PHYSIOLOGICAL RESPONSES TO SHADE AND DROUGHT IN YOUNG WILLOW PLANTS

GUARNASCHELLI, A.B.[1], GARAU, A.M.[1], CACCIA, F.D.[1] and S.C. CORTIZO[2,3]

[1] Dep. of Vegetal Production and [2] Dep. of Applied Biology, Faculty of Agronomy, University of Buenos Aires, Buenos Aires, ARGENTINA
[3] E.E.A. Delta del Paraná. INTA. Buenos Aires, ARGENTINA.

INTRODUCTION

- ✓ The Paraná River Delta of Argentina is one of the largest regions in the world with willow plantations.
- ✓ These short-rotation species are planted mainly for pulp and particleboard industries.
- ✓ Plantations are mostly established in the inner and lowest areas of the islands, characterized by the presence of abundant and tall vegetation, called “pajonal”.
- ✓ The pajonal represents an important source of competition for light, water and nutrients, and constitutes one of the main impediments for willow establishment.

- ✓ Plants can adjust their physiological and morphological attributes under conditions of resource deficits (Schlichting 1986) .
- ✓ Such adjustments would facilitate plants acclimation to the new environmental conditions, improving competitiveness and productivity
- ✓ However, the challenge is how plants face multiple deficit conditions. Some authors indicate that there is a trade-off between the capacity to tolerate simultaneously drought conditions and shade conditions (Smith y Huston 1989).
- ✓ Since, there is scarce information about physiological plasticity in willows,
- ✓ And about how the adjustment in physiological attributes will facilitate plants acclimation, as well as their capacity to tolerate weed competition

OBJECTIVE

- To assess the effects of multiple resource deficits on physiological responses of young willow plants growing under a controlled experiment of different combinations of water and light availability.

MATERIALS AND METHODS

- In September 2005, cuttings of *Salix matsudana* × *Salix alba* cv. 'A 13/44' were planted in 15l containers, filled with organic soil.

- In mid November 2005, we established a factorial design with THREE LEVELS OF LIGHT AVAILABILITY:

  - Full sunlight (FS)
  - Moderate shade (MSh)
  - Severe shade (SSh)

  (Repreesenting 100%, 25% and 10% of full sunlight respectively), and

  TWO WATER REGIMES:

  - Without water restriction (W+)
  - With water restriction (W-)

  (W+ plants were irrigated daily and W- plants were submitted to an increased water restriction treatment)

Measurements

In five to six plants per treatment:

- Plant water potential at pre dawn (Ψ_{pd}) and at midday (Ψ_{mid}) were measured with a pressure chamber (PMS 1000, PMS Instruments Co., Corvallis, OR), following standard procedures .
- Stomatal conductance (g_s) was measured at noon with a steady-state porometer (LI 1600, Li-Cor Inc., Lincoln, NB).

After 45-days:

- Plant water relation parameters were estimated through pressure-volume (P-V) curve analysis. The repeat pressurization method was used to generate the curves (Hinckley et al. 1980).

Data Analysis

- The effects of light levels (3) and water regimes (2) with five to six replications were assessed by two-way ANOVA.
- When significant, means were separated by Tukey´s test.
- Statistical analysis were performed with SAS statistical package (SAS Institute, Cary, NC, 1987).

RESULTS

- From the beginning of December 2005 drought reduced Ψ_{pd} significantly at all levels of light ($p<0.007$). These differences were maintained until the end of the experiment, showing all W- plants similar values ($p<0.001$) (Figure 1 A).

