbed by plants when applied exogenously

(Noman *et al*. 2015). One approach for inducing oxidative stress tolerance would be to increase the cellular level of enzyme substrates such as ascorbic acid (AsA). AsA is a small, water-soluble antioxidant molecule which acts as a primary substrate in the cyclic pathway of enzymatic detoxification of hydrogen peroxide. AsA is the first substance in detoxification and neutralizing of superoxide radicals (Noctor and Foyer 1998). Application of ascorbic acid as an antioxidant can decrease the harmful effects of abiotic and biotic stresses (Shalata and Neumann 2001; Pignocchi and Foyer 2003; Noman *et al*. 2015).

The goal of current study was to investigate the effect of application of foliar ascorbic acid in increasing the tolerance of sweet corn to drought stress and improving the grain yield under this stress.

Materials and Methods

The sweet corn seed for this experiment (Hybrid Chase) was purchased from the Seminis Company. The experiment was conducted as a split-plot experiment based on randomized complete block design with three replicates under field condition in the Agricultural Research Station of Ardabil during 2016 growing season. Before the commencement of the experiment, soil samples were taken to determine the physical and chemical properties. A composite soil sample was collected at a depth of 0-30 cm. It was air dried, crushed, and tested for physical and chemical properties. The experimental area had a silty loam soil. The main plots were four levels of drought stress as irrigation after 70 (as control), 100, 130 and 160 mm evaporation from the class A pan, and the sub-plots were four levels of foliar ascorbic acid (AsA); (0 as the control, 150, 200 and 250 ppm). Ascorbic acid was sprayed on the sweet corn plants at the 4 to 6-leaf stage after general irrigation of the field, while the drought stress levels were applied until harvest. The experimental plots were four rows of 3-m long with 0.75 m spacing and within row spacing of 0.25 m between hills. Three seeds were planted in a hill and thinned to two plants per hill three weeks after sowing to attain a population density of 60,000 plants per hectare. The measured traits included ear length, number of kernels per ear, number of kernel rows per ear, number of kernels per row, dry weights of husks, 300–kernel weight and grain yield.

Statistical analysis

Statistical analysis of data included the test of assumptions of normality of errors and homoscedasticity, analysis of variance and comparison of means using SPSS software. Means were compared by the Tukey' s test at $p \leq 0.05$.

Results and Discussion

Analysis of variance showed that the interaction of drought stress with AsA was significant for number of kernels per ear, number of kernel rows per ear, number of kernels per row, 300-kernel weight and grain yield in sweet corn. The interaction of drought stress with AsA was not significant for husk weight and ear length, however, the effect of drought stress on these traits was significant (data not shown).

According to Figure 1, drought stress significantly reduced number of kernels per ear, especially at 160 mm evaporation from the class A pan. The highest number of kernels per ear was observed at the normal conditions. Golbashy *et al*. (2010) and ELSabagh *et al*. (2015) reported on the deleterious effects of drought stress on number of kernels per ear. It seems that drought stress reduced pollen number in sweet corn and/or anthesis-silking interval, which has caused the lack of fertilization of uppermost ovaries on the ear. On the other hand, foliar application of AsA increased the number of kernels per ear at all irrigation levels. Although at normal conditions, the foliar application of AsA was effective at all levels (150, 200, and 250 ppm), but at 130 and 160 mm evaporation from the class A pan, AsA it was effective only at 200 and 250 ppm levels as compared to the control (0 ppm).

Number of kernel rows was not significantly affected by the drought stress, however, the lowest value belonged to the 160 mm evaporation from the class A pan (Figure 2). Sheikhi *et al*. (2013) indicated the decrease in number of kernel rows due to drought stress. The response of number of kernel rows to foliar application of AsA was erratic. At 70 mm evaporation from the class A pan, foliar application of 200 ppm AsA significantly increased number of kernel rows, however, at 70 mm evaporation from the class A pan it was effective at the dose of 150 ppm.

