CROP WATER STRESS INDEX AS A TOOL TO ESTIMATE VINE WATER STATUS

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Abstract:

Context and purpose of the study – Crop Water Stress Index (CWSI) has long been a ratio to quantify relative plant water status in several crop and woody plants. Given its rather well relationship to either leaf or stem water potential and the feasibility to sample big vineyard areas as well as to collect quite a huge quantity of data with airborne cameras and image processing applications, it is being studied as a tool for irrigation monitoring in commercial vineyards. The objective of this paper was to know if CWSI estimated by measuring leaf temperature with an infrared hand held camera could be used to substitute the measure of stem water potential (SWP) without losing accuracy of plant water status measure.

Material and methods – Four vine water status were set up in 2017 on a Cabernet-Sauvignon vineyard grafted onto 110R at Morata de Tajuña (Madrid). Data herein involved correspond to 2018 growing season. Total Irrigation amount was 157, 241, 470 and 626 mm for treatments 1, 2, 3 and 4 respectively in 2018. Plants were 2-bud spur pruned along a unilateral cordon with 11-12 shoots per meter of raw. Training system was a Vertical Shoot Position (VSP). Experimental design was a randomize complete 4-block design with 3 rows per single plot, one central control row and two adjacent ones acting as buffer. Canopy development was measured by determining shaded soil at 10:30. Weather data were collected from a weather station at the same vineyard site. To calculate CWSI, leaf-treatment, wet leaf temperature and dry-leaf temperatures were measured with an infrared camera model FLIR E60. All data were collected around noon at the same time as stem water potential (Ψs), on 5 cloudless days along 2018 - June 19th, July 24th, August 7th, September 4th and 25th-. Four leaves per treatment were sampled each time of measurement. It was established a linear regression between CWSI and stem water potential. One treatment per measuring date (4 pair data) was kept out of the lineal regression and saved them to validate the model; All statistics analysis was performed with the Statistix10 package.

Results – Differences in CWSI arose from the first date of measure, June 19th. Differences in CWSI arise even before than in SWP; Highest SWP was -5.32 and the lowest was -13.80bar. At the end of the season, when overwhelming ambient conditions stayed long time CWSI did not show any difference between treatments despite SWP widely ranged between -6.85 and -10.53 bar between treatments**.** We found a significant linear relationship between CWSI and SWP (Ψs = 23.58·CWSI -2.87 R^2= 0.63***). In an attempt to dig into the variables involved in plant water status we looked into a multiple regression in which SWP was dependent either on CWSI, vapor pressure deficit (VPD), canopy development (SS) and soil water content (Θs). However, none of these variables turned out to be significant but CWSI (R^2=0.63**). Shaded soil was significant for P = 0.08. So far we can conclude that CWSI works out when stem water potential is below 14.0 bar.

Keywords: Grapevine, Stem Water Potential, Leaf temperature, Vapor Pressure Deficit, Canopy development, soil water content, Crop Water Stress Index, infrared camera data

1. Introduction.

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INTRODUCTION. Crop Water Stress Index has been published to be an indirect measurement of plant water status measured as either leaf or stem water potential (Bellvert et al. 2015). As measured according to Idso et al. (1981) it seems to be quite laborious as it is necessary to have some plants over irrigated to collect the lowest leaf temperature, and some others under severe water stress to get the upper leaf temperature. In this work we have obtained the former one from the temperature registered on constantly wet cloth, while the water stress leaf temperature was assumed to be ambient temperature +5ºC. The **OBJECTIVES** of this work were: i) to know the feasibility of this method to calculate CWSI ii) to know the accuracy of the CWSI to estimate vine water status iii) to study which other parameters may account and improve the estimation of stem water potential.

MATERIAL AND METHODS. Four irrigation treatments were established in 2017 in a Cabernet-Sauvignon vineyard at SW Madrid (Spain). Total Irrigation amount was 157, 241, 470 and 626 mm for treatments 1, 2, 3 and 4 respectively in 2018. Irrigation season started in June, 11th and finished in September 30th. Plants were 2-bud spur pruned along an unilateral cordon with 11-12 shoots per meter of raw. Training system was a Vertical Shoot Position (VSP). Experimental design was a randomize complete 4-block design with 3 rows per single plot, one central control row and two adjacent ones acting as buffer ones. During 2018 growing season Stem Water Potential and Crop Water Stress Index were measured at noon (Table 1 and 2). Leaf temperature was collected on the same canopy side and similar leaves as the stem water potential. Weather parameters were collected from a weather station placed at the same plot at this study. Canopy development was measured through shaded soil (%) at 10:30 hour by placing a plywood of known area and making a picture to calculate by an image software the shaded area respect to the total area (Williams and Ayars 2005). Leaf temperature was taken with a hand-held camera (FLIR E60).

RESULTS. Stem water potential seemed to be less sensitive than leaf temperature to detect changes between irrigation treatments (Table 1 and 2) while at near the end of the season its seemed the other way round, SWP was more sensible than CWSI. Treatments 3 and 4 perform similarly which could be as they are over irrigated for the layout of this trial; only the 7th of August, the warmest day they differed in SWP. CWSI as measured herein has proved to be a good estimation of SWP. Although validation is good we have to admit that CWSI cand explain 68% of the SWP variability. To know the account of other variables involved in vine water status, a multirreg test was performed taking into account canopy development (shaded soil, %), Vapor Pressure Deficit (VPD, mbar) and CWSI, only CWSI resulted significant. It is likely to happen that even T1 is not severe water stress to make VPD and canopy development significant variables.

Table 1. Midday Stem Water Potential in 2018

Treatment	19th June	24th July	7th August	4th September	25th September
1	7.05	10.02 a	11.41 a	13.10	10.53 a
2	5.79	8.91 b	10.39 a	12.02	9.66 ab
3	5.53	6.81 c	8.93 b	10.96	7.16 b
4	5.32	6.54 c	7.26 c	10.73	6.85 b
Significance	ns	***	***	ns	*

Table 2. Crop Water Stress Index in 2018

1	0.498 a	0.612 a	0.660 a	0.533	0.545
2	0.434 ab	0.542 ab	0.598 a	0.55	0.548
3	0.376 b	0.407 bc	0.468 b	0.499	0.465