Multi-copter RPAS for water stress detection in vineyards

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Stomatal conductance (g_s) is a physiological parameter that has been proposed to determine the physiological water status of grapevine plants. Previously, it was shown that g_s could be approximately estimated using the plant temperature. In the present study, a six-engine multi-copter RPAS was equipped with a thermographic camera in an attempt to determine the water status of plants in an experimental vineyard. This type of multi-copters can be an improved aerial platform for precision agriculture and water stress detection over other traditional manned and unmanned vehicles.

Plant material and treatment

- 4 years old grapevine cv. Garnacha plants cultivated in UIB´s experimental field and grafted on 110-Ritcher. Plants were conducted in a bilateral cordon system. Three water treatments were applied: Watered (W), moderate drought (no watering from flowering, MD) and severe drought (SD, never watered) (Fig. 1).

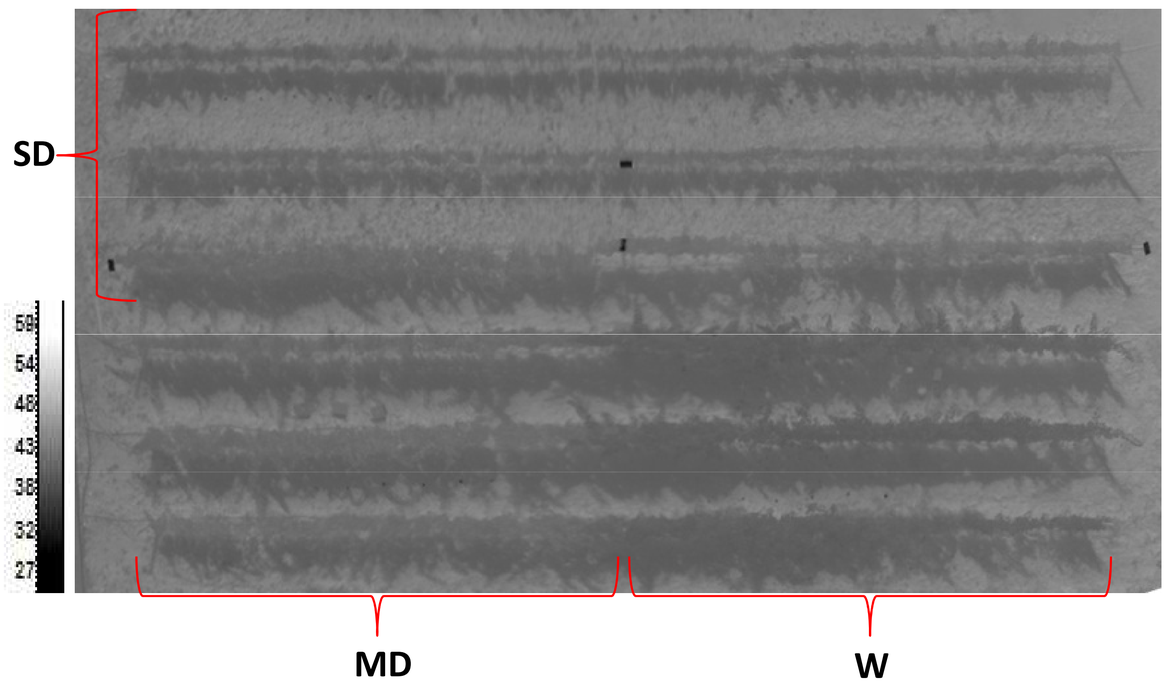

Fig. 1. High-resolution thermographic view acquired with the RPA of the experimental vineyard at 11.00 am 23/08/12. The three water treatments can be easily distinguished taking in account differences in the grey scale. Image resolution is 2.5 cm/pixel. *GCPs are the black rectangles in the picture. RMSE<0.05.*