The combined effect of drought stress and foliar application of AsA on number of kernels per row is shown in Figure 3. Although drought stress decreased number of kernels per row at all stress levels, but it's effect was only significant at 160 mm evaporation from the class A pan. Sabagh *et al*. (2015) reported that number of kernels per row decreased under drought stress. Some levels of AsA also increased number of kernels per row at 70, 100 and 160 mm evaporation from the class A pan (Figure 3).

According to Figure 4, drought stress significantly reduced 300-kernel weight at all stress levels as compared to the control (70 mm evaporation from the class A pan). The seed weight depends on the photosynthetic capacity of the plant and remobilization of assimilates from the stems. Also, the rate and length of grain filling determines the weight of seeds. In the experiments conducted by Campos *et al.* (2004) and Echard *et al*. (2006) on maize, it was shown that drought stress limited the storage of assimilates in the stems and eventually decreased seed weight. Banziger *et al*. (2002) and Recap (2004) also reported the reduction of seed weight under drought stress conditions. All levels of AsA significantly improved 300-kernel weight at 100 and 160 mm evaporation from the class A pan but at 130 mm evaporation, only the foliar application of 200 ppm AsA significantly increased the 300-kernel weight (Figure 4).

All drought stress levels (100, 130 and 160 mm evaporation from the class A pan) substantially reduced husk weight as compared to the control (Figure 5). Emam and Ranjbar (2001) reported the reduction of ear dry weight under drought stress.

Drought stress significantly affected the ear length at all stress levels compared with the

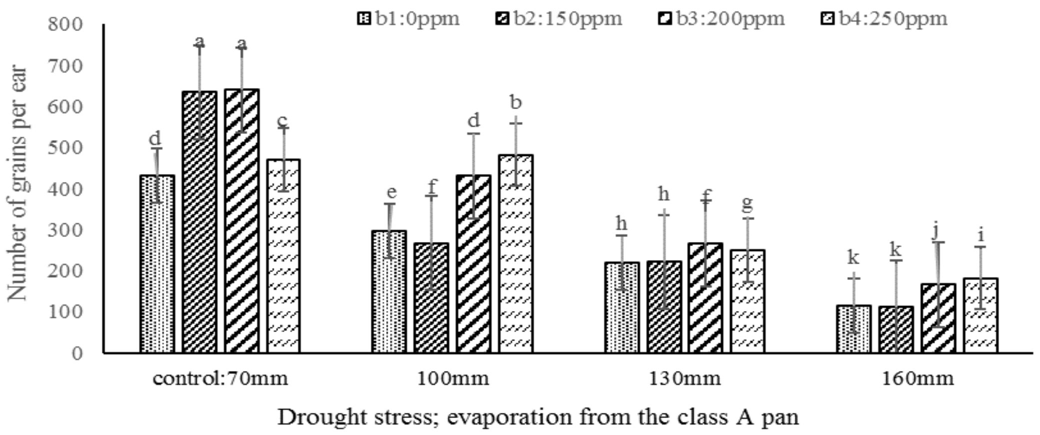

Figure 1. Combined effect of drought stress and foliar ascorbic acid (AsA) on number of kernels per ear in sweet corn; b1: 0 ppm, b2: 150 ppm, b3: 200 ppm and b4: 250 ppm AsA.

