Physical & Environmental Sciences
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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 decline at higher temperatures due to stomatal closure associated with increased vapour pressure deficit (VPD).

While we have a general understanding of how photosynthetic temperature responses vary among crops, less research has focused on quantifying intraspecific differences. In wine grapes (*Vitis vinifera*, the focus of my study), only a limited number of studies have quantified intraspecific 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 and Pinot noir of cool climate origin, and Cabernet sauvignon of warm climate origin) and three white varieties (Riesling and Sauvignon blanc from cool climates, and Viognier of warm climate origin). 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 and/or varieties of different domestication origins?**

**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 $\mu$mol 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.

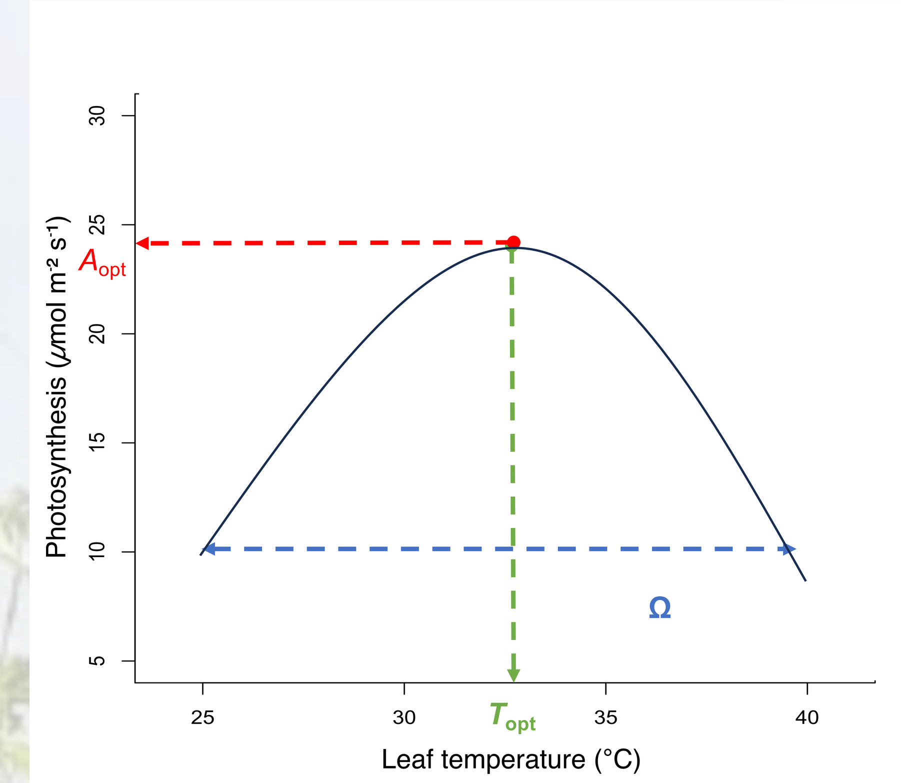


**Fig. 2.** Conceptual figure of optimum temperature for photosynthesis ($T_{opt}$), photosynthetic rate at optimum temperature ($A_{opt}$), and width of temperature response curve (Ω).

