

CO₂ assimilation in young *Prosopis* plants

M. Pinto

Departamento de Producción Agrícola, Facultad de Ciencias Agrarias y Forestales, Universidad de Chile, Casilla 1004, Santiago, Chile

Introduction

Prosopis trees (Leguminosae) are widely distributed in the dry regions of North and South America. Their biomass and fruit production which can be very large (Pinto and Riveros, 1989), and their N₂-fixing ability (Felker and Clark, 1980) are important characteristics to be considered within forestation programs.

At present, water economy of most important *Prosopis* species is well known (Mooney *et al.*, 1982; Acevedo *et al.*, 1985a; Aravena and Acevedo, 1985) but data on the CO₂ assimilation by any single species of *Prosopis* are lacking. According to Acevedo *et al.*, (1985b), *Prosopis tamarugo* is a C3 plant and the net assimilation rates of other *Prosopis* species could be similar to that of some mediterranean fruit trees (Wilson *et al.*, 1974; Hanson, 1982; Mooney *et al.*, 1982). In old *Prosopis* trees, this assimilation could display large variations (Wilson *et al.*, 1974) and in some cases assimilation rates could be too low to support fruit growth. This has been suggested as one reason for the observed occasional premature fall of fruits (Salvo, 1986). *Prosopis* shows important variations in net CO₂

assimilation during the season (Mooney *et al.*, 1982). Due to the genetic variation of these trees (Hunziker *et al.*, 1975), it is possible to find differences between individuals. The objective of this work was to determine net CO₂ assimilation rates, under different light intensities and CO₂ levels, in provenances of Chilean Algarrobo (*Prosopis chilensis*) which exhibited different rates of growth and to compare them with those of *P. tamarugo* and *P. juliflora* at different temperatures.

Materials and Methods

CO₂ assimilation rates (*A*) were measured on *P. chilensis* under different light intensities with 350 ppm CO₂ in ambient air and under different CO₂ concentrations at light saturation, on 18 mo old plants of *P. chilensis*. Plants from 8 provenances with high growth rates and 9 with low growth rates were cultivated in 15 l plastic bags with a mixture of organic and sandy soil (1:1, pH 6.5). One plant per provenance was selected for measurements. Two, which developed leaves 20 cm from the apex on the main stem, were selected and CO₂ assimilation rates measured in a Parkinson chamber (Parkinson *et al.*, 1980) connected to an infrared gas analyzer (ADC, LCA-2). Temperature in the chamber was 20°C. The different CO₂ concentrations

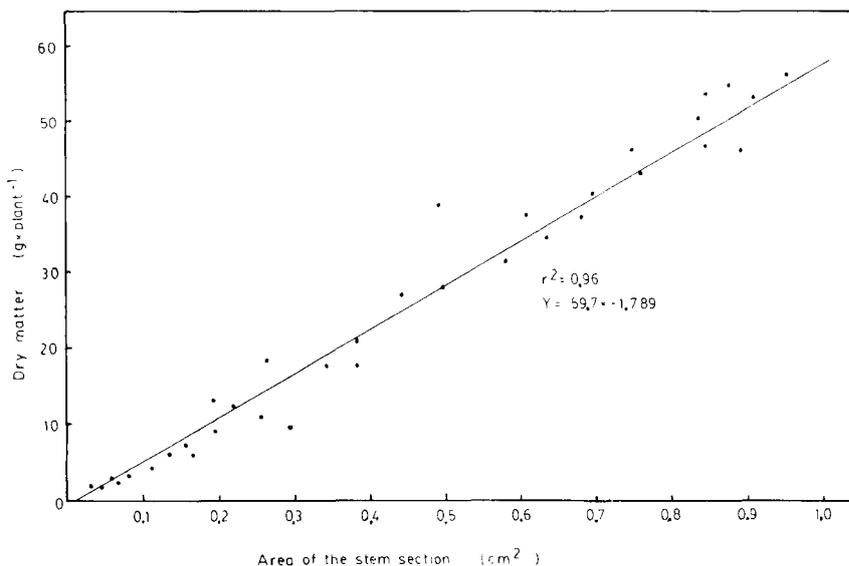


Fig. 1. Regression established in young *Prosopis* plants between the area of stem section, measured 10 cm above the ground, and total dry matter.

