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Photosynthetic temperature responses in six common wine grape (*Vitis vinifera)* varieties

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Introduction

Temperature plays a key role in governing plant photosynthetic rates, and by extension growth and reproduction. These relationships are critical in agroecosystems, where photosynthetic temperature responses underpin variation in crop function and yield. Generally, crop models expect photosynthesis for a given crop to peak at an optimum temperature, and subsequently declines at higher temperatures due to stomatal closure associated with increased vapour pressure deficit (VPD) at higher temperatures.

While we have a general understanding of how photosynthetic temperature responses vary among crops, less research has focused on quantifying differences among varieties within crop species. In wine grapes (*Vitis vinifera*, the focus on my study), only a limited number of studies have quantified intraspecific variation variation in temperature responses among the 100s of wine varieties in field conditions.

My research examines photosynthetic temperature responses of six common wine grape varieties, including three red (Cabernet franc, Cabernet sauvignon, Pinot noir) and three white varieties (Riesling, Sauvignon blanc, Viognier). I asked the following research questions :

1. Do wine grape varieties differ in photosynthetic temperature response curves and related parameters (Fig. 2)?

2. If so, do these differences differ systematically across red vs. white varieties?

3. What is the relationship between optimum temperature, photosynthesis rate at optimum temperature, and temperature tolerance across varieties (Fig. 4)?

Methods

Vines were sampled at a vineyard in Niagara-on-the-Lake, Ontario in July 2023. Three fully developed leaves from different plants were sampled for each variety. Plants were of similar sizes, and all leaves were undamaged, fully exposed, and located on the east-facing side of each vine.

Photosynthetic temperature response was measured using a LI-6800 portable photosynthesis system. Leaf temperature was increased from 25-40° C, and photosynthetic rates were logged after stabilization at each temperature point. Other variables controlled in the chamber included light (at 1500 μmol m^{-2} s^{-1}), CO_2 (420 ppm), and an absolute water vapour rate (fixed at a relative humidity of 60% at 25°C). Statistical analyses were performed using R software.

Fig. 1. The LI-6800 executing a temperature response program on a *Vitis vinifera* vine, in the Niagara vineyard.

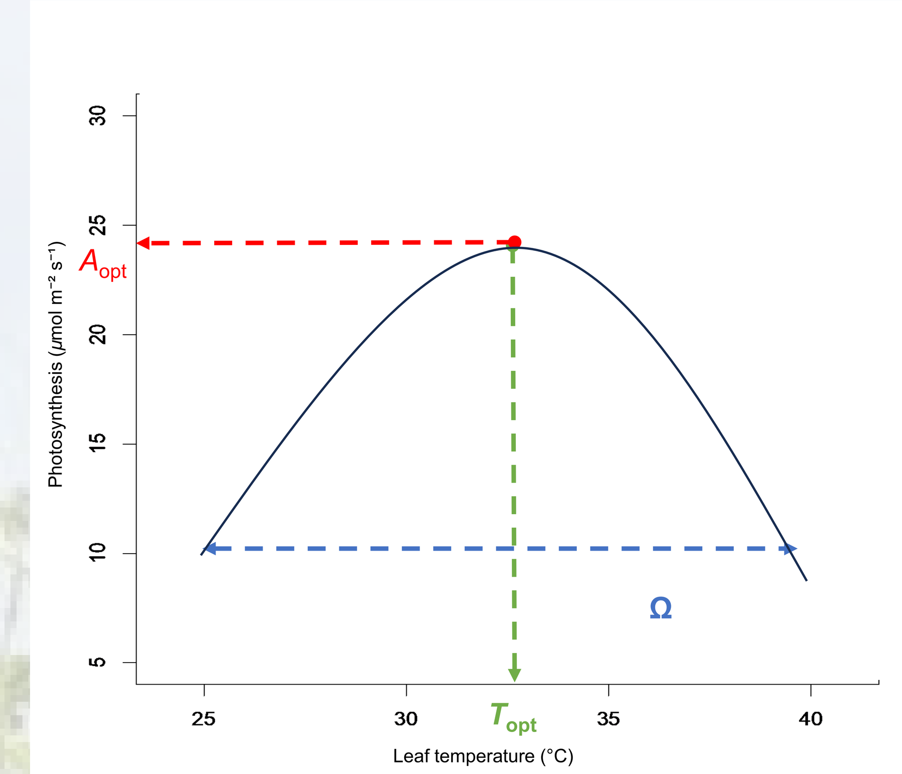

Fig. 2. Conceptual figure of optimum temperature for photosynthesis (T_{opt}), photosynthetic rate at optimum temperature (A_{opt}), and width of temperature response curve (Ω).