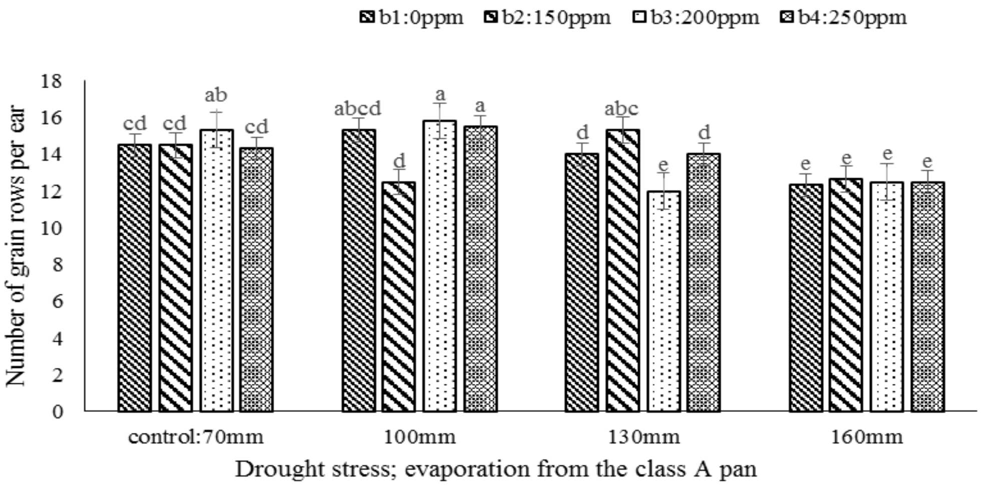

Figure 2. Combined effect of drought stress and foliar ascorbic acid (AsA) on number of kernel rows per ear in sweet corn; b1: 0 ppm, b2: 150 ppm, b3: 200 ppm and b4: 250 ppm AsA.

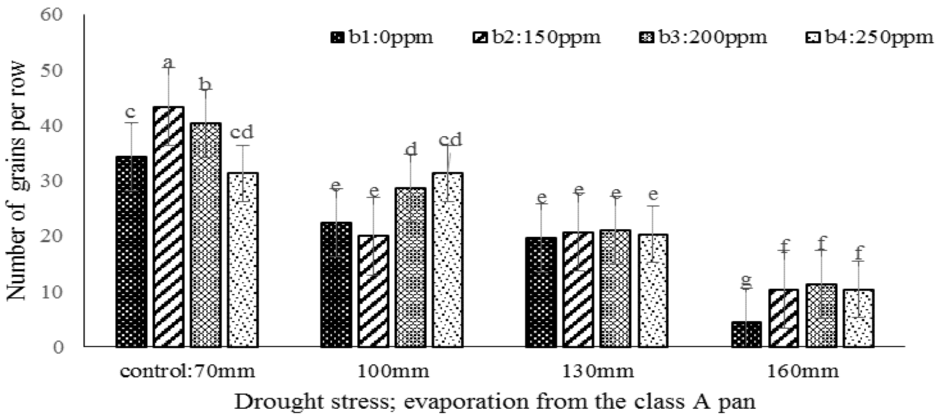

Figure 3. Combined effect of drought stress and foliar ascorbic acid (AsA) on number of kernels per row in sweet corn; b1: 0 ppm, b2: 150 ppm, b3: 200 ppm and b4: 250 ppm AsA.