Table I. Biomass production, leaf area and chlorophyll content in different provenances of Chilean Algarrobo (*Prosopis chilensis*).

Provenances	Biomass (g·pt ⁻¹)	Leaf area (m ² ·pt ⁻¹)	Chlorophyll (a + b) (% fwt)
High growth rate (8 replicates)	45.7 a	775.0 a	0.18 a
Low growth rate	12.2 b	336.0 b	0.17 a

Means followed by the same letters are not different ($P \leq 0.05$).

were obtained by a gas diluter (ADC, 6D-600) and the different light intensities using plastic nets between the lamp (Hg 400 W General Electric) and the assimilation chamber.

A measurements at different air temperatures were made at light saturation, with 350 ppm CO₂. In this case, one provenance of each *P. chilensis*, *P. tamarugo* and *P. juliflora* was selected and 4 plants per provenance were used for measurements. Leaf area was determined by photographic prints and chlorophyll (a + b) content from 500 g of fresh leaves per plant according to MacKenney (1941). Aerial biomass was estimated by measuring the area of the stem section of the plant. A significant cor-

relation ($r = 0.98$; $P \leq 0.05$) between area of stem section, measured 10 cm above the ground, and total dry matter per plant was established with plants of the same age from different provenances (Fig. 1).

Results

The aerial biomass accumulation during the 18 mo period by the selected Algarrobo provenances is shown in Table I. Differences between both types of plants

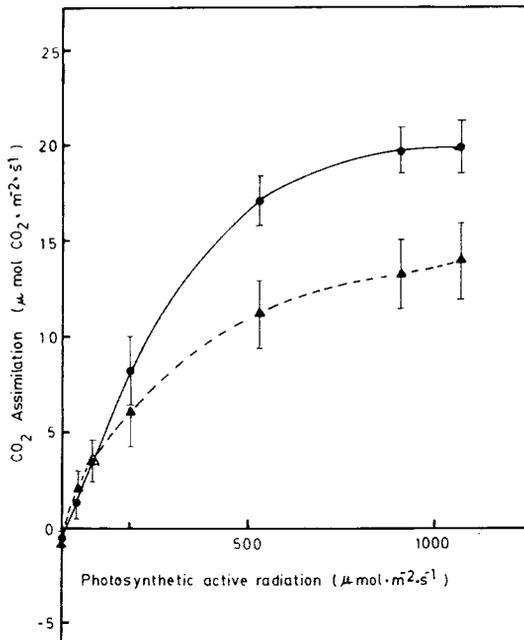


Fig. 2. CO₂ assimilation rate of *P. chilensis* provenances with high (●) and low (▲) growth rates under different light intensities. Air temperature: 20°C and CO₂ concentration: 350 ppm. Bars indicate mean and confidence interval from 8 or 9 replicates.

were considerable. High growth provenances also had a significantly greater leaf area than those with low growth rates. In these plants, this area was distributed in 4 or 5 branches, whereas in low growth provenances it was distributed only in one stem. The chlorophyll content was similar in both types of plants.

A was very different between both types of plants under different light and CO₂ levels. High growth provenances had a maximal *A* 43% higher than those with low growth rates. However, at low light intensities, the apparent quantum yield was similar in both types of plants (Fig. 2). Plants with high growth rates also presented higher *A* at all CO₂ levels (Fig. 3). Differences in the compensation point and CO₂ evolution in CO₂-free air were also

detected. The carboxylation efficiency (Ku and Edwards, 1977) was $5.6 \times 10^{-2} \text{ mol} \cdot \text{ppm}^{-1} \text{ CO}_2$ in plants with high growth, 22% higher than those with low growth which had $4.6 \times 10^{-2} \text{ mol} \cdot \text{ppm}^{-1} \text{ CO}_2$.