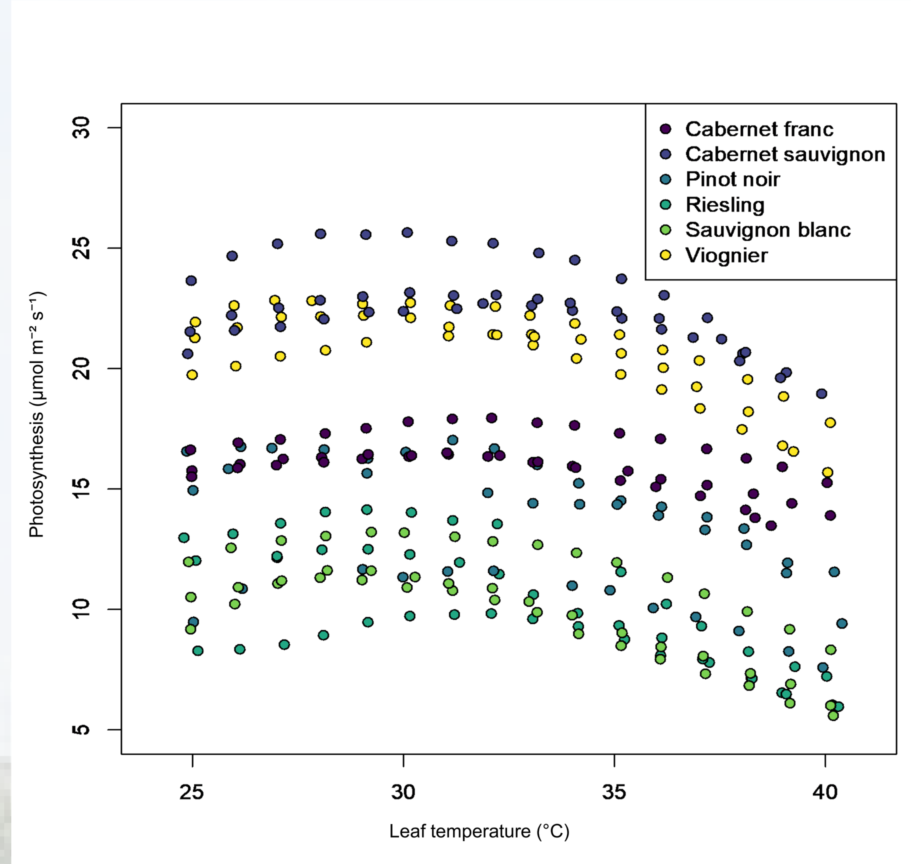

Fig. 3. Photosynthesis temperature response curves for six wine grape varieties.