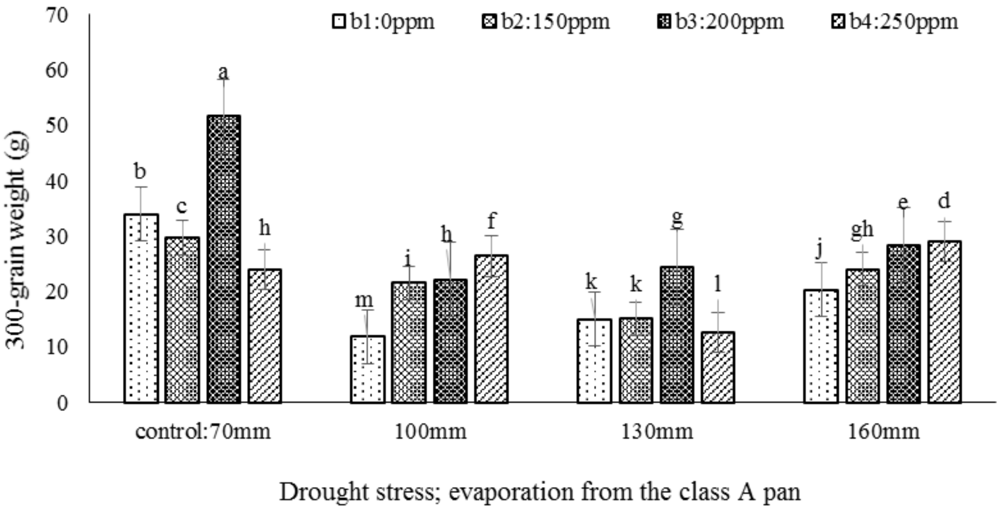

Figure 4. Combined effect of drought stress and foliar ascorbic acid (AsA) on 300-kernel weight of sweet corn; b1: 0 ppm, b2: 150 ppm, b3: 200 ppm and b4: 250 ppm AsA.

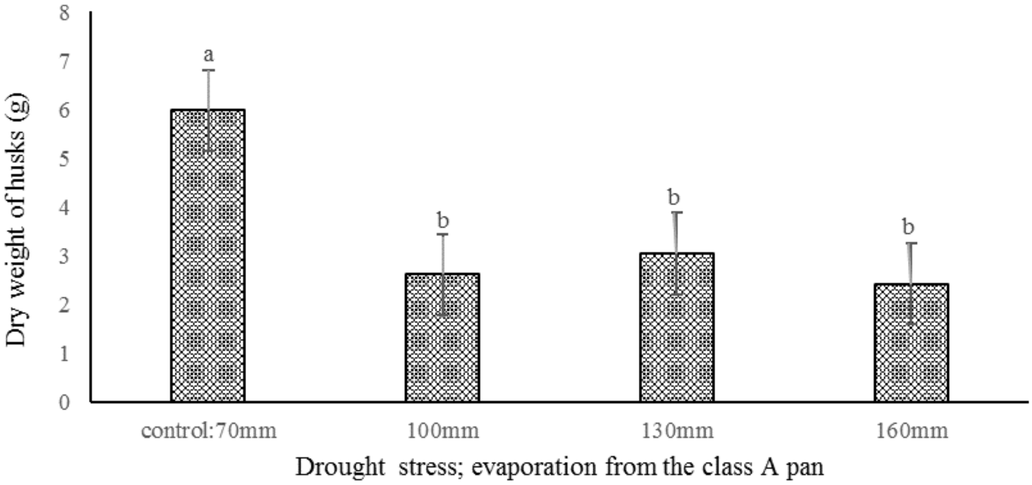

Figure 5. Effect of drought stress on dry weight of husks in sweet corn.

control (Figure 6). Thus the highest ear length belonged to 70 mm evaporation from the class A pan as the control. According to the results obtained from Talaat *et al*. (2015), the cell growth declined under stress conditions.

Combined effect of drought stress and foliar application of AsA on grain yield of sweet corn are presented in Figure 7. All water-stress levels significantly reduced sweet corn yield. Sabagh *et al*. (2015) also reported the reduction of maize yield and its components under drought stress as compared with the normal irrigation conditions. Similar studies have reported the adverse effects of drought stress on maize (Islam *et al*. 2011; Koksal 2011, Barutcular *et al*. 2016). Obviously, drought stress has reduced the final grain yield by limiting the yield components.