A values for young plants of *P. chilensis*, *P. tamarugo* and *P. juliflora* presented a maximum value between 20 and 35°C. In *P. tamarugo*, *A* was significantly lower than in the other species (Fig. 4).

Discussion

Maximal CO₂ assimilation rates (*A*) observed here on *Prosopis* plants are similar to those of other mediterranean C₃ species (Mooney *et al.*, 1982). *A* values in CO₂-free air suggest that some prov-

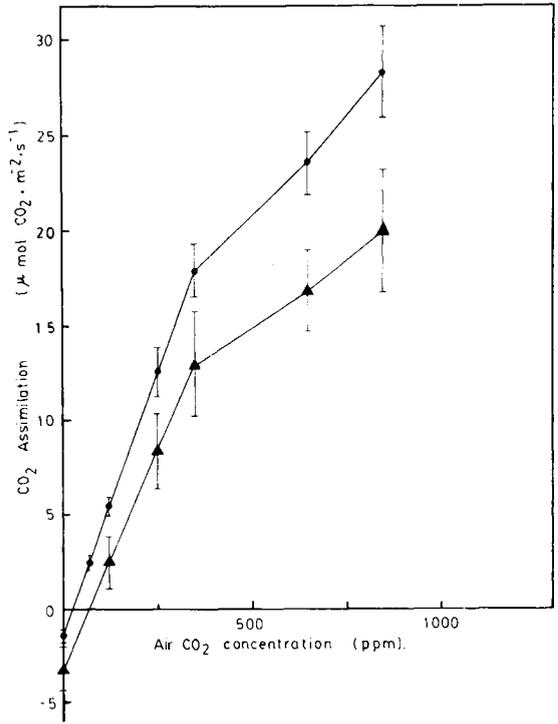


Fig. 3. CO₂ assimilation rate of *P. chilensis* provenances with high (●) and low (▲) growth rates under different CO₂ concentrations. Air temperature: 20°C and light saturation conditions. Bars indicate mean and confidence interval from 8 or 9 replicates.

enances may have important photorespiration rates.

Differences observed in *A* rates between the provenances, in this case, may not be related to differences observed in aerial biomass accumulation. Net CO₂ assimilation rate per unit leaf area is not always related to biomass production and other factors may be more important (Gifford and Jenkins, 1982; Walker and Sivak, 1986). Provenances with high growth rates had many branches and a greater leaf area development than those with low growth rates.

Differences in *A* observed here confirm that it is possible, due to the great genetic variability of *Prosopis* trees, to find photosynthetic differences between individuals.

Optimal temperatures for net CO₂ assimilation by young *Prosopis* plants were similar in all studied species, in spite of the differences in the ecological conditions of their habitats. However, *P. tamarugo*, which comes from the driest region of Chile, had the lowest assimilation rates. Studies of stomatal conductance and other leaf processes will be necessary to explain these differences.

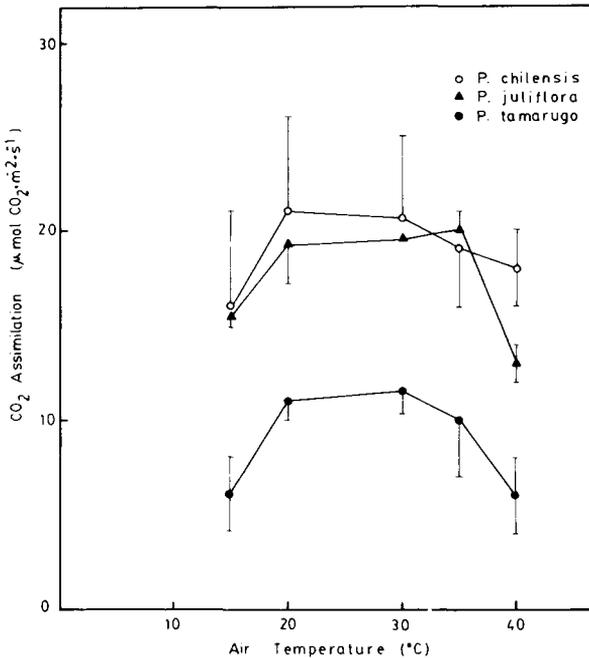


Fig. 4. CO₂ assimilation rates of 3 *Prosopis* species under varying temperatures. CO₂ concentration: 350 ppm and light saturation conditions. Bars indicate mean and confidence intervals from 4 replicates.

