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Effect of Abiotic Stresses on Ascorbic Acid (Vitamin C) Content in Paprika (*Capsicum annuum* L.)

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SUMMARY

Paprika (*Capsicum annuum* L.) is one of the richest sources of vitamin C (ascorbic acid) among vegetables (Rodríguez-Burruezo and Nuez, 2006; Rodríguez-Burruezo *et al.*, 2009). Considerable amounts are found in *Capsicum* peppers at any stage of ripening, particularly when fully ripe (Bosland and Votava, 2000; Rodríguez-Burruezo and Nuez, 2006). Nevertheless, as it can be utilized in both ripe and unripe stages both stages of ripening are considered by breeders. In addition, antioxidants in plants have been reported to be affected by abiotic stresses, although their effect is unclear. Thus, in previous works we reported that open field cultivation increased, compared to greenhouse, ascorbic acid, phenolics, and carotenoids levels in *C. annuum*, *C. baccatum*, and *C. pubescens* fruits, probably due to a higher light intensity (Rodríguez-Burruezo *et al.*, 2009). By contrast, Navarro *et al.* (2006) found that the effect of irrigation with moderately saline water on different antioxidants was variable depending on the ripening stage and the antioxidant. In terms of abiotic stresses, horticulture in the Mediterranean Coast of Spain is affected by two main factors: salinity and water supply. In the present experiment, the effects of ripening stage, abiotic stresses, and their interaction in the levels of ascorbic acid content (AAC) in *C. annuum* cultivar C-40 (Ramiro Arnedo Seeds) were studied. Plants were grown in Valencia (Spain) under greenhouse and winter-spring growing season (transplanting date January 15th, 2010). Three treatments were applied: i) control (usual drip fertigation in Valencia), ii) saline stress (TS: control fertigation with salinity increased at 5 dS/m) and iii) hydric deficit stress (TH: control fertigation reduced to 40%). AAC (mg/100 g f.w.) was estimated by potentiometric titration, using a Titrino 702 automatic titrater, in both unripe (green ripe) and fully ripe stages. The experimental design involved 4-blocks (2 plants each) per treatment. Four samples (1 per block) per combination treatment×ripening stage were prepared and analyzed. ANOVA analysis was performed to study the effects on AAC of treatment, ripening stage, and their interaction. The ANOVA analysis revealed that ripening stage was the most relevant factor in the level of expression of AAC, which is in coincidence with previous reports (Bosland and Votava, 2000; Rodríguez-Burruezo and Nuez, 2006). In addition, the effect of treatments was moderately significant ($P<0.10$), although to a lesser extent than ripening stage (Tab. 1). By contrast, there was no significant effect of the treatment×ripening stage interaction. The comparison of treatment×ripening stage combinations confirmed that ripe fruits have AAC considerably higher than unripe fruits in all cases (Fig. 1). Thus, AAC

levels were comprised between 167 and 197 mg/100 g in unripe fruits, while fully ripe fruits showed a range of 259-283 mg/100 g (about 42-65% higher) (Fig. 1). In general, the stresses applied had a clear decreasing effect on AAC at the unripe stage, which is in coincidence with the experiments of Navarro *et al.* (2006) with moderately saline water irrigation. By contrast, only irrigation with saline water had a significant effect when fruits were fully ripe, suggesting that AAC might not be affected by water deficiency at this ripening stage.

Tab. 1

ANOVA table with mean squares for the effects of treatment, ripening stage, treatment×ripening stage interaction, and error on AAC

Effect	Degrees of freedom	Mean squares
Ripening stage	1	51207***
Treatment	2	1561*
Treatment×ripening stage	2	505^{NS}
Error	17	514

^{NS}, *, and *** indicate nonsignificant and significant at P>0.10, <0.10 and <0.001, repectively

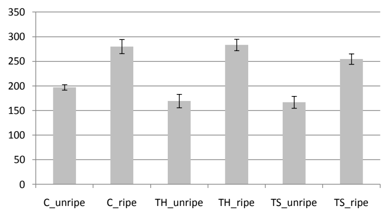

Fig. 1. Mean AAC (mg/100 g f.w.±SE bars) of unripe and fully ripe fruits from control plants (C) and plants submitted to irrigation with hydric deficit (TH) and moderately saline water (TS)

Keywords: *Capsicum* peppers, ascorbic acid, ripening stage, saline water, hydric deficit

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