Universidad Autónoma de Nuevo León (UANL)
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Acclimatation of Co-occurring Tree Species to Water Stress and their Role as Site-indicators in Mixed Pine-oak Forests in Northeast Mexico

Introduction

Mixed pine-oak of the eastern Sierra Madre, Mexico, are exposed to extreme climatic conditions of high temperatures and low precipitation distributed irregularly through the year (Fig.1).

Under field conditions, soil water availability is one of the major limiting factors in plant growth and affects most physiological processes in these ecosystems.

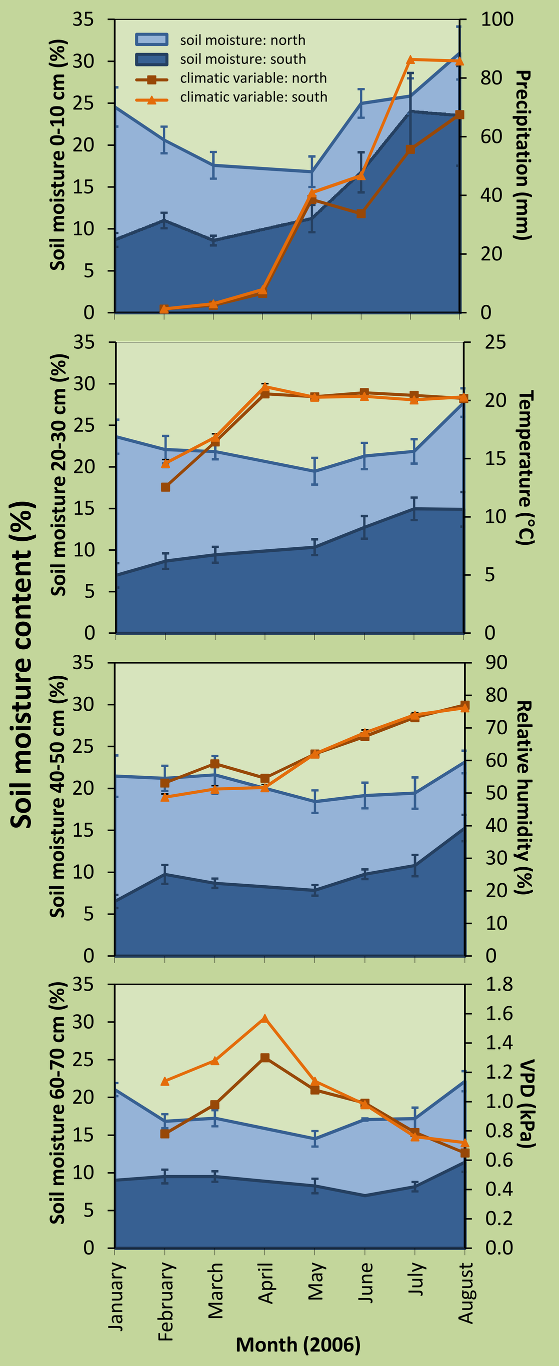

Fig.1:Seasonal variation in mean air temperature (°C), relative humidity (%), vapour pressure deficit (VPD; kPa), actual precipitation (mm) and mean soil moisture (%) at four soil profile depths (n=5) during the study period from February until August 2006;bars represent standard errors.

Objective

The main objective was to understand the functional features of mixed pine-oak forest species in relation to principal limiting factors, water scarcity and salt excess, and to determine or rather distinguish the physiological capacities of several common native tree species.

Vegetation at the closed, north-facing stand Plot-N (a) and at the open fragmented stand Plot-S (b).

Leaf water potential measurements taken with a Scholander pressure chamber (Model 3005, Soil Moisture Equipment Corp., Santa Barbara, CA, USA).

Sample collection and conservation in the field for Ψ_s measurement.

Osmotic potential measurement using a Wescor HR 33T (Wescor Inc., Logan, UT) automatic scanning dew point microvoltmeter with three sample chambers (Wescor C-52).

Methods

Leaf water (Ψ_w) and osmotic potentials (Ψ_s) of *Juniperus flaccida, Pinus pseudostrobus* and *Quercus canbyi* were measured under drought and non-drought conditions under two different aspects, North- and South-Plot, in the Sierra Madre Oriental. Furthermore, climatic variables and soil moisture content were registered simultaneously.

Results

In general, all species showed high predawn and low midday values that declined progressively with increasing drought and soil-water loss. Seasonal and diurnal fluctuation of Ψ_w and Ψ_s were higher for *J. flaccida* and *Q. canbyi* than for *P.pseudostrobus* (Fig.2 and Fig.3).

