Photosynthetic capacity of passion fruit genotypes at high temperatures is determined by transpiration capacity under non-stressed conditions

Passion fruit (*Passiflora* spp.) is mostly indigenous to the tropical highlands, generally with decreasing growth and productivity in high temperature conditions. Purple passion fruit (*P. edulis*) has lower juice acidity with excellent fresh eating quality, but its growth and productivity are severely inferior at high temperatures. Yellow passion fruit (*P. edulis* f. *flavicarpa*) is tolerant to high temperatures and can be cultivated in some tropical lowlands, but its juice shows high acidity and is not suitable for fresh consumption. Hybrids of these species have been bred in various areas of the world. However, summer productivity remains poor, and little is known about the leaf photosynthetic responses to high temperatures, which can affect growth during hot summers.

We measured the individual leaf photosynthesis of 13 genotypes of passion fruit at high temperatures above 30°C using a portable gas-exchange system in a growth chamber under precisely controlled environments (Fig. 1) to analyze the traits that correlated highly with photosynthetic capacity. At leaf temperatures up to 40°C, gross and net photosynthetic rates decreased mainly due to stomatal closure, while above 40°C, only the net photosynthetic rate decreased due to increased respiration (Fig. 2). The reduction in photosynthesis at high leaf temperatures above 35°C was strongly correlated ($p < 0.01$) with transpiration rate and stomatal conductance under non-stress conditions (leaf temperature of 30°C), and genotypes with well-opened stomata exhibiting higher transpiration rates showed a smaller net photosynthetic rate reduction at high temperatures (Fig. 3). The reductions in net photosynthetic rate at high temperatures and the values of transpiration rate and stomatal conductance under non-stress conditions (leaf temperature of 30°C) were strongly correlated with stomatal size ($p < 0.01$) in 9 genotypes of *P. edulis* group (Table 1), excluding 4 genotypes of lowland relatives (*P. alata* and *P. laurifolia*). These results indicate that genotypes with larger stomatal sizes maintained higher net photosynthetic rates at extremely high leaf temperatures above 40°C and had higher net photosynthetic rates and stomatal conductance under non-stress conditions.

This information can be useful for further selection of passion fruit genotypes with resilience to ongoing global warming. We need to consider separately the application to crossbreeding using lowland relatives, in which stomatal traits did not clearly correlate with transpiration capacity; however, transpiration capacity under non-stress conditions can be one of the target traits for breeding passion fruit genotypes that are highly tolerant to high temperatures.

Authors: Matsuda, H., Takaragawa, H. [JIRCAS]

Fig. 1. Measurement in a growth chamber
Photosynthesis measurements were conducted in 13 passion fruit genotypes.

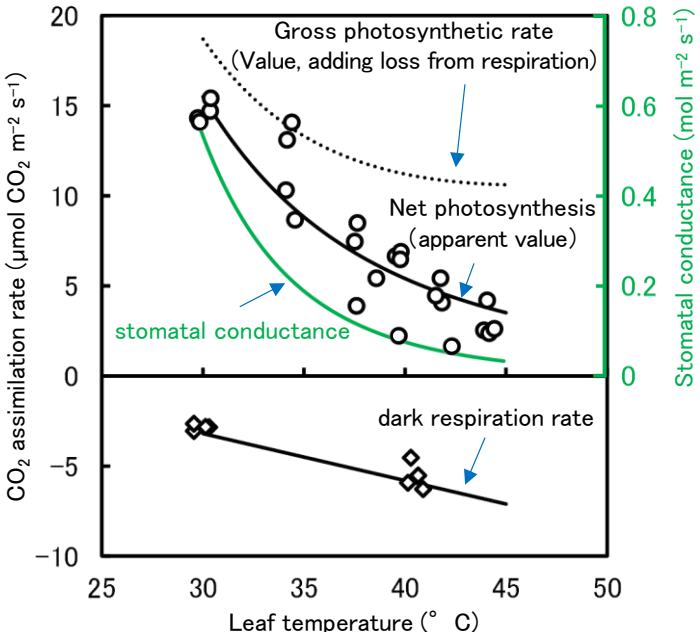

Fig. 2. Relationship between leaf temperature and photosynthetic rate, respiration rate, and stomatal conductance (cultivar 'Ruby Star')
Sigmoidal curve and linear regression were performed.

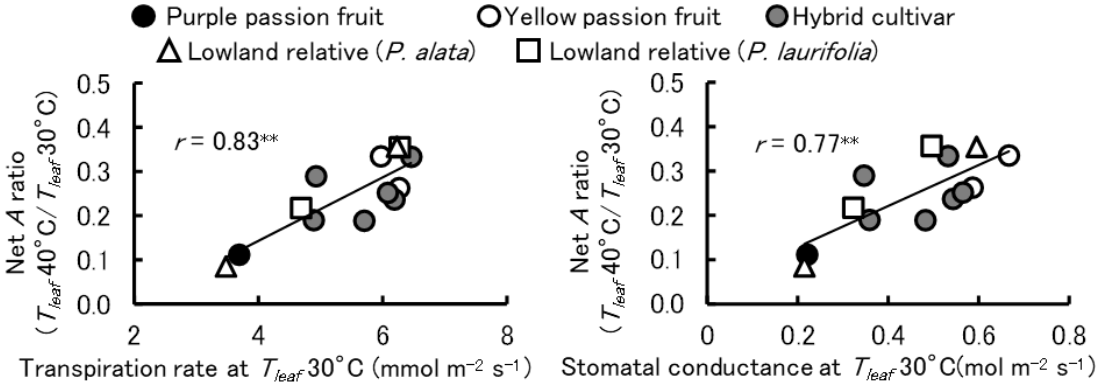

Fig. 3. Relationship between photosynthetic rate (*A*) reduction at high temperature and transpiration under non-stress condition at leaf temperature (T_{leaf}) of 30°C
** represents significant correlation at $p < 0.01$.

Table 1. Correlation coefficients between photosynthetic reduction and transpiration capacity and stomatal traits (excluding lowland relatives)

	Stomatal density		Stomatal size	
Net *A* ratio (T_{leaf} 35°C/ T_{leaf} 30°C)	− 0.76	**	0.43	NS
Net *A* ratio (T_{leaf} 40°C/ T_{leaf} 30°C)	− 0.55	NS	0.90	**
Net *A* ratio (T_{leaf} 45°C/ T_{leaf} 30°C)	− 0.60	NS	0.82	**
Transpiration rate at T_{leaf} 30°C	− 0.67	*	0.79	**
Stomatal conductance at T_{leaf} 30°C	− 0.59	NS	0.88	**

* and ** indicate significant correlation at $p < 0.05$ and $p < 0.01$, respectively. NS means no significance.

Reference: Matsuda and Takaragawa (2023) *The Horticulture Journal* 92: 412–423.