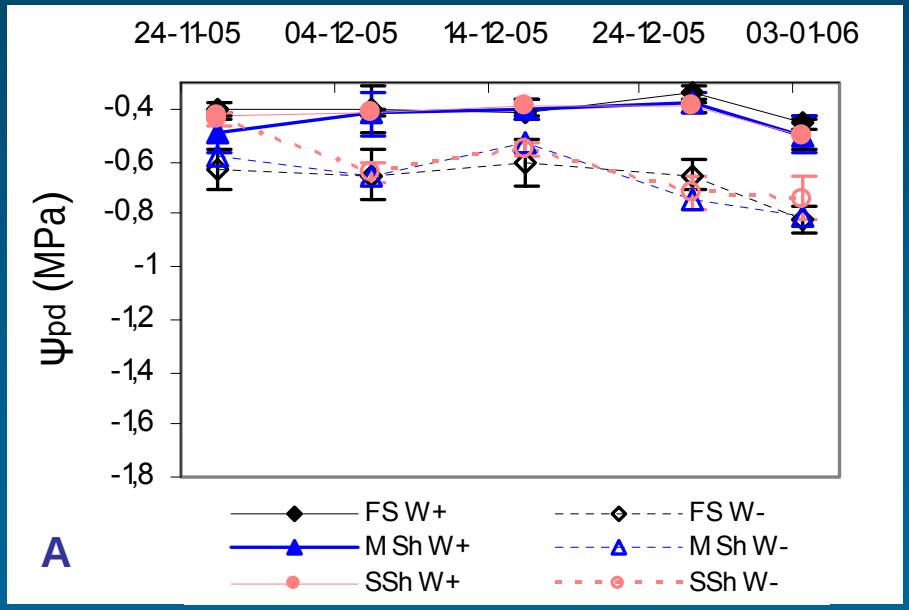

Figure 1 A

- Initially SSh plants had higher values of Ψ_{mid} than FS and MSh plants ($p<0.001$); drought had no significant effect. Later on, Ψ_{mid} decreased in W- plants ($p<0.001$); at the same time Ψ_{mid} was significantly higher ($p=0.011$) as the level of irradiance decreased (Figure 1 B).

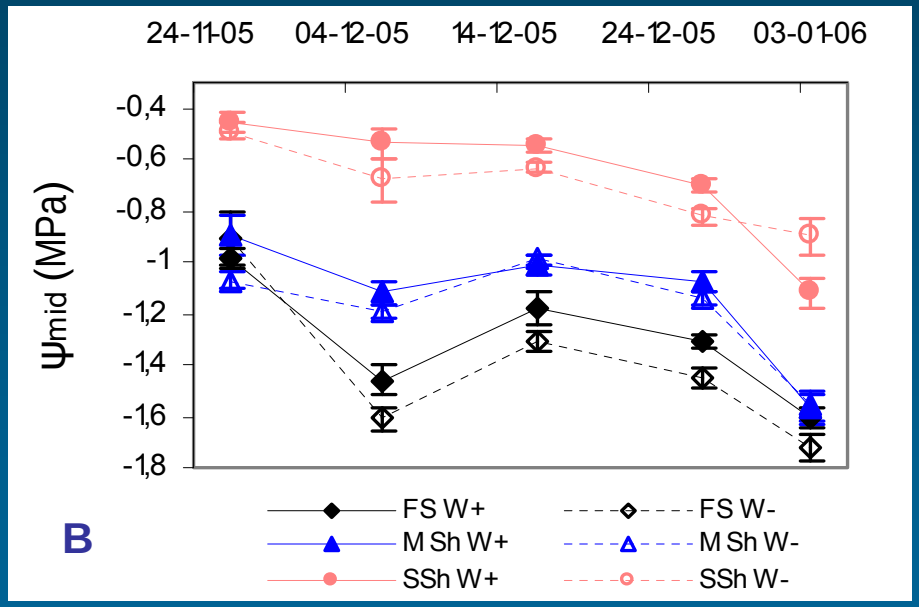

Figure 1 B

- Water stress decreased g_s in FS and MSh plants, without a significant reduction in SSh plants (p<0.001). In the last two measurements g_s was similarly reduced in W- plants at all levels of light availability (p<0.001) (Figure 2).