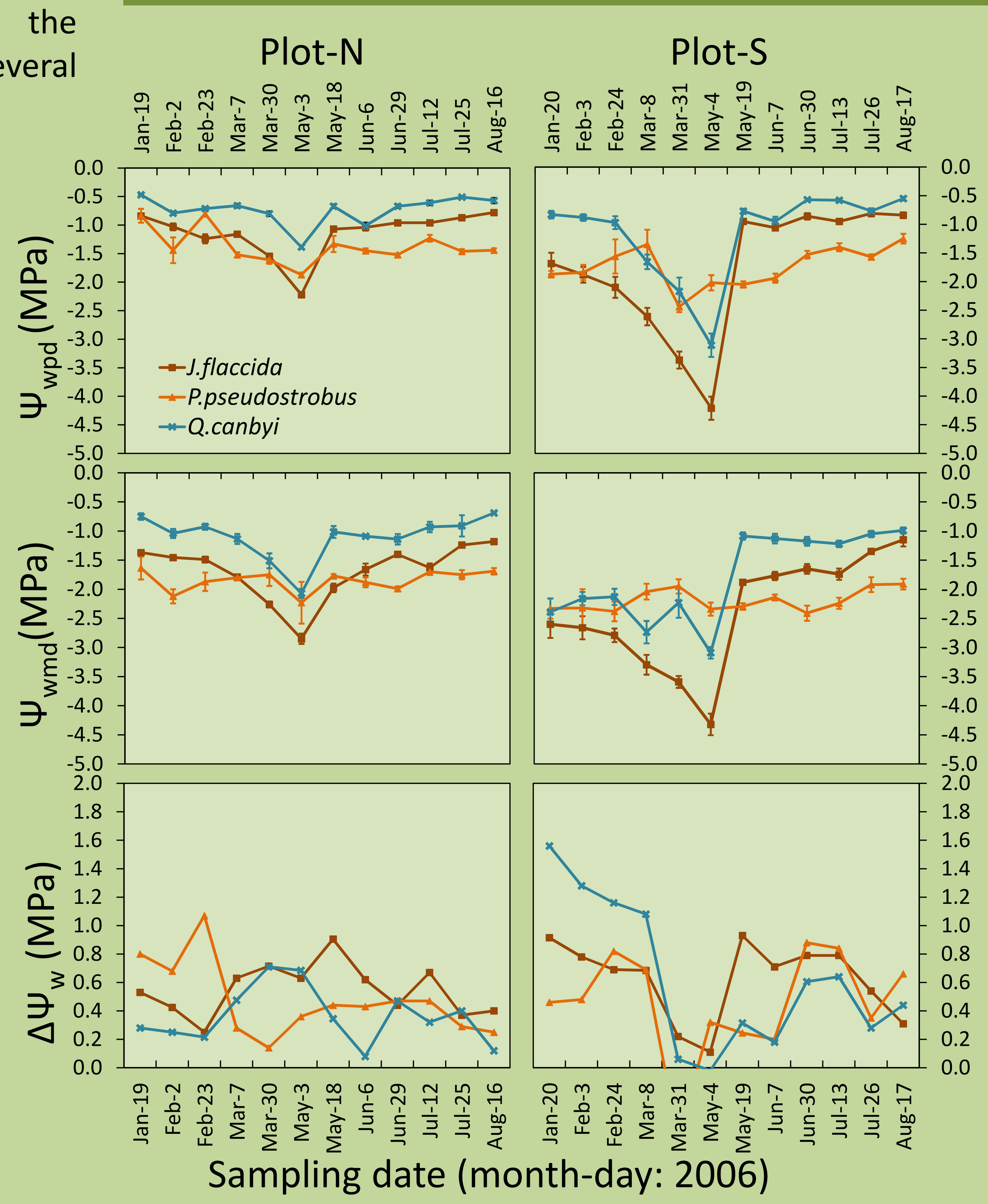

Fig.2: Seasonal variation in predawn (Ψ_{wpd}) and midday (Ψ_{wmd}) water potential as well as the difference between midday and predawn ($\Delta\Psi_w$) leaf water potential in three tree species at two different aspects, Norht (Plot-N) and South (Plot-S); values are means (n=5), bars represent standard error.)