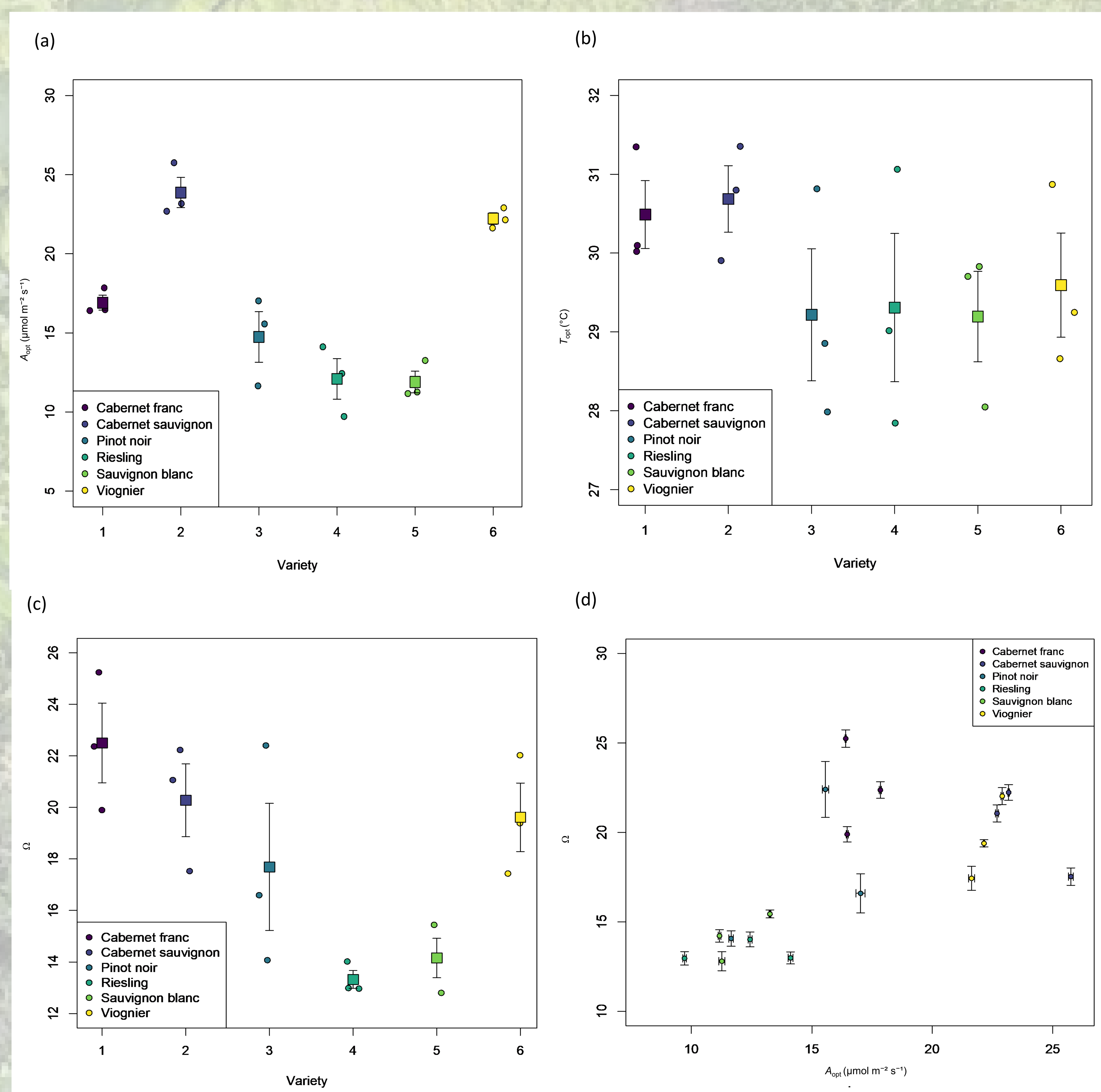

Fig. 4. a) Photosynthesis rate at optimum temperature (A_{opt}); **b)** Optimum temperature for photosynthesis (T_{opt}) for each variety; **c) Width** of the temperature response curve, or Ω, for each variety; and **d)** Relationship between Ω and A_{opt} across varieties.