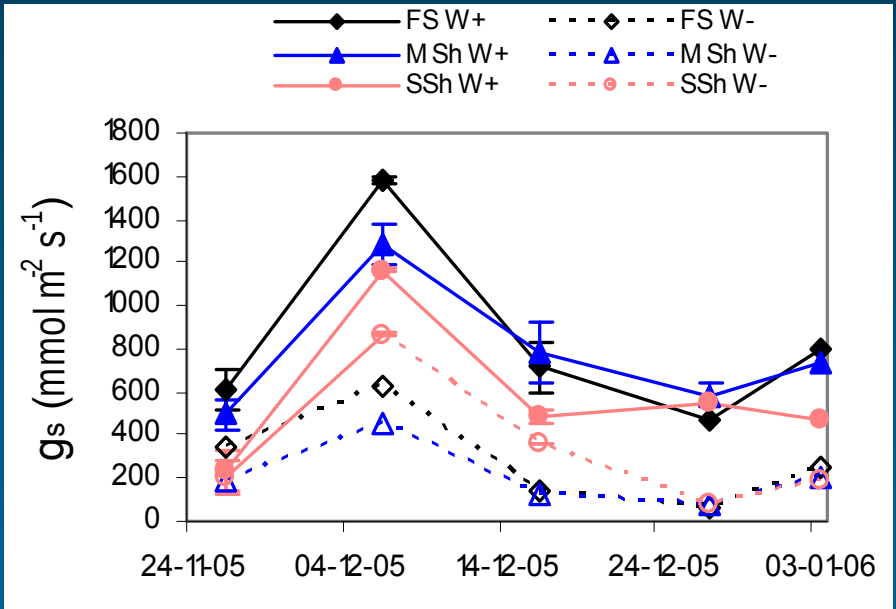

Figure 2

- **P-V analysis showed that most of tissue water parameters were significantly modified by the resource restriction.**

Source of Variation	$\Psi_{\pi 100}$ *p*	$\Psi_{\pi 0}$ *p*	ξ_{max} *p*	Ψ_{p100} *p*
WR	<0.001	0.001	0.082	0.002
LL	0.003	<0.001	ns	0.024
WR x LL	0.043	ns	ns	ns

WR: Water regimes, LL: Light levels. $\Psi\pi_{100}$: osmotic potential at full turgor, $\Psi\pi_0$: osmotic potential at turgor loss point , ξmax: maximum bulk modulus of elasticity, Ψp_{100} : maximum pressure potential

- **Drought reduced osmotic potential at full turgor ($\Psi_{\pi 100}$), being the interaction significant.**
- **Osmotic adjustment (AO) was 0.42 MPa in MSh plants (Figure 3 A).**

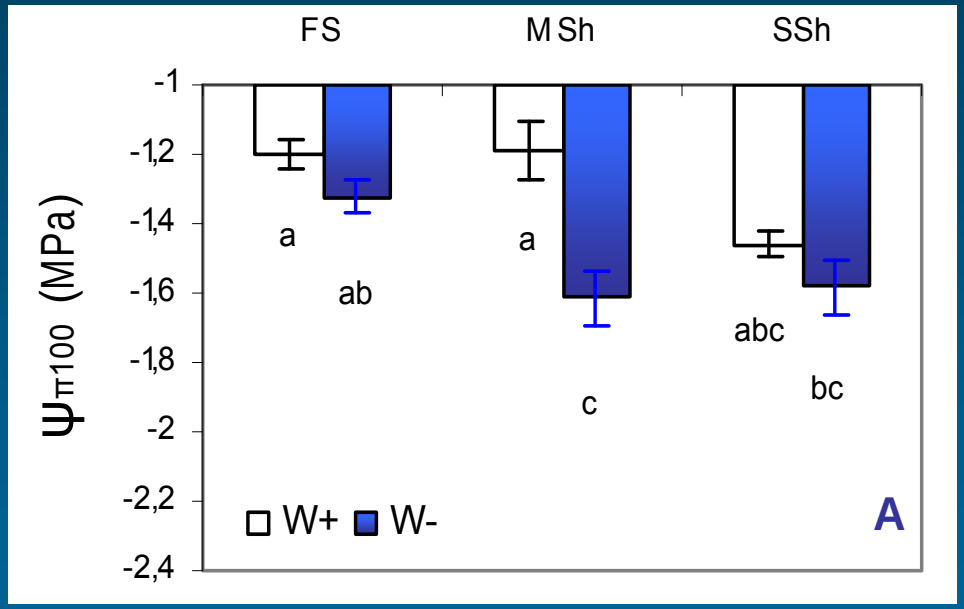

Figure 3 A

- **The maximum bulk modulus of elasticity (ξ_{max}) tended to increase with drought, but no changes were observed among light levels (Figure 4 A).**

