EFFECTS OF WATER DEFICIENCY ON SOIL-PLANT-WATER RELATIONS IN CANOLA

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ABSTRACT

Two canola cultivars (Global and Vanguard) available on the Argentinian market have been tested in order to determine their suitability for the semiarid region of Argentina. Under ample water availability there were no significant yield differences between the two cultivars, though under moistures stress, Global gave a higher yield than Vanguard (66%). Osmotic potential was higher in Global than in Vanguard under water deficiency. Leaf diffusive conductance tended to be lower in Global than in Vanguard when the plants were subjected to water stress.

INTRODUCTION

Production experience with canola is very limited in the temperate semiarid region of Argentina; however, though its current production is estimated at less than 50,000 hectares, it has considerable potential as a major winter cash crop in the area.

There are few new crops that can be introduced into the production system of the region without entailing a high level of investment and economic risk. From the cost-benefit point of view the introduction of canola appears favorable compared with that of wheat. It provides an important spring cash flow to help farmers cover the costs of an eventual summer crop. Furthermore, the introduction of canola is an effective way to diversify agricultural production.

The main limiting factor for rape production in this region is water supply. When drought was applied at any time during reproductive development of *Brassica napus*, seed yields were markedly reduced and was lowest when drought was applied from the moment of flowering (Richards and Thurling, 1978).

The objective of the present study was to gain insight into the changes taking place in the water relations of the soil-plant system of two canola cultivars under water deficiency, thus facilitating the identification and development of genotypes adapted to the temperate semiarid region.

MATERIAL AND METHODS

Seeds of the cultivars Vanguard and Global were planted 1 cm deep in 25 cm-diameter plastic pots containing 11 kg of soil. The soil was a silt loam. The pots were placed in a greenhouse, and the seedlings were thinned to three per pot. The plants were watered to field capacity daily until they reached full bloom, at which point the treatments were begun. Half of the pots continued to be watered daily (Control treatment). Water was withheld from the remaining half until the plants wilted, they were then watered once and a new drought cycle was started up to four times for each cultivar (Stress treatment). Each treatment had 12 replicas. Soil samples were taken with an auger and the moisture content (SMC) was determined gravimetrically. Leaf water potential (ψ_L) was measured with a pressure bomb. The osmotic potential (ψ_S) was determinated with a 5500 Wescor Vapor Pressure osmometer. Three leaves were introduced into a plastic vial with a sieved bottom. The vial was frozen for an hour, defrosted at room temperature, placed in a centrifuge tube, and centrifuged at 8000 rpm for 10 minutes at 4° C. The almost dry leaf tissue was discarded and the osmotic potential was determined on the cell sap. Relative water content (RWC) was determined by taking discs 5 mm in diameter using a cork borer and immediately weighing them. They were then placed in water for 12 h until achieving full turgor, at which point they were removed from the water, blotted dry and reweighed to obtain the dry weight. Leaf diffusive conductance (LDC) was measured with an AP4 Delta-T porometer.

Measurements of ψ_s, RWC and LDC were carried out each time the plants of the stressed treatments wilted. SMC and ψ_L were determined twice a week. For SMC, ψ_L, ψ_s, RWC and LDC each measurement was repeated 3, 2, 4, 3 and 4 times, respectively.

Yield and seed size were determined for all treatments. The number of siliquas per plant was calculated only on the Global cultivar.

The design of the experimental lay-out was completely random. All variables were tested by analysis of variance and means were separated using Duncan's multiple range test. Correlation coefficients were calculated between all parameters of water status in soil and plant.

RESULTS AND DISCUSSION

It was decided to study the effect of water deficiency on water relations during full bloom since this is one of the most sensitive periods of the plant. Neither soil moisture content nor leaf water potential differed significantly among cultivars, nor was there much variation in these parameters along the experimental period (Table 1). The osmotic potential tended to be lower in Vanguard than in Global under water deficiency (Table 1). The variation of the relative water content of the plant was higher in Vanguard than in Global when under water stress (Table 1).

TABLE 1- Components of the water relationships of Vanguard and Global under control and stress treatments.

			October	November				
Cultivar	Treatment		25	3	8	14	22	30
Global	Control	SMC (%)			26.1	28.7	28.4	29.0
		ψ_L (MPa)			-1.1	-1.0	-1.1	-1.4
		ψ_S (MPa)			-1.24	-1.03	-1.13	-1.55
		RWC (%)			86	84	80	76
		LDC (cm. s^{-1})			3.21	3.10	1.22	0.89
	Stress	SMC (%)			14.5	14.3	11.9	12.6
		ψ_L (MPa)			-1.5	-1.7	-1.7	-2.5
		ψ_S (MPa)			-1.58	-1.69	-1.58	-2.31
		RWC (%)			65	62	63	60
		LDC (cm. s^{-1})			0.031	0.028	0.063	0.071
Vanguard	Control	SMC (%)	25.2	27.3	28.1	27.1		
		ψ_L (MPa)	-1.2	-1.2	-1.1	-1.1		
		ψ_S (MPa)	-1.48	-1.27	-1.02	-1.01		
		RWC (%)	85	83	84	81		
		LDC (cm. s^{-1})	3.80	3.18	2.94	3.12		
	Stress	SMC (%)	13.9	14.5	13.1	12.5		
		ψ_L (MPa)	-1.5	-1.6	-1.7	-3.1		
		ψ_S (MPa)	-1.59	-1.60	-1.79	-2.96		
		RWC (%)	68	63	63	56		
		LDC (cm. s^{-1})	0.15	0.18	0.12	0.085		

The role of stomata in the regulation of transpiration is well-known. A low leaf diffusive conductance is one of the ways of achieving water economy, enabling the plant to enhance its drought resistance and improve its water use pattern. Leaf conductance under water stress tended to be considerably lower in Global than in Vanguard (Table 1).

Yield was highest in the control treatment of Vanguard, but under the stress treatment Vanguard had the lowest yield (Table 2). Seed weight was higher in Global (Table 2). In the control treatment of Global the number of siliqua per plant was 62% higher than in the stress treatment (Table 2).

TABLE 2- Seed yield and yield components of Vanguard and Global under control and stress treatments.

Cultivar	Treatment	Yield ($g\ plant^{-1}$)	Seed weight ($g\ (1000)^{-1}$)	Siliquas per plant
Vanguard	Control	3.789 a*	3.265	
	Stress	1.222 b	3.349	
Global	Control	3.654 a	3.431	118.9 a
	Stress	2.026 b	3.641	73.6 b

* Means within a column followed by different letters are significantly different ($p<0.05$) by Duncan's multiple range test.

The correlation between the tissue water status components differed only in magnitude between the two cultivars (Table 3).

TABLE 3- Coefficients of correlation between soil moisture content (SMC), leaf water potential (ψ_L), osmotic potential (ψ_S), relative water content (RWC) and leaf diffusive conductance (LDC)

		SMC	ψ_L	ψ_S	RWC
ψ_L	Vanguard	0.71			
	Global	0.80			
ψ_S	Vanguard	0.74	0.98*		
	Global	0.74	0.98*		
RWC	Vanguard	0.96*	0.82*	0.81	
	Global	0.93*	0.87*	0.83*	
LDC	Vanguard	0.97*	0.66	0.65	0.96*
	Global	0.76	0.74	0.72	0.92*

* $p<0.05$

The study has allowed us to arrive at a better definition of water relations in Vanguard and Global during water stress.

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