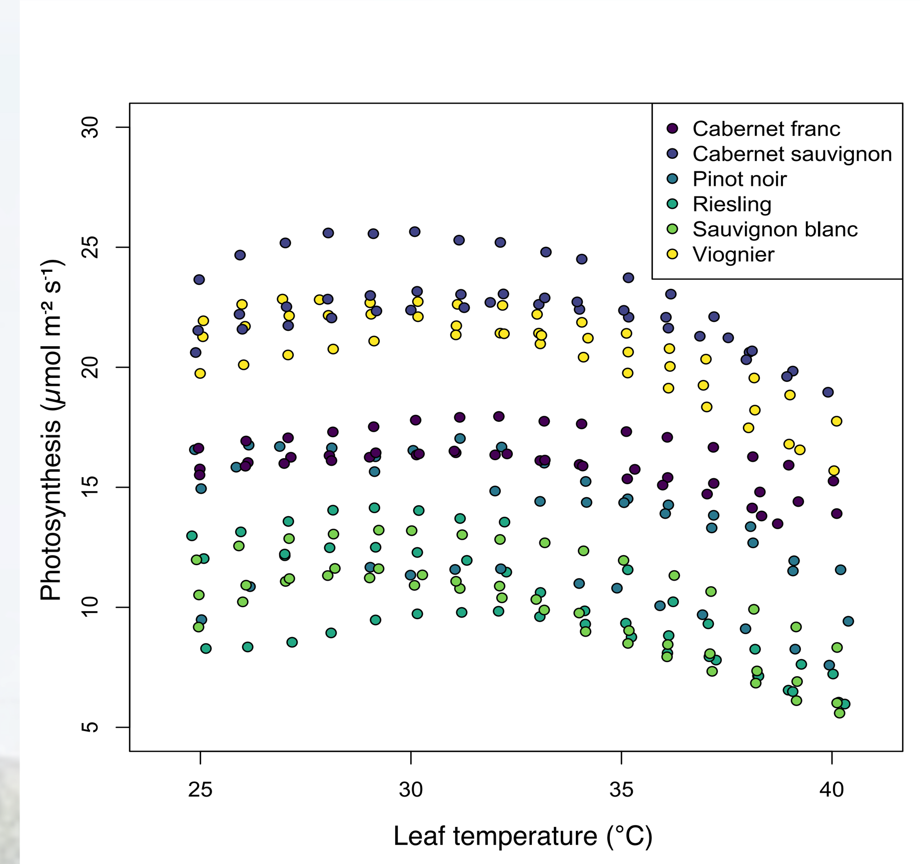


**Fig. 3.** Photosynthesis temperature response curves for six wine grape varieties.

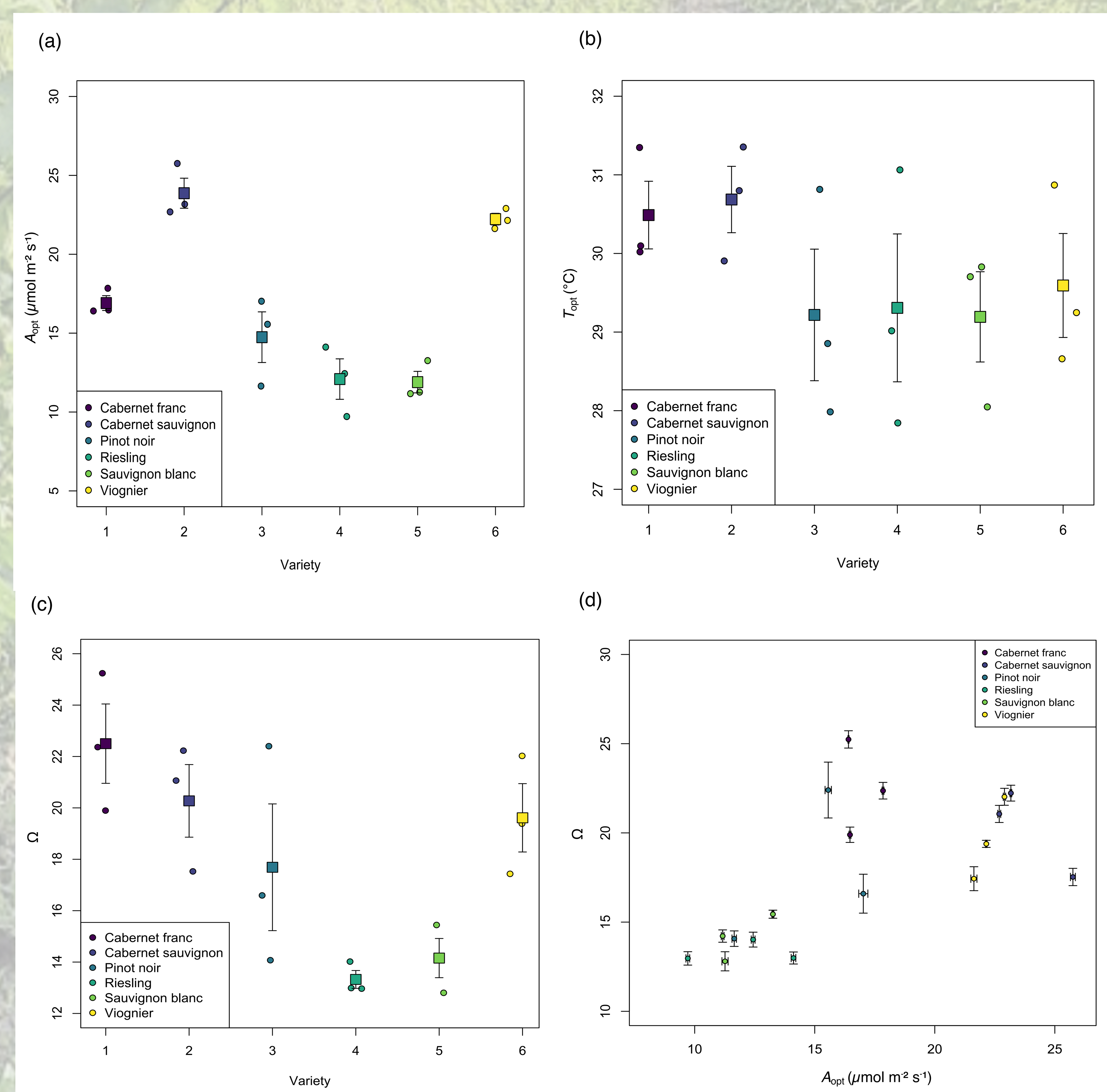


**Fig. 4. a)** Photosynthesis rate at optimum temperature ($A_{opt}$); **b)** Optimum temperature for photosynthesis ($T_{opt}$) for each variety; **c)** Width of the temperature response curve, or Ω, for each variety; and **d)** Relationship between Ω and $A_{opt}$ across varieties.