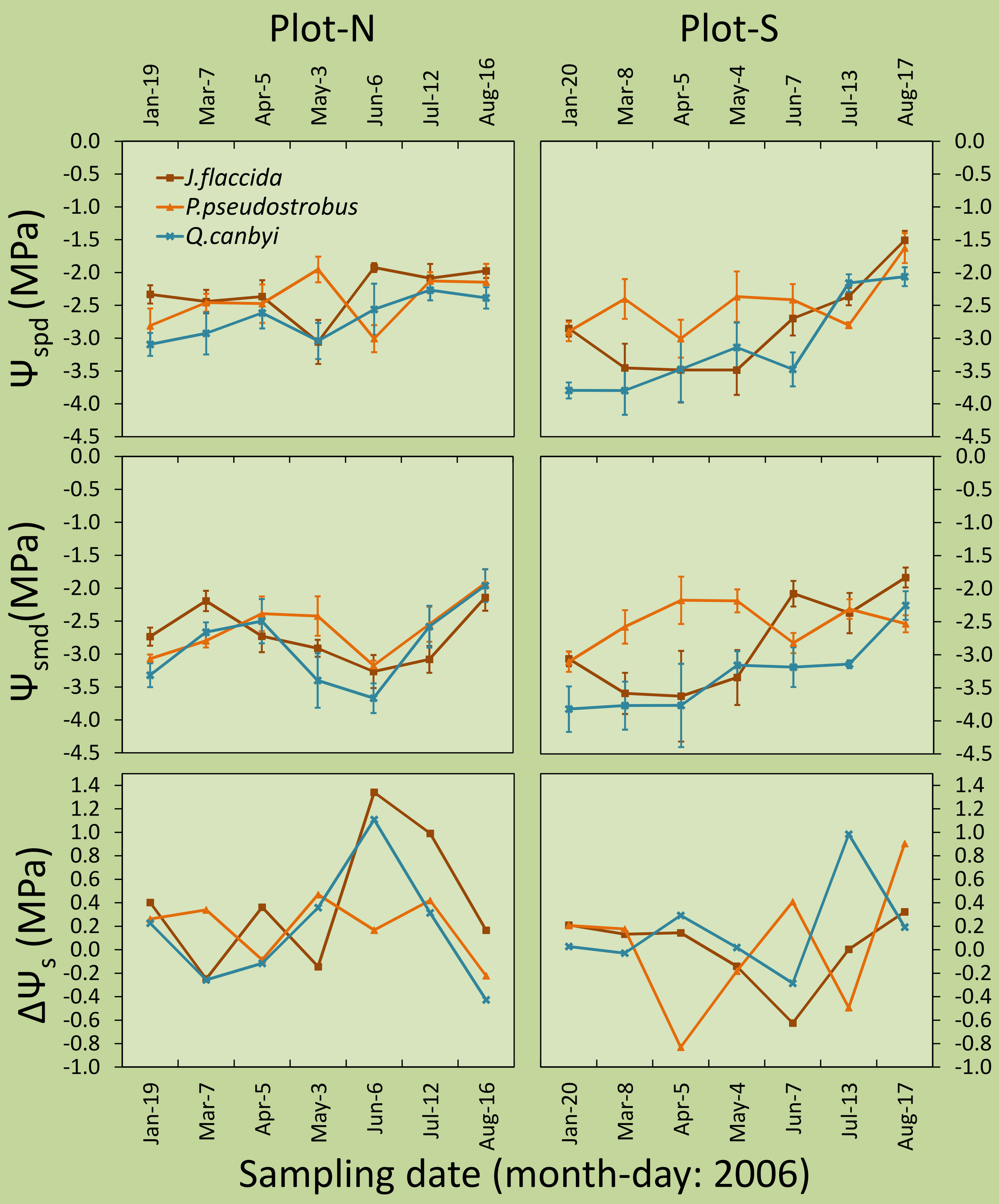

Fig.3: Seasonal variation in predawn (Ψ_{spd}) and midday (Ψ_{smd}) osmotic potential in three tree species at two different aspects, Norht (Plot-N) and South (Plot-S); values are means (n=5), bars represent standard error.)

Table 1: Results of the three-way ANOVA with species (between-subject), aspect (between-subject) and sampling date (within-subject) as factors, degrees of freedom (df) and coefficient of determination (r^2). The F-value, proportion of the explained variance (SS_x/SST_c) and the level of significance (NS, P>0.05; *P<0.05; **P<0.01; ***P<0.001) for each factor and the interaction are indicated. [a] In the case of soil moisture, the factor "species" is replaced by "soil depth"; [b] Smpling date

