Association between stomatal conductance and yield in *Phaseolus vulgaris* and *Phaseolus coccineus*

Mario Gutiérrez Rodríguez, José Alberto Escalante Estrada

Programa de Botánica, Colegio de Postgraduados. Carretera México-Texcoco Km. 36.5, 56230, Montecillo, México. México

Introduction

Diffusion of CO_2 into the mesophyll of leaves and water vapour from the leave to the atmosphere is mainly driven by the stomatal aperture. Higher photosynthetic rates could in turn favor a high biomass and crop yield, and higher stomatal conductance appears to favor higher yields (Taiz & Zeiger, 2002). The selection of genotypes with high gas exchange may provide the development of bean (*Phaseolus vulgaris*) lines with high yield (Bressan-Smith & Pereira, 2003). The objective of the present work was to determine stomatal conductance and transpiration rate in different genotypes of *Phaseolus vulgaris* L. and *Phaseolus coccineus* L. grown under field conditions.

Material and methods

The study was carried out in Montecillo, Mexico (19°19' N, 98°54' W, 2250 m of altitude) during rainy season (June-September, 2004) and with a temperate climate. Seeds of thirteen genotypes of *Phaseolus vulgaris* L. (Bayo-18, Bayomex, Canario-107, Flor de Durazno, Flor de Mayo, Negro 98, Morito, Ojo de Cabra, Peruano, Pinto, Pinto Cabaña, Promesa, and Zacatecas) and three genotypes of *Phaseolus coccineus* L. (Ayocote blanco, Ayocote Morado, and Ayocote Negro) were sown in a soil with a pH of 6.8-7.5 and an electro-conductivity of 2-5 dS m^{-1}. The design was a random block with four replications, and a plant density of 6.25 plants m^{-2}. All the plots were fertilized with 100-100-00 NPK. Measurements of stomatal conductance, transpiration rate and leaf temperature were taken using a portable steady-state porometer Model LI-1600 (Licor Instruments, Nebraska) at pod filling stage (85 days after the sowing). Seed yield, biomass and other yield components were measured at physiological maturity

Results and discussion

The *P. vulgaris* genotypes showed a lower seed yield and biomass than the *P. coccineus* genotypes (Table 1). The *P. coccineus* genotypes had a bigger size than did *P. vulgaris* genotypes. As a result of the size *P. coccineus* had a higher seed weight, height, raceme number, and pod number. In contrast, *P. vulgaris* genotypes showed a higher seed number per pod with a low weight.

Table 1. Average of seed yield, biomass and other yield components measured at physiological maturity in genotypes of *Phaseolus vulgaris* and *Phaseolus coccineus* grown under field conditions. Montecillo, México.

	Seed yield ($g\ m^{-2}$)	Biomass ($g\ m^{-2}$)	100 seeds (g)	Height (cm)	Racimes m^{-2}	Pods m^{-2}	Seeds pod^{-1}
Phaseolus vulgaris	206.2 b†	393.5 b	38.6 b	52.8 b	185.0 b	203.8 b	3.6 a
Phaseolus coccineus	579.9 a¶	1568.8 a	182.3 a	137.3 a	252.5 a	341.3 a	2.5 b

†Different letters indicate statistical significant differences (Tukey, $p \leq 0.05$).

Instead of the low stomatal conductance and transpiration rate of *P. coccineus* genotypes, they had a high yield than *P. vulgaris* genotypes (Table 1, 2). Leaf temperature was decreased with a high stomatal conductance value as happened with *P. vulgaris* genotypes. Evapotranspiration at the leaf surface lowers leaf temperature, and higher stomatal conductance enhances this leaf cooling (Taiz & Zeiger, 2002).

Table 2. Average of stomatal conductance, transpiration rate and leaf temperature measured during the pod filling stage (85 days after the sowing) in genotypes of *Phaseolus vulgaris* and *Phaseolus coccineus* grown under field conditions. Montecillo, México.

	Stomatal conductance (mmoles m^{-2} s^{-1})	Transpiration rate (mmoles H_2Om^{-2} s^{-1})	Leaf temperature (°C)
Phaseolus vulgaris	239.1 a	6.9 a	25.5 b
Phaseolus coccineus	149.1 b	4.6 b	26.4 a

Table 3. Correlation coefficients and significance between gas exchange and yield measured during pod filling stage in *Phaseolus vulgaris* and *Phaseolus coccines* genotypes grown under field conditions. Montecillo, México

	Stomatal conductance	Transpiration rate
Phaseolus vulgaris		
Seed yield	0.59*	0.63*
Biomass	0.40	0.45
Phaseolus coccineus		
Seed yield	0.88	0.82
Biomass	0.99**	0.98*

*Correlation coefficient significant at the 0.05 level of probability.
**Significance level 0.01.

When stomatal conductance and transpiration rate were associated with seed yield and biomass in each species, the results indicated a high relationship (Table 3). The *P. coccineus* genotypes with a higher stomatal conductance than *P. vulgaris* genotypes showed a stronger correlation. Recent studies of this type focusing on historical series of bread wheat (*Triticum aestivum*) have shown a remarkable positive correlation between yield increases and increases in stomatal conductance (Fisher *et al.*, 1998).

Conclusions

In conclusion, stomatal conductance was associated with biomass and seed yield in *P. vulgaris* and *P. coccineus* genotypes.

Literatura cited

Bressan-Smith R., Pereira M.G.. 2003. Inheritance analysis of photosynthetic characteristics in bean (*Phaseolus vulgaris* L.). *Physiology and Molecular Biology of Plants* 9: 249-253.

Fischer R.A., Rees D., Sayre K.D., Lu Z.M., Condon A.G., Larqué-Saavedra A. 1998. Wheat yield progress associated with higher stomatal conductance and photosynthetic rate, and cooler canopies. *Crop Science* 38, 1467-1475.

Taiz. L., E. Zeiger. 2002. *Plant Physiology*. Sinauer Associates, Sunderland MA.