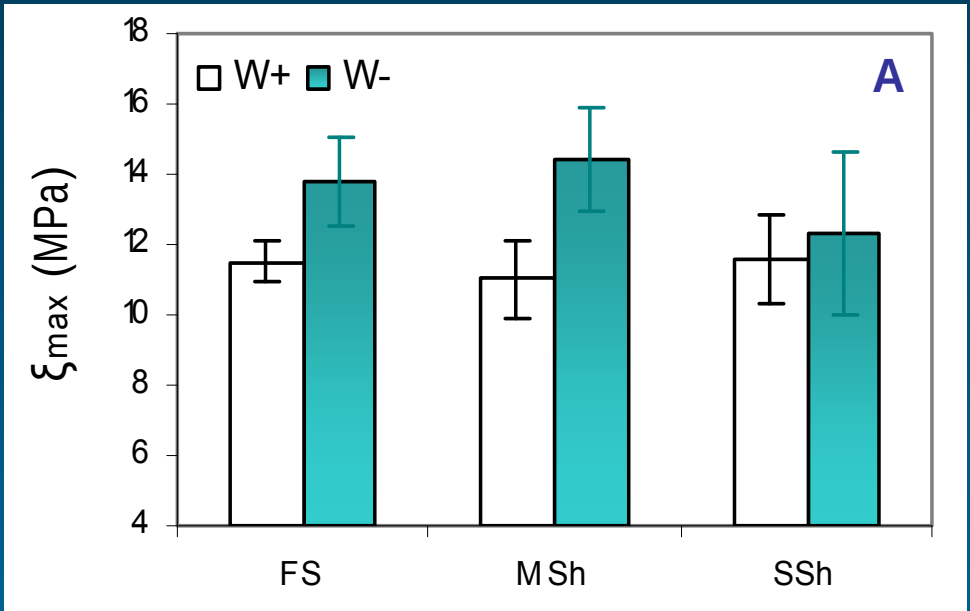

Figure 4 A

- **Osmotic potential at turgor loss point ($\Psi_{\pi 0}$) decreased with drought, but also due to shade, with lower values in MSh and SSh plants (Figure 3 B).**