Acknowledgments

This work was supported by a grant from the International Foundation for Science, Sweden.

References

- Acevedo E., Sotomayor D. & Zenteno D. (1985a) Parametros hidricos de tejidos foliares en *Prosopis tamarugo* Phil. In: *Estado actual del conocimiento sobre Prosopis tamarugo*. (Habit M., ed.), FAO, U. de Tarapaca, CONAF, Chile, pp. 271-277
- Acevedo E., Sotomayor D. & Zenteno V. (1985b) Antecedentes sobre mecanismo de fijacion de CO₂ en *Prosopis tamarugo* Phil. In: *Estado actual del conocimiento sobre Prosopis tamarugo* (Habit M., eds.), FAO, U. de Tarapaca, CONAF, Chile, pp. 279-287
- Aravena R. & Acevedo E. (1985) Estudio de la relation hidrica de *Prosopis tamarugo* mediante isotopos estables, oxigeno-18 y deuterio. In: *Estado actual del conocimiento sobre Prosopis tamarugo*. (Habit M., ed.), FAO, U. de Tarapaca, CONAF, Chile, pp. 263-269
- Felker P. & Clark P.R. (1980) Nitrogen fixation (acetylene reduction) and cross inoculation in 12 *Prosopis* (mesquite) species. *Plant Soil* 57, 177-186
- Gifford R.M. & Jenkins C.L.D. (1982) Prospects of applying knowledge of photosynthesis toward improving crop production. In: *Photosynthesis Vol. II Development, Carbon Metabolism, and Plant Production* (Godvindjee, ed.), Academic Press, London, pp. 419-457
- Hanson J.D. (1982) Effect of light, temperature and water stress on net photosynthesis in two populations of honey mesquite. *J. Range Manage* 35, 455-458
- Hunziker J.H., Poggio L.A., Naranjo C.A., Palacios R.A. & Andrada B.A. (1975) Cytogenetics of some species and natural hybrids in *Prosopis* (Leguminosae). *Can. J. Genet. Cytol.* 17, 253-262
- Ku S.B. & Edwards G. (1977) Oxygen inhibition of photosynthesis. II. Kinetic characteristics as

affected by temperature. *Plant Physiol.* 59, 991-999

Mackenney G. (1941) Absorption of light by chlorophyll solutions. *J. Biol. Chem.* 140, 315-322

Mooney M.A., Simpson B. & Solbrig O.T. (1982) Mesquite. In: *Mesquite US/IBS. Synthesis Series H.* B. Simpson Stroudsburg, PA, pp. 259

Parkinson K.J., Day W. & Leach J.E. (1980) A portable system for measuring the photosynthesis and transpiration of gramineous leaves. *J. Exp. Bot.* 31, 1441-1453

Pinto M. & Riveros E. (1989) Variation of fruit production and quality of different exotypes of

Chilean Algarrobo tree (*Prosopis chilensis* (Mol) Stuntz). In: *New Crops for Food and Industry.* (Wickens G.E., Haq N. & Day P., eds.), Chapman and Hall, London, pp. 280-287

Salvo B. (1986) Estudio de la floracion y desarrollo de los frutos de algarrobo (*Prosopis chilensis* (Mol.) Stuntz). Thesis, Universidad de Chile, Santiago, Chile

Walker D. & Sivak M. (1986) Improving photosynthesis by genetic means. *Span* 29, 47-49

Wilson R.T., Krieg D.R. & Dhal B.E. (1974) A physiological study of developing pods and leaves of honey mesquite. *J. Range Manag.* 27, 202-203