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Research Note

Susceptibility of Chardonnay grapes to sunburn

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K e y w o r d s : Chlorophyll fluorescence, epicuticular waxes, sunburn.

Introduction: Fruit of many horticulturally important crops (Ma and Cheng 2004) including some grape varieties (Spayd *et al.* 2002) are susceptible to high-light, high-temperature-induced sunburn. This is characterized by pigment changes in the skin that result in yellow, bronze or brown lesions (Schrader *et al.* 2003), often associated with loss of chlorophyll (Merzlyack *et al.* 2002). For grapes in commercial production areas of Australia, little is known about the incidence of sunburn. Anecdotal evidence suggests 5-15% of grapes are affected as a consequence of high summer temperatures.

Recently, Wünsche *et al.* (2001) demonstrated that chlorophyll fluorescence from fruit declined in concert with increasing severity of sunburn. Chlorophyll fluorescence could, therefore, serve as a useful probe for sunburn on other fruit such as grapes, especially as it is more objective than visual assessment of sunburn.

Thus, the objectives of the study were to assess the incidence and severity of sunburn in Chardonnay grapes and to assess chlorophyll fluorescence as a tool to quantify sunburn in grapes.

Material and Methods: The study was carried in 2003 and 2004 at the Charles Sturt University Vineyard in Wagga Wagga, NSW, Australia, using Chardonnay grapes. Three vines were allocated to two treatments; control vines where bunches were shaded and exposed vines where bunches were well sunlit throughout the growing season. Ten bunches in each were selected for study.

When the berries were 5 mm diameter, chlorophyll fluorescence was measured *in situ* on two berries of each bunch. Measurements were repeated at approximately 15-d-intervals until harvest. Fluorescence (OS1-FL, Opti-sciences, Tyngsboro, USA) was measured at about 1500 µmol m^{-2} s^{-1} irradiance. The fibre-optic probe covered the sunburn lesion on each berry. Steady-state fluorescence, F_t was recorded and then a saturating flash (4000 µmol m^{-2} s^{-1} for 0.8 s) applied to determine maximum fluorescence, F_m'. Fluorescence yield was determined as $(F_m' - F_t) / F_m'$.

At harvest, grapes were sorted into 6 categories of sunburn, based on size of lesion and depth of browning; slight sunburn (category 1-2) was assessed as lesions <5 mm diameter and light brown; moderate sunburn (category 3) <6 mm diameter and mid-intensity brown and severe sunburn (category 4-5) as >6 mm diameter and dark brown in colour. The number of berries in each category was then counted.

Berries with different sunburn categories were collected and a slice of skin (6 mm diameter) cut from the sunburn lesion of two berries from each category. The slice was attached to a brass stub, frozen at -170 °C on the cold stage of a scanning electron microscope (JEOL Australasia, Sydney, Australia). The appearance of epicuticular waxes covering the sunburn lesion was assessed microscopically from the scanning images.

Data analyses were carried out using general linear models with SAS 9.1 (SAS Institute, Cary NC) and means and standard errors calculated.

Results and Discussion: Sunburn of Chardonnay grapes was characterized by brown lesions that increased in size and depth of colour with increasing severity. The most severe lesions were probably associated with cell death in the epidermal layers of the skin. Well-exposed bunches in one year had up to 35 % of berries per bunch with sunburn of symptoms of varying severity while shaded bunches had less than 1 % with sunburn. In the second year, 22 % (43/197 kg) of the overall crop had moderate to severe sunburn. These results conform with high extents of sunburn reported anecdotally for grapes in Australia but in keeping with estimates for other crops (Wünsche *et al.* 2001, Melgarejo *et al.* 2004). Variation in sunburn between the two years could relate to differences in maximum temperatures prior to harvest which on average were 40.8 °C (2003) compared with 30.8 °C (2004) while net radiation ranged between13.8 MJ m^{-2} d^{-1} and 15.5 MJ m^{-2} d^{-1}. These results support the conclusion of Bergqvist *et al.* (2001) that effects of radiation on grapes are highly temperature-dependent.

Berry chlorophyll fluorescence changed little early in the season (Fig. 1) although F_m' of sun-exposed berries was significantly lower than in shaded berries. However, shortly after veraison, there was a marked decline, notably in F_m', and thereafter fluorescence from the Chardonnay berries became negligible in both shaded and sun-exposed bunches. Similar results occurred in dark-acclimated and sun-exposed berries of the cv. Kerner (Düring and Davtyan 2002), *i.e.* a sharp decline occurred after veraison. This may relate to decreases in chlorophyll concentration occurring shortly after ripening commenced (Hardie *et al.* 1996), especially as the fluorescence decline coincided in shaded and sun-exposed berries.

