

Drought Tolerance in Several *Tagetes* L. Cultivars

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Abstract Drought is the most important single environmental stress factor that reduces crop yields worldwide. In the context of global climate change, selection and/or development of drought-resistant varieties of cultivated plants is becoming an urgent need for agriculture in arid and semiarid regions. In this work we have analysed physiological (growth inhibition) and biochemical (proline levels) responses to water stress of 5 cultivars of *Tagetes patula* and 5 cultivars of *T. tenuifolia*. The most drought-tolerant cultivars were found to be 'Bolero' in *T. patula* and 'Luna gold' in *T. tenuifolia*, while 'Orion' and 'Luna orange' were the most sensitive for each species.

Keywords: *Tagetes patula*, *Tagetes tenuifolia*, drought, abiotic stresses, proline.

Introduction Among all the abiotic stress factors affecting agricultural production, drought causes the most drastic reduction in crops yield worldwide. On the background of global warming, with increasing scarcity of water resources for irrigation, studies on the responses to drought of cultivated plants and selection of relatively resistant varieties are becoming extremely important. In addition, effective approaches to increase stress tolerance of plants using modern biotechnological tools require a deep knowledge of the intricate physiological, biochemical and molecular networks underlying plant stress tolerance mechanisms. One of the most general responses to abiotic stress is based on the biosynthesis and accumulation of specific osmolytes for cellular osmotic adjustment and, for many species, proline (Pro) content is considered as a reliable marker of the level of stress affecting the plants. The present work focuses on plants of the *Tagetes* genus, which are among the most well-known ornamentals, but are also valuable medicinal plants and are used as well in the food and cosmetics industries (Sehrish *et al.* 2013)

Aims The main objectives of the work were to measure the degree of growth inhibition of

5 cultivars of *Tagetes patula* L. and 5 cultivars of *T. tenuifolia* Cav. subjected to water stress treatments, to establish their relative tolerance to drought and the possible correlation with proline contents in plants of the different cultivars.

Materials and Methods Seeds of five commercial cultivars of each species were sown in pots on a mixture of peat and vermiculite and watered with Hoogland's nutritive solution for three weeks; then watering was completely stopped for the plants subjected to the drought treatment and continued for control plants. After three-week treatments, plants were sampled and weighed on a precision balance (fresh weight, FW); a portion of each sample was dried in an oven for several days to determine the dry weight (DW). Pro was quantified by the classic method of Bates (1973), with slight modifications (Vicente *et al.* 2004).

Results Differences in drought tolerance were detected between the two species investigated (average inhibition of growth was relatively higher in *T. patula*), and among cultivars within each species. 'Bolero', in *T. patula*, and 'Luna gold', in *T. tenuifolia*, appear to be more tolerant than the other four studied cultivars of each species, showing a smaller reduction of fresh weight after

Tab. 1. Inhibition of growth under water stress (WS) conditions (3 weeks without irrigation) in *Tagetes patula* and *T. tenuifolia* cultivars

Species	Cultivar	FW (g) FW (% of control)		Species	Cultivar	FW (g) FW (% of control)	
		Control	WS			Control	WS
<i>T. patula</i>	Szinkeverek	8.68	17.28	<i>T. tenuifolia</i>	Sarga	11.25	12.88
<i>T. patula</i>	Orion	8.78	13.32	<i>T. tenuifolia</i>	Luna gold	9.08	57.71
<i>T. patula</i>	Bolero	6.53	25.75	<i>T. tenuifolia</i>	Luna rot	6.03	37.69
<i>T. patula</i>	Robuszta	5.18	18.11	<i>T. tenuifolia</i>	Luna lemon	5.47	9.24
<i>T. patula</i>	Orange flame	6.19	22.29	<i>T. tenuifolia</i>	Luna orange	7.16	5.19

Tab. 2. Proline accumulation after water stress (WS) treatments in *Tagetes patula* and *T. tenuifolia* cultivars

Species	Cultivar	Pro ($\mu\text{mol/g}$ DW) Control	Pro (fold-increase over control) WS	Species	Cultivar	Pro ($\mu\text{mol/g}$ DW) Control	Pro (fold-increase over control) WS
<i>T. patula</i>	Orion	3.88	67.35	<i>T. tenuifolia</i>	Luna gold	15.61	2.89
<i>T. patula</i>	Bolero	6.85	9.81	<i>T. tenuifolia</i>	Luna rot	8.71	30.26
<i>T. patula</i>	Robuszta	4.48	61.53	<i>T. tenuifolia</i>	Luna lemon	7.23	31.91
<i>T. patula</i>	Orange flame	5.31	47.11	<i>T. tenuifolia</i>	Luna orange	6.21	39.34

three weeks without irrigation, as compared to the non-stresses controls; conversely, 'Orion' and 'Luna orange' seem to be the most drought-sensitive cultivars for each species, as they show the largest degree of growth inhibition (Table 1)

Pro contents in the plants increased in all cases in response to drought treatments, but with large differences among cultivars, from ~ 3-fold in 'Luna gold' to almost 70-fold in 'Orion'. For each species, and considering all cultivars, a good qualitative correlation was observed between the relative increase in Pro levels and the sensitivity to water stress. Thus, the most tolerant cultivars ('Bolero' and 'Luna gold') accumulated less Pro, indicating that they were indeed less stressed than other cultivars under the same experimental conditions.

Conclusion All investigated *T. patula* and *T. tenuifolia* cultivars were negatively affected by water stress, but showing widely variable levels

of growth inhibition; it is therefore possible to select specific cultivars with significantly higher drought tolerance. The good correlation between relatively higher resistance to water stress with lower accumulation of Pro confirms this osmolyte as a reliable stress marker in *Tagetes* species.

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