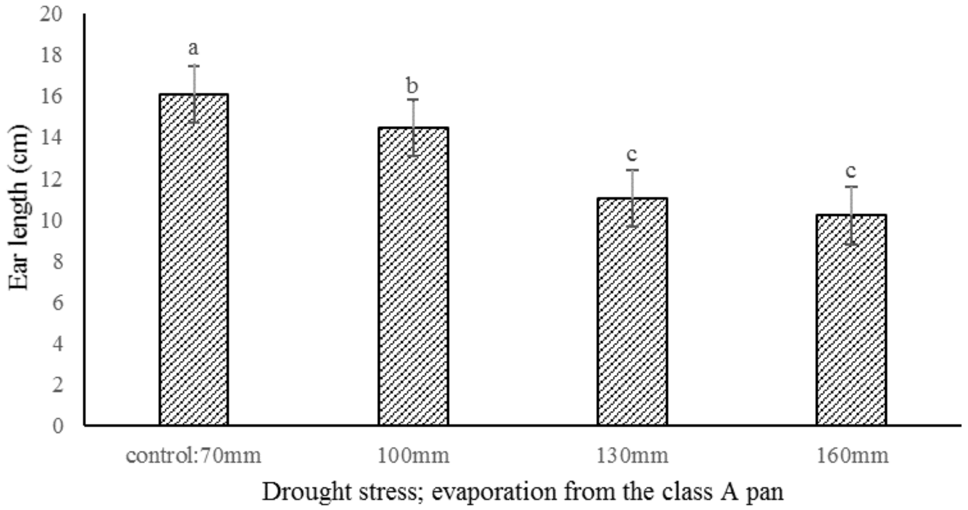

Figure 6. Effect of drought-stress levels on ear length of sweet corn.

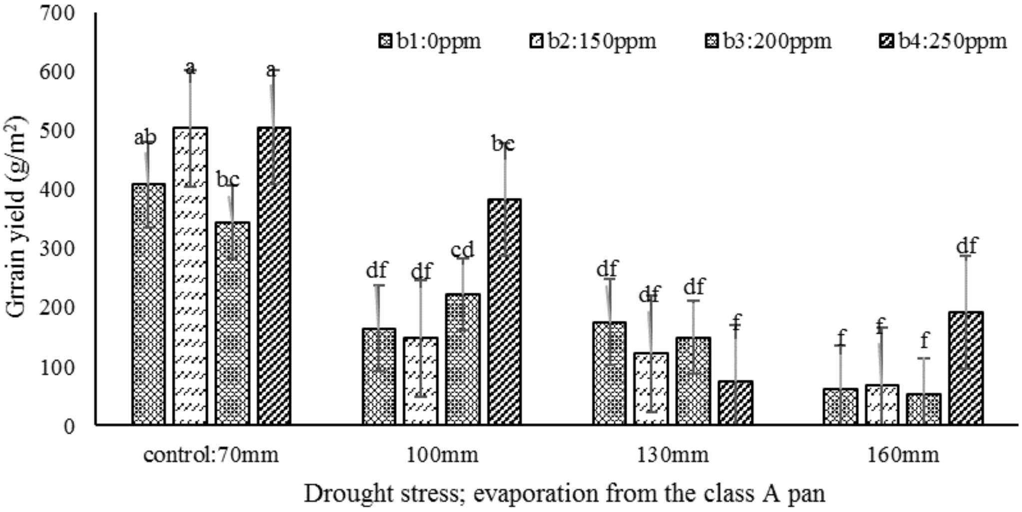

Figure 7. Combined effect of drought stress and foliar ascorbic acid on grain yield of maize; b1: 0 ppm, b2: 150 ppm, b3: 200 ppm and b4: 250 ppm AsA.

Foliar application of AsA at the concentration of 250 ppm had positive effects on increasing grain yield and improving the tolerance of sweet corn under drought stress conditions (at 100 mm evaporation from the class A pan) compared to the control treatment (Figure 7). Pignocchi and Foyer (2003) indicated the useful impact of AsA in alleviating the adverse effects of abiotic and biotic stresses. Foliar application of AsA has increased biomass in maize under drought stress (Noman *et al*. 2015). It has been reported that exogenously applied AsA increased the growth of maize (Tuna *et al*. 2013) and wheat (Athar *et al*. 2008) under salinity stress. Increased dry mass under salinity has indicated the contribution of AsA in maintaining water level in wheat (Athar *et al*. 2009). AsA foliar application increased stem and leaf dry weight, leaf fresh weight and grain weight when plants were treated by AsA (Dolatabadian *et al*. 2010).

