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A multivariate analysis of combined effects of (micro)climate, vegetative and reproductive growth on grey mould incidence in grapevine

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Abstract: Over three years (2004-06), a field experiment was carried out near Montpellier (southern France) to investigate the relationships between grey mould expression at harvest and some of the major factors affecting the disease development in vineyards, *i.e.* (micro)climate, fruit composition and vine vegetative and reproductive growth. By implementing irrigation and cover cropping practices, various levels of vine growth were generated and led to different levels of disease development. Disease incidence was correlated positively to key variables of vine vegetative growth: total leaf number, leaf dry matter, leaf layer number, leaf area per m of row, pruning mass and nitrogen accumulation. These relationships were established in the context of an interaction between (micro)climate and grapevine vegetative growth. In 2004, under conducive weather conditions, *B. cinerea* developed in all experimental plots. Favourable (micro)climatic variables were precipitation, duration of relative humidity > 90% in the canopy and low potential evapotranspiration. However, in 2005 and 2006, under dry summer conditions, disease developed only in the most vigorous vines which were both irrigated and fertilized. These vines showed a very high canopy growth associated with compact clusters and delayed fruit maturity.

Key words: *Vitis vinifera*, vegetative vigour, vine capacity, *Botrytis cinerea*, bunch compactness

Introduction

Many actors in viticulture recognize the importance of potential quantitative relationships between susceptibility to fungal pathogens and grapevine growth or vigour (Goulet *et al.*, 2006). However, these relationships have been poorly documented in the literature. Some studies of grape quality have, incidentally, shown interactions between grey mould development and vegetative and reproductive growth patterns in grapevine (Reynolds and Wardle, 1994; Morlat and Bodin, 2006). Because of the complex relationships between *B. cinerea* development, canopy size, microclimate, morphological and physiological features of clusters and berries (Vail and Marois, 1991), our main objective was to find out which main variables characterizing canopy microclimate, grapevine vegetative and reproductive growth and fruit composition can be associated and best describe grey mould expression at harvest (Valdés-Gómez, 2007).

Material and methods

The 3-year field experiment was conducted from 2004 to 2006 in a commercial vineyard (cv. Aranel, white variety, grafted on Fercal rootstock) located near Montpellier (43°31' N-3°51' E) in the Mediterranean area. The vines were planted in 1997 at 2.5 m inter-row and 1.2 m intra-row spacing and were trained with a midwire bilateral cordon system and a canopy height of 1.0 to 1.1 m (rows oriented from NW to SE). No fungicide was applied to control *B. cinerea* during the experiment. In order to create different vine growth levels, different types of cropping systems were used: i) chemical weed control all over the soil surface ("W"), ii) perennial cover crop sown with a mixture of tall fescue (*Festuca arundinacea* Shreb) and ray grass (*Lolium perenne* L.) in every inter-row ("C"). Weeds growing under the vine rows were controlled with glyphosate. Every treatment was divided into two blocks differing by their slope (1: slope near 0 %, 2: slope near 2 %). In 2005 a new treatment ("I") was added in block 1, irrigated once a week from budbreak to harvest (3400 m^3 ha^{-1} in 2005, 7400 m^3 ha^{-1} in 2006), fertilized with nitrogen (80 kg N ha^{-1} in 2005, 120 kg N ha^{-1} in 2006) and under chemical weed control. Different variables regarding vine vegetative and reproductive growth were measured including total leaf number, leaf dry matter, leaf layer number, leaf area per m of row, pruning mass, nitrogen accumulation, vine yield, mean bunch mass and fruit composition (sugar concentration, titratable acidity). Some key canopy microclimate variables, particularly canopy air temperature (Tc) and canopy air relative humidity (RHc), were collected between veraison and harvest. At maturity stage, 180-200 bunches per sub-plot (sub-plot = cropping system x block) were scored individually and visually to assess grey mold incidence.

Results and discussion

Climatic and microclimatic conditions and grey mould development

Under our experimental conditions, the primary risk factor leading to grey mould development was identified as the climatic and microclimatic conditions. From veraison to harvest, the rainfall (47 mm) was higher in 2004, increasing disease incidence, than in 2005 and 2006 (less than 20 mm). In 2004, within each block, grey mould incidence differed significantly between the two cropping systems. The perennial cover crop treatment led to, approximately, four times less disease compared with the chemical weed control treatment (Fig. 1). In 2005 and 2006 which were less conducive to grey mould, the disease developed mostly in the irrigated plot (I) with an incidence of 13.9 % and 21.5 %, respectively. A principal component analysis based on climatic and microclimatic variables (data not shown), allowed us to identify five climatic and microclimatic variables of prime importance: precipitation, potential evapotranspiration, predawn leaf water potential (PLWP), relative air humidity higher than 90% and temperature higher than 30°C in the canopy (Fig. 2).