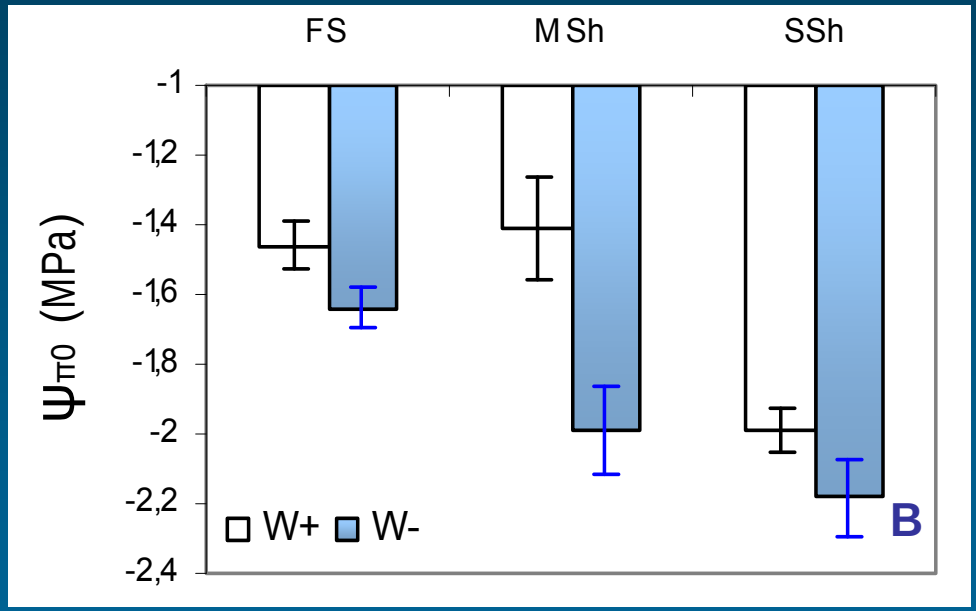

Figure 3 B

- **Water restriction increased pressure potential at full turgor (Ψ_{p100},), especially under MSh conditions; in addition SSh plants showed significantly higher Ψ_{p100} than those growing under FS conditions (Figure 4 B).**

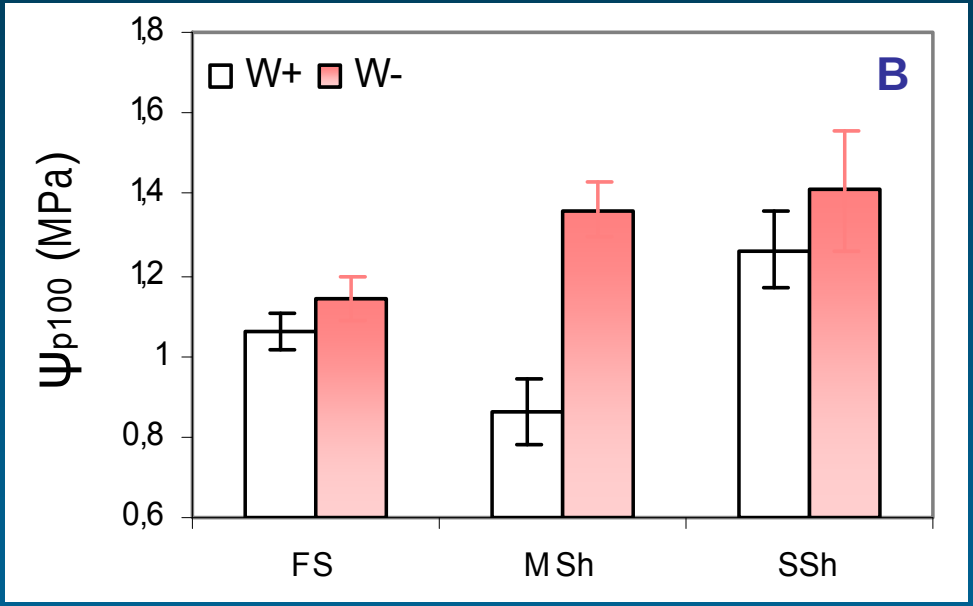

Figure 4 B

DISCUSSION

- ✓ Water stress and light restriction modified most of physiological parameters. Some of these responses could be associated with mechanisms of acclimation to resource deficits.
- ✓ Stomatal conductance and water potential decreased with drought but in general less intensively under shade, which means that shade alleviated the effects of drought.
- ✓ Osmotic adjustment, mechanism generally associated with drought tolerance under sunny environments, was triggered also under shade, helping plants turgor maintenance.
- ✓ This would imply that, although it has been hypothesized that plants cannot tolerate the combined effects of drought and shade, this clone had the ability to cope with drought in shaded conditions.

- ✓Our results show that the physiological adjustments detected in clone ‘A 13/44’ would allow the resource acquisition under stressful conditions imposed in the present experiment.
- ✓ Under field conditions weeds exert competition for both belowground and aboveground resources.
- ✓We suggest that the diverse strategies of acclimation to drought and shade detected in this study, could also be triggered under multiple stress conditions generated by the competition of the vegetation presented in the “pajonales” of the Paraná Delta.
- ✓Field experimental data would allow to confirm this hypothesis and would also permit to adapt vegetation management techniques during the establishment of willow clones.

Thanks Very much !