Conclusions

In this study, the yield of sweet corn and its components significantly decreased under drought stress. However, some concentrations of foliar AsA improved grain yield and its components when drought stress was imposed. Therefore, to increase the tolerance of sweet corn to water deficit, foliar application of ascorbic acid may be useful under water-deficit stress conditions, however, more research is needed to reach to a conclusive evidence about the positive effect of AsA at the presence of drought stress.

Conflict of Interest

The authors declare that they have no conflict of interest with any organization concerning the subject of the manuscript.

References

Anjum SA, Ashraf U, Tanveer M, Khan I, Hussain S, Shahzad B, Zohaib A, Abbas F, Saleem MF and Ali I 2017. Drought induced changes in growth, osmolyte accumulation and antioxidant metabolism of three maize hybrids. Frontiers in Plant Science 8: 1-12.

Athar HR, Khan A and Ashraf M, 2008. Exogenously applied ascorbic acid alleviates salt induced oxidative stress in wheat. Environmental and Experimental Botany 63: 224-231.

Athar HR, Khan A and Ashraf M, 2009. Inducing salt tolerance in wheat by exogenously applied ascorbic acid through different modes. Journal of Plant Nutrition 32: 1799-1817.

Banziger MG, Edmeades O and Lafitte HR, 2002. Physiological mechanisms contributing to the increased N stress tolerance of tropical maize selected for drought tolerance. Field Crops Research 75: 223-233.

Barutcular C, Yildirım M, Koc M, Akinci C, Toptas I, Albayrak O, Tanrikulu A and El Sabagh A, 2016. Evaluation of SPAD chlorophyll in spring wheat genotypes under different environments. Fresenius Environmental Bulletin 25(4): 1258-1266.

Campos H, Cooper M, Habben JE, Edmeades GO and Schussler JR, 2004. Improving drought tolerance in maize: a view from industry. Field Crops Research 90(1): 19-34.

Dolatabadian A, Modaress Sanavy SAM and Asilan KS, 2010. Effect of ascorbic acid foliar application on yield, yield components and several morphological traits of grain corn under water deficit stress conditions. *Notulae Scientia Biologicae 2(3):45-50.*

Echard L, Andrade FH, Sadras VO and Abbate P, 2006. Grain weight and its response to source manipulations during grain filling in Argentinean maize hybrids released in different decades. Field Crop Research 96: 307-312.

El Sabagh A, Barutçular C and Saneoka H, 2015. Assessment of drought tolerance of maize hybrids at grain growth stage in Mediterranean area. International Journal of Agricultural and Biosystems Engineering 9: 962-965.

Emam Y and Ranjbar GH, 2001. The effect of plant density and water stress during vegetative phase on grain yield, yield components and water use efficiency of maize. Iranian Journal of Crop Sciences 2(3): 50-62 (In Persian with English abstract).

Golbashy M, Ebrahimi M, Khavari Khorasani S and Choucan R, 2010. Evaluation of drought tolerance of some corn (*Zea mays* L.) hybrids in Iran. African Journal of Agricultural Research 5: 2714-2719.

Islam MS, Akhter MM, El Sabagh A, Liu LY, Nguyen NT, Ueda A, Masaoka Y and Saneoka H, 2011. Comparative studies on growth and physiological responses to saline and alkaline stresses of foxtail millet (*Setaria italica* L.) and Proso millet (*Panicum miliaceum* L.). Australian Journal of Crop Science 5: 1269-77.

Koksal ES, 2011. Hyperspectral reflectance data processing through cluster and principal component analysis for estimating irrigation and yield related indicators. Agricultural Water Management 98: 1317-1328.

Moharramnejad S, Sofalian O, Valizadeh M, Asgari A, Shiri MR and Ashraf M, 2019. Response of maize to field drought stress: oxidative defense system, osmolytes' accumulation and photosynthetic pigments. Pakistan Journal of Botany 51: 799-807.

