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In-the-field water stress detection at plant scale using Laser Induced Fluorescence

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Chlorophyll fluorescence emission has long been used to monitor the physiological status of plants because this process occurs in competition with photosynthetic pathway or dissipation as heat. The distribution of the absorbed energy between these three processes varies depending on the response of the plant to different environmental conditions. The majority of research in the chlorophyll fluorescence topic has been developed at leaf level, under controlled laboratory conditions. The work presented here was carried out at the whole plant level of a vineyard undergoing a water stress of several weeks during a dry summer period. Both irrigated (control) or stressed plants were monitored. The experiment was conducted at the experimental farm of "Las Tiesas" in Barrax (Albacete, Spain).

Laser induced fluorescence measurements (LIF) were performed continuously at several meters of distance using a micro-lidar (Ounis et al. 2001). The instrument also recorded several environmental parameters including leaf and air temperatures, incident PAR and the light reflected from the target. Infrared thermometers were installed to monitored the temperature at the level of vegetation canopy, whereas soil moisture sensors monitor soil water loss. The chlorophyll content was monitored with a SPAD-502 (Minolta). In parallel, the physiological state of vegetation was characterized by measurements of the water potential using a Scholander bomb and measurements of CO2 assimilation and stomatal conductance using Li-6400 gas analyzer.

Our results show that LIF variations at plant level were small (<20%) under control conditions. Several features characterize LIF under drought conditions: i) The diurnal pattern showed the typical M-shape of a stressed plant (Evain et al. 2004) although of smaller amplitude; ii) LIF at midday decreased, becoming smaller than LIF at night (F0) during all the stress period. Water potential, photosynthesis, stomatal conductance data corroborated these results while the chlorophyll content remained unchanged.

After 40 days withholding water, a rapid reversion of the LIF stress signature is observed within 24 hours after a single irrigation. However several irrigation sequences were required for a complete recovering. These experiments demonstrated the possibility to detect water stress status in field conditions and at plant level several meters away using the LIF technique.