

Genetic variation of plant water status, water use efficiency and grape yield and quality in response to soil water availability in grapevine

J.M. Escalona^{1*}, M. Tomás¹, J. Bota², J.M. Gallegos and H. Medrano¹

¹ Research Group on Plant Biology under Mediterranean Conditions. University of Balearic Islands. Ctra Valldemossa Km 7,5. 07122. Palma de Mallorca. Spain
² IRFAP, Balearic Government. Eusebio Estada nº 145. 07009 Palma de Mallorca. Spain
 email: jose.escalona@uib.es

Intrinsic water use efficiency (WUE) was evaluated in 23 local and foreign grapevine cultivars under field conditions during 2009. A very relevant genetic variation of specific leaf mass (SLM) and plant water status (as stem water potential) was found. Clear and significant relationships were also found between intrinsic water use efficiency, stomatal conductance, carbon isotopic discrimination and grape production and quality. Progressive soil water deficit also determined an increase of SLM and WUE at the time as A_N and g_s declined.

Plant material and treatment

- Ten years old plants cultivated in the same experimental field and grafted on R110. Plants are conducted in bilateral cordon system.
- No irrigation was applied at flowering. Afterwards, no irrigation was applied during summer. Experiment was conducted in 2009.

	CULTIVAR	SLM(veraison) (gm-2)	SLM(harvest) (gm-2)	Ystem (MPa)	Grape yield (Kg)	Ravaz Index	Sugar (Baume)
Local Cultivars	Argamussa	62,40±1,57	93,42±4,45	-1,49±0,12	7,86±0,50	7,53±1,26	9,95±0,38
	Callet	56,53±2,82	85,54±1,93	-1,70±0,07	3,61±0,40	5,80±0,44	11,50±0,33
	Callet blanc	72,10±2,68	94,59±1,97	-1,54±0,02	4,74±1,02	4,56±0,99	11,55±0,13
	Escursach	56,66±3,97	84,95±5,38	-1,29±0,09	3,48±0,29	2,35±0,37	11,40±0,10
	Espero de gall	65,81±3,33	87,58±2,38	-1,30±0,09	2,08±0,30	1,54±0,16	12,95±0,12
	Galmeter	75,43±1,28	100,72±2,04	-1,45±0,11	4,26±0,24	5,20±0,68	12,90±0,10
	Giro ros	66,48±2,56	95,17±2,92	-1,64±0,08	2,62±0,45	1,52±0,17	15,10±0,13
	Gorgollasa	65,17±1,61	82,25±2,95	-1,30±0,04	0,82±0,11	0,56±0,10	12,2±0,18
	Malvasia	54,11±2,01	77,95±5,98	-1,43±0,03	1,27±0,16		14,05±0,13
	Manto Negro	59,43±1,74	78,82±4,51	-1,24±0,09	0,66±0,10	0,71±0,32	15,20±0,39
	Moll	67,62±3,33	97,51±1,69	-1,28±0,08	6,94±1,04	4,47±0,49	11,60±0,33
	Sabater	70,45±2,85	100,13±2,99	-1,38±0,06	5,32±0,62	6,06±0,62	12,15±0,19
	Valent blanc	53,50±1,88	106,26±4,07	-1,30±0,02	2,94±0,49	3,68±0,59	11,95±0,24
	Valent negre	49,33±1,77	100,72±3,35	-1,68±0,07	6,30±0,58	4,42±0,52	10,70±0,23
Foreign Cultivars	Vinater blanc	72,89±5,57	108,89±5,94	-1,26±0,06	3,61±0,29	3,42±0,21	13,20±0,14
	Vinater tinto	61,69±3,80	96,34±5,15	-1,43±0,14	3,66±0,79	5,59±1,49	11,45±0,29
	Cabernet	54,31±1,90	81,74±4,91	-1,41±0,07	3,68±0,81		14,05±0,13
	Garnacha	65,77±2,91	93,42±2,74	-1,30±0,05	6,91±0,84		13,45±0,30
	Macabeo	62,79±1,95	88,46±3,18	-0,98±0,05	8,96±0,54		10,80±0,44
	Merlot	60,35±1,47	97,80±3,64	-1,39±0,11	3,46±0,47		14,95±0,32
	Siraz	-	85,24±5,20	-1,30±0,07	5,41±0,43		13,05±0,16
	Tempranillo	62,36±3,04	85,54±3,07	-1,34±0,07	5,73±1,22		12,45±0,13
	Cabernet	54,31±1,90	81,74±4,91	-1,41±0,07	3,68±0,81		14,05±0,13

Table 1: Specific leaf mass at veraison and harvest time, and stem water potential and grape yield, Ravaz Index and sugar content at harvest time.