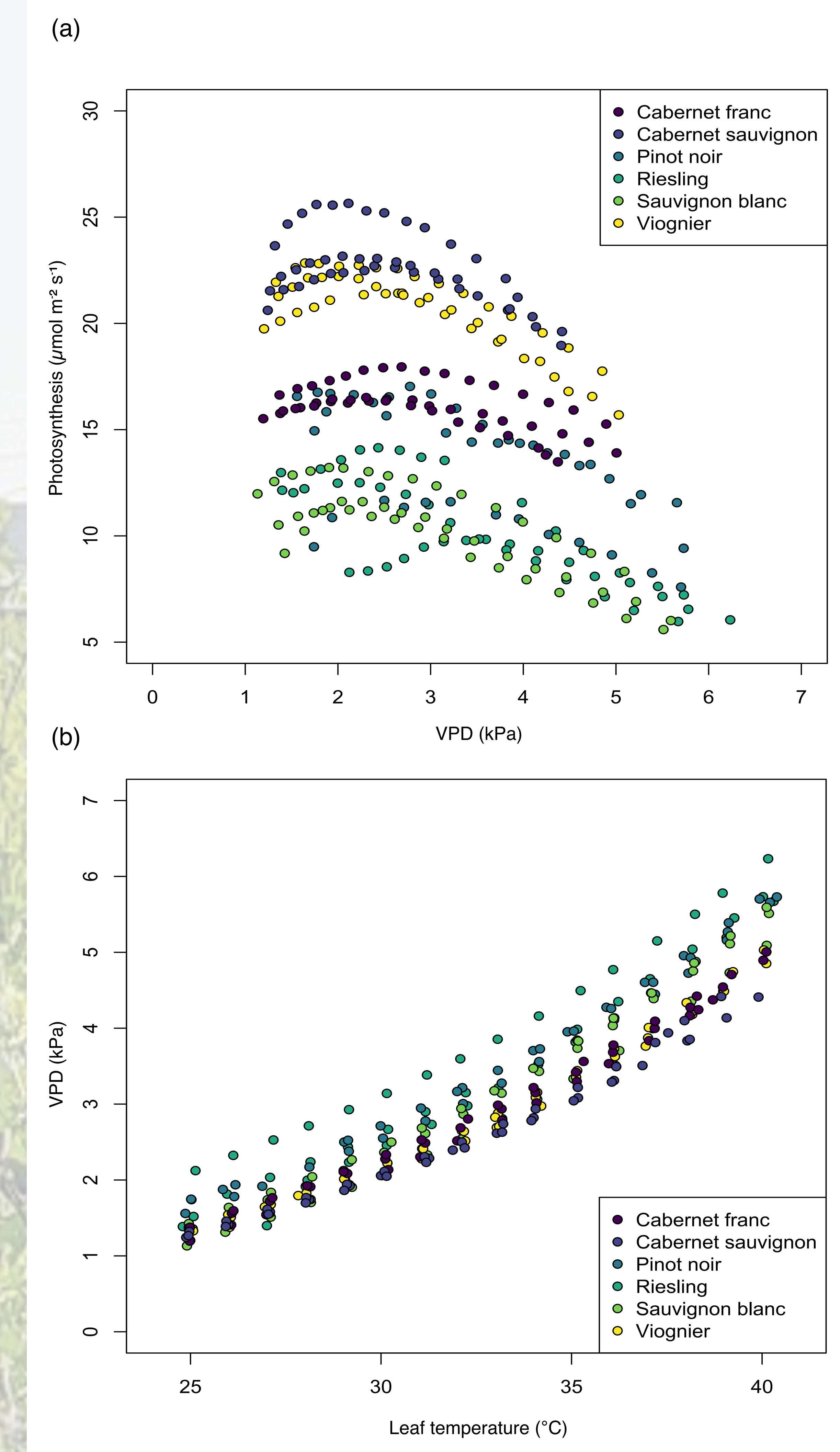


**Fig. 5.** Relationships **a)** Photosynthetic rate and VPD, and **b)** VPD as a function of leaf temperature.

## 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.** Varieties domesticated in warm, dry climates showed higher $A_{opt}$ (**Fig. 4a**) and broader temperature response curves (**Fig. 4c**) than those with cool-climate origins. There was no systematic difference in temperature response between red and white varieties.

**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).

These results suggest wine grapes are indeed vulnerable to rising temperatures, which may impact yield and quality of grapes and wine. Varieties domesticated in warm climates may be more resilient and have greater adaptive capacity to climate warming.