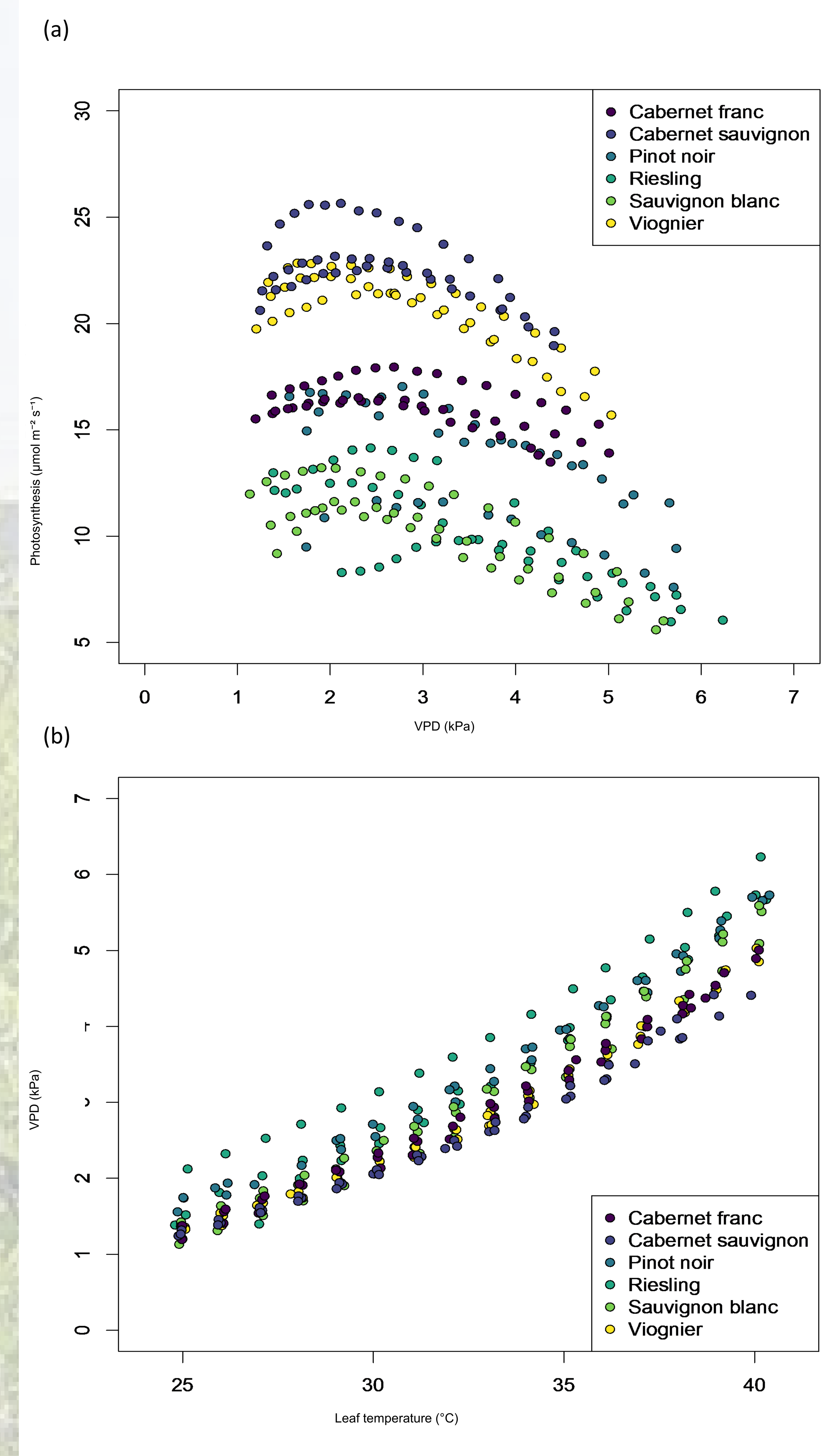

Fig. 5. Relationships **a)** Photosynthetic rate and VPD, and **b)** VPD as a function of leaf temperature.

Key Results and Discussion

Question 1. Photosynthetic rates for all varieties showed similar response curves (**Fig. 3**), but mean T_{opt} did not vary significantly across varieties (**Fig. 4b**). However, A_{opt} and Ω did vary significantly across varieties (**Fig. 4a** and **Fig. 4c**).

Question 2. Red varieties showed higher A_{opt} than whites, except Viognier (**Fig. 4a**). Red varieties also expressed broader temperature response curves than white varieties, except Viognier (**Fig. 4c**).

Question 3. Across varieties, Ω is positively related with A_{opt} (r^2=0.348) (**Fig. 4d**), but there is no relationship between Ω and T_{opt}, or between T_{opt} and A_{opt} (data not presented here).

Cultivation history may explain intraspecific variation in temperature response curves: Sauvignon blanc and Riesling historically thrived in cooler environments vs. Cabernet sauvignon, Cab. franc, Pinot noir, and Viognier. This may potentially explain higher A_{opt} and Ω in these vs. other varieties.