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The effect of osmolytes such as: glycine betaine, ascorbic acid and potassium sulfate on physiological and biochemical properties of quinoa under drought stress in climatic conditions of Kerman region

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Abstract

Drought stress is the most important factor in crop yield reduction in arid and semi-arid regions. Quinoa plant (*Chenopodium quinoa* Wild.) has a high nutritional value and shows tolerance to abiotic stresses such as drought and salinity. The effect of glycine betaine and ascorbic acid osmolytes and the application of potassium sulfate on the agronomic, physiological and biochemical traits and the protein and nutritional elements of seeds in this plant under different irrigation regimes were investigated. For this purpose, a factorial split plot experiment was conducted in the form of a randomized complete block design with three replications and during two crop years at the center of Research, Agriculture and Natural Resources in Kerman. The main factor included three levels of irrigation treatment (irrigation to full maturity, irrigation to the beginning of the flowering stage and irrigation to the beginning of the dough stage). Ascorbic acid factor at two levels (0 and 2 mM), glycine betaine factor at two levels (0 and 3 mM) and potassium sulfate factor at two levels (0 and 8 Kg/1000m^2) as sub-factors were considered. The results showed that the year and its interaction with other factors had no significant effect on all measured traits. The simple effect of irrigation factors, glycine betaine, ascorbic acid and potassium sulfate and their interactions on most traits were significant. Under the conditions of water stress, the content of photosynthetic pigments, relative water content, leaf and seed protein, thousand seed weight, biological yield and seed decreased. While, the content of proline, carbohydrates, malondialdehyde, phenol, flavonoid, activity of antioxidant enzymes, electrolyte leakage and the content of potassium and phosphorus of the seed showed an increase. Foliar spraying with glycine betaine and ascorbic acid osmolytes and application of potassium sulfate led to the improvement of physiological and biochemical traits and subsequently the quality and yield of seeds in all three irrigation treatments. The treatment of the combined use of three compounds (glycine betaine, ascorbic acid and potassium sulfate) had a better effect on improving most traits. The highest seed yield was under irrigation regime of control and the combined use of three compounds (337.9 g/m^2) and the lowest was under severe water stress and no use of three compounds (95.6 g/m^2). Therefore, these osmolytes and potassium sulfate can be used to reduce the harmful effects of water stress and thus increase the yield and quality of quinoa seeds. Seed yield was positively correlated with 1000 seed weight, biological yield, content of photosynthetic pigments, proline, carbohydrate, phenol, total flavonoid, relative water content and activity of antioxidant enzymes and negatively correlated with electrolyte leakage. Biological yield was the first trait that entered the regression model and explained 95% of the changes in seed yield. Harvest index traits and content of carbohydrates content were entered into the model in the second and third stages, respectively. Together, these three traits explained 99% of the changes in seed yield.

Key words: biochemical traits, osmolytes, physiological traits, potassium sulfate, quinoa and water stress