There was a curvilinear relationship between chlorophyll fluorescence and the severity of sunburn in Chardonnay berries as shown elsewhere (Wünsche *et al.* 2001). The highest fluorescence occurred on grapes with no sunburn and decreased mostly between control berries and those with slight to moderately severe sunburn. With more severe sunburn, fluorescence became relatively steady at about 30 % of that for control berries. The tightest relationship between sunburn and fluorescence occurred with

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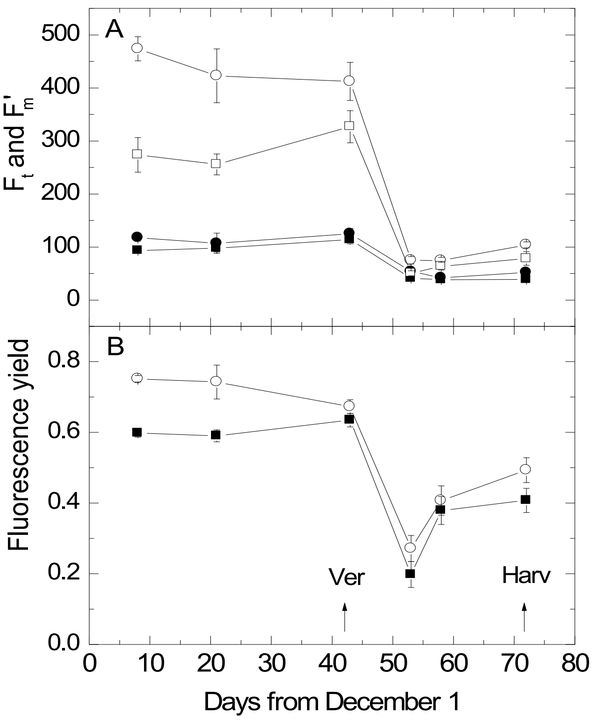

Fig. 1: Changes in (**A**) steady-state (F_t), maximum (F_m’) fluorescence and (**B**) the fluorescence yield of Chardonnay exposed (circles) and shaded (squares) berries throughout two growing seasons. The arrows indicate veraison and harvest.

maximum fluorescence (F_m’) and shows it can be used to quantify sunburn in grapes.

The almost total loss of fluorescence occurring about 20 d prior to harvest of the Chardonnay berries coincided with increased appearance of visual sunburn symptoms. This loss of fluorescence could be attributed to increased skin browning of the berries as sunburn occurred. Sun-exposure of varieties such as Cabernet Sauvignon, Merlot, Grenache, Shiraz and Pinot Noir berries increased total phenolic concentrations (Bergqvist *et al.* 2001, Spayd *et al.* 2002). The brown appearance of the Chardonnay berry lesions also suggests appearance of secondary phenolic compounds (Wünsche *et al.* 2004).

The high susceptibility of Chardonnay grapes to sunburn may relate to changes in epicuticular waxes. In berries with no sunburn, the waxes had an intricately arranged platelet structure orientated perpendicular to the surface of the berry (Fig. 2). With even the slightest symptoms of sunburn, these waxes lost the crystalline structure and became relatively amorphous. The epicuticular waxes appeared to be very sensitive to the conditions causing sunburn and seem to be implicated in the susceptibility of Chardonnay grapes to high light and high temperature.

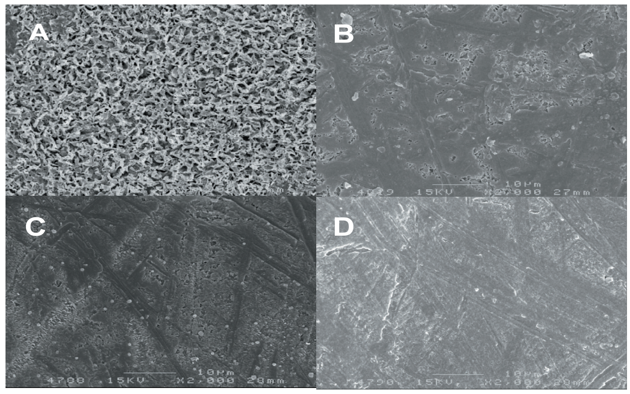

Fig. 2: Scanning electron micrographs (x 2000 magnification) of epicuticular waxes on Chardonnay grapes. (**A**) Control grapes with no sunburn; (**B**) slight sunburn; (**C**) moderate sunburn; (**D**) severe sunburn.

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