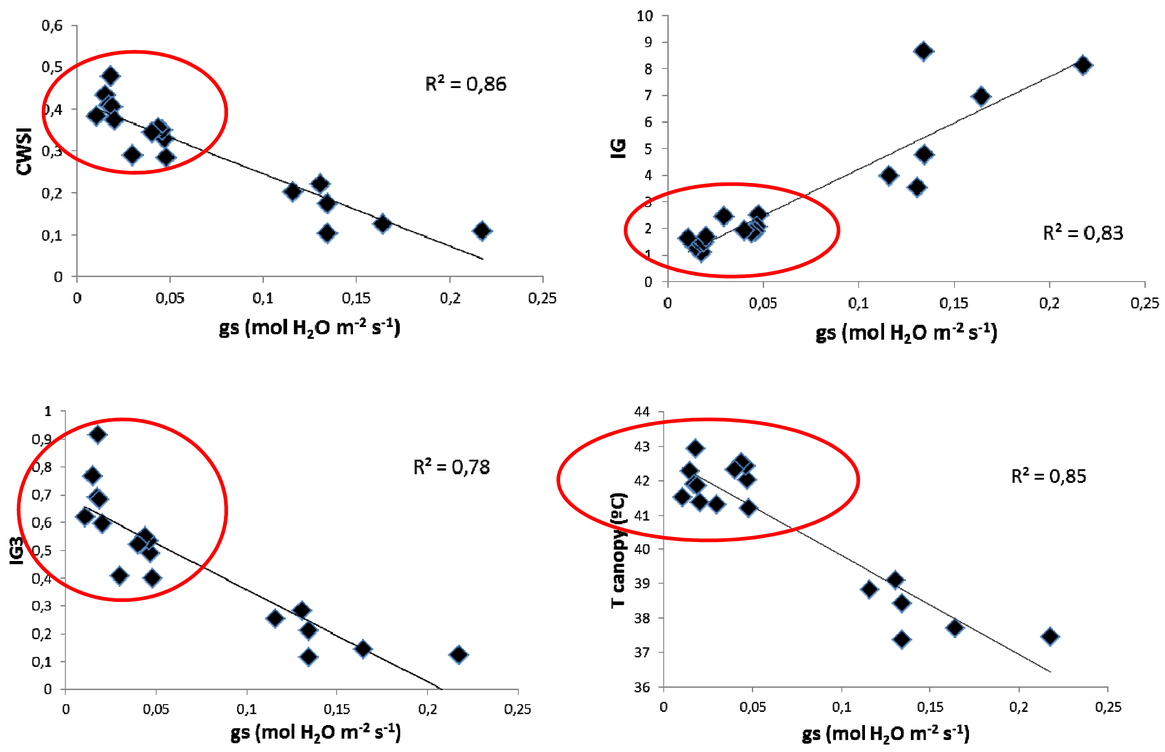

Fig. 2. Relationship between thermographic indexes and stomatal conductance (g_s) for the plants under the three water treatments. Points inside red circles correspond to plants under drought stress.

Measurements

- Leaf gas exchange parameter: stomatal conductance (g_s) was measured using a Li-Cor 6400 infrared open system in fully-expanded leaves in 6 plants per water treatment.

- RPAS platform used in this study was a six-engine multi-copter (Mikrokopter) where was fitted the Gobi384 (Xenics) thermographic camera.

- Geometrically rectification, mosaicking and georeferencing was realized using Structure from Motion photogrammetric techniques and GCP´s (Ground Control Points).

- Thermographic indexes were calculated as follows:

$$CWSI = \frac{Tcanopy - Twet}{Tdry - Twet} \qquad IG = \frac{Tdry - Tcanopy}{Tcanopy - Twet}$$

$$I3 = \frac{Tcanopy - Twet}{Tdry - Tcanopy}$$

Water stress detection in the vineyard by thermal indexes from the RPAS aerial images

- High-resolution thermal images were generated facilitating precise plant canopy temperature extraction (Fig. 1).

- Thermographic indexes as CWSI, IG, I3 and canopy temperature correlated well with g_s (R2>0.75). Plants under water stress can be clearly distinguished with thermographical indexes (inside the red circles, values <0.1 g_s indicating severe physiological stress) (Fig. 2).

- RPAS multi-copter equipped with thermographic camera can be a useful tool for precision agriculture and vineyard water stress detection. In this sense, it could be used to map vineyard heterogeneity for irrigation plan design.

Moreover, this technology offers new advantages and opportunities due its low-cost, high pay-load, stability and reduced flight heights to improve the spatial and temporal thermal vineyard resolution.

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