Noctor G and Foyer CH, 1998. Ascorbate and glutathione: keeping active oxygen under control. Annual Review of Plant Physiology and Plant Molecular Biology 49: 249-279.

Noman A, Ali S, Naheed F, Ali Q, Farid M, Rizwan M and Irshad MK, 2015. Foliar application of ascorbate enhances the physiological and biochemical attributes of maize (*Zea mays* L.) cultivars under drought stress. Archives of Agronomy and Soil Science 61(12): 1659-1672.

Pignocchi C, and Foyer CH, 2003. Apoplastic ascorbate metabolism and its role in the regulation of cell signaling. Current Opinion Plant Biology 6: 379-389.

Recap AC, 2004. Effect of water stress at different development stages on vegetative and reproductive growth of corn. Field Crops Research 98:1-16.

Shalata A and Neumann PM, 2001. Exogenous ascorbic acid (vitamin C) increases resistance to salt stress and reduces lipid peroxidation. Journal of Experimental Botany 52: 2207-2211.

Sheikhi M, Sajedi N and Jiriaie M, 2013. Effects of water deficit stress on agronomical traits of maize hybrids in Arak climate condition. Journal of Agronomy and Plant Breeding 8: 101-110.

Talaat NB, Shawky BT and Ibrahim AS, 2015. Alleviation of drought-induced oxidative stress in maize (*Zea mays* L.) plants by dual application of 24-epibrassinolide and spermine. Environmental and Experimental Botany 113: 47-58.

Tuna LA, Kaya C, Altunlu H and Ashraf M, 2013. Mitigation effects of non-enzymatic antioxidants in maize (*Zea mays* L.) plants under salinity stress. Australian Journal of Crop Science 7: 1181-1188.

Witt S, Galicia L, Lisec J, Cairns J, Tiessen A, Araus JL, Palacios-Rojas N and Fernie AR, 2012. Metabolic and phenotypic responses of greenhouse-grown maize hybrids to experimentally controlled drought stress. Molecular Plant 5: 401-417.

Zarabi M, Alahdadi I, Akbari GA and Akbari GA, 2011. A study on the effects of different bio-fertilizer combinations on yield, its components and growth indices of corn (*Zea mays* L.) under drought stress condition. African Journal of Agriculture Research 6: 681-685.

اثر اسید آسکوربیک روی عملکرد و اجزای عملکرد دانه در ذرت شیرین تحت تنش خشکی

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چکیده

به منظورارزیابی اثر آسکوربیک اسید روی میزان درصد کاهش عملکرد و اجزای عملکرد دانه ذرت شیرین تحت تنش خشکی طی سال زراعی ۱۳۹۵، آزمایشی به صورت اسپلیت پلات بر پایه طرح بلوک‌های کامل تصادفی در سه تکرار در مرکز تحقیقات کشاورزی اردبیل انجام گرفت. عامل اصلی چهار تنش خشکی (۷۰، ۱۰۰، ۱۳۰ و ۱۶۰ میلی‌متر از تشتک تبخیر کلاس A) و عامل فرعی چهار سطح اسید آسکوربیک (کنترل، ۱۵۰، ۲۰۰ و ۲۵۰ پی پی ام) بودند. نتایج نشان داد که تنش خشکی به طور معنی‌دار عملکرد دانه، طول بلال، تعداد ردیف دانه در بلال، تعداد دانه در ردیف بلال، وزن خشک بلال و وزن ۳۰۰ دانه کاهش داد. اسید آسکوربیک اثر مثبت و معنی‌داری روی ذرت شیرین تحت تنش خشکی داشت. به طور کلی براساس نتایج حاصل از این تحقیق چنین به نظر می‌رسد که اسید آسکوربیک مورد استفاده در ذرت سبب کاهش اثرات مضر خشکی و افزایش میزان تحمل به خشکی را افزایش می‌دهد.

واژه‌های کلیدی: اسید آسکوربیک؛ تنش خشکی؛ ذرت شیرین؛ وزن خشک.