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Micromorphological studies on the relation between fruit development and creasing in orange (*Citrus sinensis* cv. 'Moro' sanguine)

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Creasing is a preharvest physiological disorder which causes cracks in the albedo, resulting in the appearance of irregular grooves on the surface of the fruit. Albedo breakdown has been reported from many citrus growing areas worldwide, but not from Iran so far. This two years study has been performed on *Citrus sinensis* cv. 'Moro' sanguine in Mazandaran province, Northern Iran. Incidence and evolution of creasing were followed in 40 trees, at successive stages of development, from anthesis to fruit maturity. Morphological symptoms of creasing appeared at color break, first on the NE quadrant of all the trees and on the shaded side of each fruit. The disorder progressed towards other sectors along with the fruit development. Small pieces of rind in mature healthy and affected fruits were fixed with glutaraldehyde and osmium tetroxide, dehydrated in ethanol series and air dried, coated with gold-palladium, and viewed under the scanning electron microscope. First microscopic evidence of the disorder was observed in apparently healthy fruits, as a small hole or a thinning area, predominantly under the oil glands. Four progressive stages of creasing were recognized, based on SEM observations. The whole albedo cracked at the final stage, at the border line of the oil glands, and the exocarp was not affected by the disorder. Creasing seems to result from separation of albedo cells, rather than cleavage of individual cells.

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Behavior of diploid and tetraploid genotypes of 'Carrizo' citrange under abiotic stresses

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Tetraploidy is a spontaneous phenomenon in citrus and some anatomical differences have been described between tetraploid (4x) citrus plants and their corresponding diploids (2x). The choice of a suitable rootstock is often very restricted by a combination of biotic and abiotic stresses. Recent data points out that tetraploidy in citrus induces interesting phenotypes like dwarfing and tolerance to abiotic constraints. In this work we investigated the behavior of 4x and 2x 'Carrizo' citrange (*Citrus sinensis* X *Poncirus trifoliata*) subjected to the main abiotic stresses that threat Spanish citrus industry. Seedlings were exposed to salinity, drought and iron deficiency and physiological parameters were measured. Results suggest that 4x plants stressed by drought were able to maintain high leaf water potential more efficiently than 2x, thus gas exchange parameters (transpiration, stomatal conductance, and photosynthesis) were less affected. Under salt stress no difference was found in leaf chloride content neither in gas exchange parameters, but leaf burn was less severe in 4x than in 2x. Concerning iron deficiency, a better tolerance of 4x compared to 2x was supported by higher ferric-chelate reductase activity, SPAD index and chlorophyll fluorescence. These preliminary results suggest that 4x 'Carrizo' citrange could be a promising rootstock, having the same general performance than the original 2x, but producing smaller trees more tolerant to abiotic stresses.

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Comparison of photosynthesis and antioxidant performance of several *Citrus* and *Fortunella* species under natural chilling stress

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Citrus plants originate from southeastern Asia, in a large area with various climates characterized by a broad range of temperatures. Temperature is assumed to be a key factor in *Citrus* species adaptation and diversification.

In a field experiment, the tolerance of the three fundamental *Citrus* species (*C. medica* –citron–, *C. reticulata* –mandarin– and *C. maxima* –pummelo–) and *Fortunella japonica* –kumquat– to photooxidative stress caused by seasonal climatic changes was evaluated on adult trees by measuring net photosynthesis (*P*net), stomatal conductance (*G*s), maximum photosynthesis (*P*max) and chlorophyll fluorescence (*F*v/*F*m). In addition, seasonal changes in oxidative status, antioxidant enzymes and antioxidant metabolites were monitored. Mandarin and pummelo appeared to be the most tolerant, showing the lowest down-regulation of photosynthetic parameters, and the lowest accumulation of oxidized compounds associated with efficiency of their antioxidant system. Kumquat showed intermediate behaviour, with a large diminution of photosynthetic parameters and marked accumulation of hydrogen peroxide, whereas the malondialdehyde content remained low, with a strong induction of glutathione synthesis. Finally, citron appeared to be the most sensitive genotype with a marked decrease in photosynthetic performance, the largest accumulation of oxidative parameters, insufficient induction of antioxidant enzymes and down-regulation of ascorbate and glutathione synthesis.

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'Flying Dragon' as a very cold hardy citrus rootstock in Northern Iran

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Because of freeze damage to citrus orchards in Northern Iran, different citrus rootstocks were evaluated since 1964 at the Ramsar Citrus Experimental Station. On request of Y. Ebrahimi, sixteen 'Flying Dragon' seeds were sent by Dr. Roose from Univ. of California Riverside to Ramsar, Iran in 1994. These sixteen seeds created the mother trees for 'Flying Dragon' seed production in Iran. Taking into consideration to grow citrus in Lakan area in Guilan province in 2006, the Agricultural Deputy of the Economical Group of Relief Committee (EGRE) of Iran established an experimental citrus pilot with 867 'Thompson' navel oranges on 'Flying Dragon' rootstock in Lakan, Rasht (Guilan province). In January 2007, a very heavy snow fall followed by a destructive freeze (-14ºC) was occurred and confirmed the cold hardness of 'Flying Dragon' rootstock. This paper describes this very destructive frost and the results which were obtained.