Vine vegetative and reproductive growth and grey mould development

In 2005 and 2006 under dry summer conditions, the disease developed mostly in the highly vigorous vines which were both irrigated and fertilized (Fig.1). This evidenced that unfavourable climatic conditions for the disease development can be counterbalanced by conditions of high vine growth and associated canopy and cluster features. The following key variables of vine vegetative growth were highly and positively correlated with the final disease incidence (Fig. 2): total leaf number per shoot, leaf layer number, leaf area per m. of row (m^2/m), total dry matter (kg/vine), pruning mass (kg/m), nitrogen accumulation in dry matter (gN/vine). The importance of such variables linked to vine vigour, foliage density and/or cane pruning mass was already stressed under production conditions (Morlat and Bodin, 2006).

As regards yield components and cluster architecture, bunch mass (g) was correlated positively and significantly (P = 0.01) with grey mould incidence (Fig. 2). This variable has been shown to make the largest contribution to cluster compactness among various cluster measurements and can be then considered as a key morphological feature increasing *B. cinerea* infection and mycelial colonisation within the grape cluster (Vail and Marois, 1991). Lastly, concerning fruit composition, disease incidence was significantly and negatively correlated with the level of fruit maturity, as indicated for example by the SC/TA ratio (sugar concentration / titrable acidity) (Fig. 2).

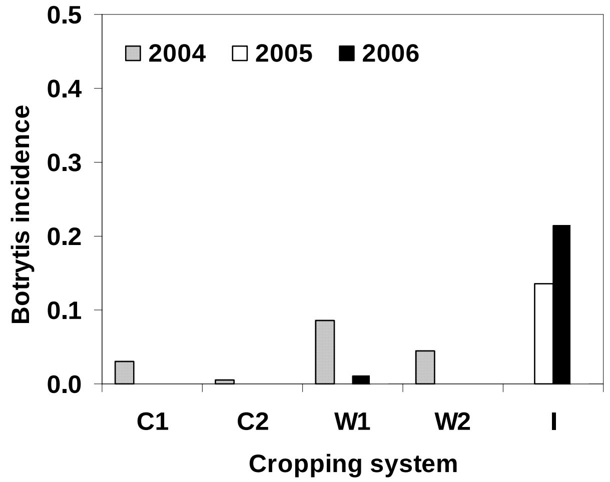

Fig. 1. Final grey mould incidence in function of the cropping system: “W”, chemical weed control treatment and “C”, perennial cover crop treatment (followed by 1 and 2 corresponding to the block number with a slope of 0 % and 2 %, respectively).

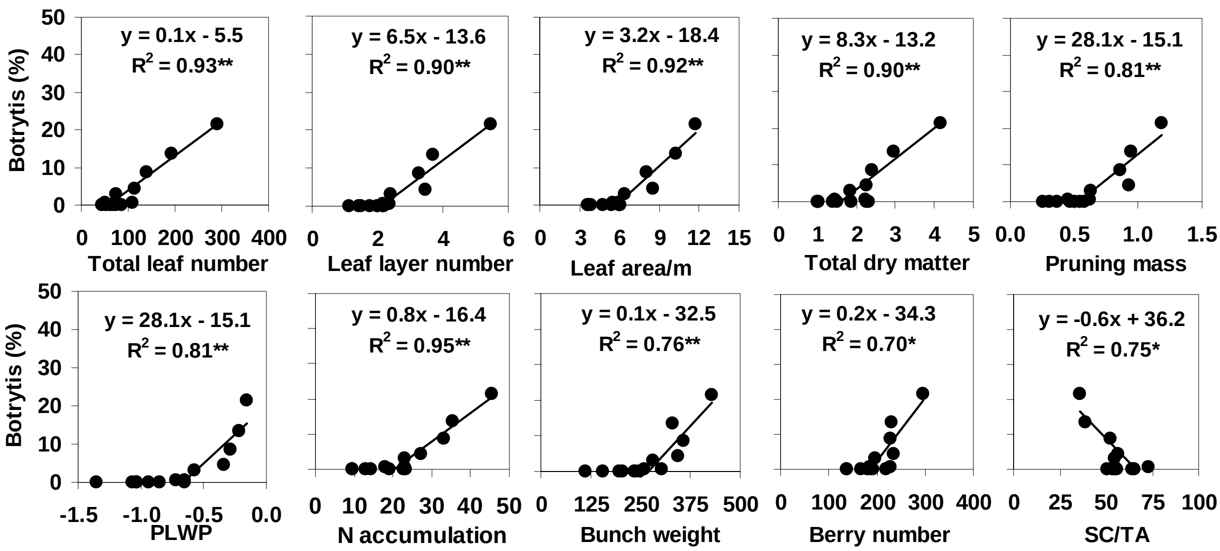

Fig.2. Significant correlations between grey mould incidence (%) and key variables of vine growth, cluster architecture, yield components and fruit composition. Linear regressions include data with grey mould incidence different from 0% only. * Significant at *P* = 1%; ** at *P* = 5%. PLWP: predawn leaf water potential, SC/TA: sugar concentration / titratable acidity.

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