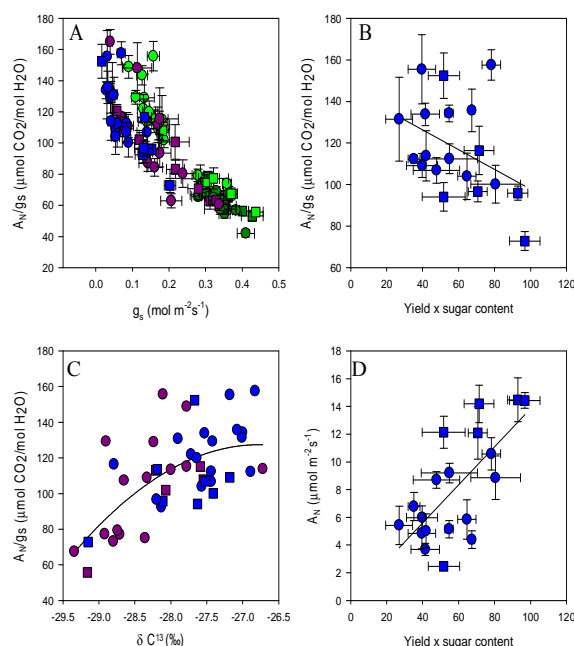


Figure 2: Relationship between intrinsic water use efficiency (WUE) and stomatal conductance (A), Carbon Isotopic composition (B), and plant yield x sugar content in must (C). Relationship between photosynthesis rate and plant yield x sugar (D). Circles represent local cultivars and squares foreign cultivars. Dark green: flowering; green: veraison; purple: ripening; blue: harvest

Measurements

- Soil water potential (psycrometers Wescor) and plant water status (stem water potential by Scholander chamber) were measured.
- Leaf gas exchange parameters: net photosynthesis (A_N), stomatal conductance (g_s) and transpiration (E), were measured using a Li-Cor 6400 infrared open system. Intrinsic water use efficiency (WUE) was calculated as A_N/g_s .
- Grape production and quality were measured at harvest in six plants per cultivar.

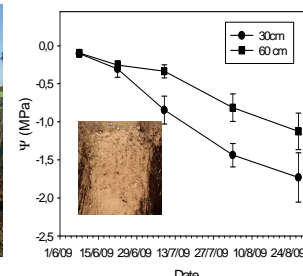


Figure 1: Changes in soil water potential during summer

Cultivar response to progressive soil water depletion

Plants remained under rain fed conditions, thus the soil water availability decline along summer time decreasing more strongly at 30 cm depth (fig 1).

- The progressive water stress caused an important increase of specific leaf mass, increasing by 30% from veraison to harvest time. Under these conditions, some cultivars showed only moderate decline of water status (defined by stem water potential) even under severe limitation of soil water availability (table 1).

- Specific leaf mass (SLM) and stem water potential (Y_{stem}) showed to be cultivar-dependent parameters, ranging from 77 to 108 g·cm⁻² and -0,98 to -1,70 MPa at harvest, respectively.

- Plant productivity, in terms of plant yield and sugar content in must, is also very dependent on the cultivar (table 1).

Water use efficiency variability

- A high correlation was found between intrinsic water use efficiency (WUE) and stomatal conductance, regardless of the cultivar. However, plant water status do not determine WUE (fig 2A).

- WUE show certain dependence with carbon Isotopic discrimination measured in leaf at different times during ripening, representing a good parameter of plant water status (fig 2 B).

- In general, higher plant production (expressed as yield x grape sugar content), corresponded to lower WUE. Only some cultivars such as Argamussa showed yields up to 7 kg per plant with WUE of 150 mmolmol⁻¹ (fig 2C).

- Leaf net photosynthesis rate measured at the end of ripening can be consider a good reference of plant yield and grape sugar content at harvest (fig 2D).