Source of variation	Ψ_{wpd}			Ψ_{wmd}		Ψ_{spd}			Ψ_{smd}		Soilmoisture		
	df	*F*	SS_x/SST_c	*F*	SS_x/SST_c	df	*F*	SS_x/SST_c	*F*	SS_x/SST_c	df	*F*	SSx/SSTc
Species(1)	2	137.9	13.8***	76.7	14.7***	2	9.3	6.5***	11.3	7.3***	2	1.9	1.8 NS
Aspect	1	210.4	10.5***	164.1	15.7***	1	14.9	5.2***	3.0	1.0NS	1	86.7	38.3*
Aspect*Species	2	6.8	0.7**	6.9	1.3**	2	2.3	1.6NS	2.9	1.9NS	2	9.1	0.9***
SD(2)	11	144.3	38.4***	77.8	30.7***	6	14.9	22.2***	9.9	17.2***	10	4.5	13.9**
Species*SD	22	22.7	12.1***	16.9	13.3***	12	3.4	10.2***	2.1	7.3*	20	6.1	5.9***
Aspect*SD	11	39.8	10.6***	19.4	7.7***	6	4.0	5.9***	4.8	8.4***	10	6.3	3.3***
Aspect*Species*SD	22	12.0	6.4***	6.1	4.8***	12	1.5	4.3NS	2.1	7.4*	20	0.3	0.9 NS
Total	359					209							
ANOVA r^2 (adj.)			0.913		0.871			0.483		0.393			0.555

Factorial ANOVA revealed significant differences in (Ψ_w) and (Ψ_s) between two aspects, species and sampling dates (Table 1).

Leaf Ψ_w and Ψ_s , especially of J. flaccida and Q. canbyi, were mainly correlated with soil water content, while Ψ_s of *P. pseudostrobus* were hardly correlated with environmental variables (Table 2).

Table 2: Spearman's correlation coefficient values (*rho*) for predawn potentials (PD) and diurnal depression (DD) of leaf water- (observed data of both plots; *n* = 2 aspect x 3 species x 5 replications x 11 sd = 330) and osmotic potential (observed data of both plots; *n* = 2 aspect x 3 species x 5 replications x 6 sd = 180) in relation to mean soil water content at four depths (SWC), daily mean air temperature, daily mean relative humidity (RH) and daily mean vapour pressure deficit (VPD) and monthly sum of precipitation in three tree species (data of the sampling dates were used for the calculation of daily means). Due to missing meteorological data in January, the first sampling date was not included in the correlation analysis. Level of significance (p > 0.05, NS; p < 0.05, *; p < 0.01, **; p < 0.001, ***) for each variable

Environmental variable	Water potential at predawn (PD) and diurnal depression (DD)						Osmotic potential at predawn (PD) and diurnal depression (DD)					
	J. flaccida		*P. pseudostrobus*		*Q. canbyi*		*J. flaccida*		*P. pseudostrobus*		*Q. canbyi*	
	PD	DD	PD	DD	PD	DD	PD	DD	PD	DD	PD	DD
SWC: 0-10 cm	**0.79*** **	0.14NS	**0.53*** **	-0.14NS	**0.71*** **	**0.35*** **	**0.70*** **	-0.15NS	0.10NS	-0.05NS	**0.66*** **	-0.08NS
SWC: 20-30 cm	**0.48*** **	0.17NS	**0.44*** **	0.01NS	**0.53*** **	**0.40*** **	**0.54*** **	-0.09NS	0.09NS	-0.13NS	**0.39** **	0.14NS
SWC: 40-50 cm	**0.40*** **	0.07NS	**0.38*** **	0.03NS	**0.45*** **	**0.30** **	**0.52*** **	-0.08NS	0.06NS	-0.10NS	**0.34* **	0.17NS
SWC: 60-70 cm	**0.21* **	0.15NS	**0.35*** **	0.08NS	**0.25* **	**0.24* **	**0.50*** **	-0.20NS	0.12NS	-0.15NS	**0.31* **	0.19NS
Temperature	**0.25** **	0.13NS	-0.08 NS	**0.24* **	0.14 NS	**0.31** **	**0.37** **	**-0.26* **	-0.02NS	0.07NS	**0.35** **	-0.06NS
RH	**0.42*** **	**0.24* **	**0.32*** **	**-0.21* **	**0.38*** **	0.07NS	**0.42*** **	-0.13NS	0.24NS	-0.09NS	**0.50*** **	-0.11NS
VPD	**-0.31*** **	**-0.22* **	**-0.41*** **	**0.29** **	**-0.33*** **	-0.02NS	-0.21 NS	0.11NS	-0.12NS	-0.06NS	**-0.30* **	0.11NS
Precipitation	**0.53*** **	-0.05NS	-0.04 NS	0.03NS	**0.30** **	**0.24* **	0.23 NS	0.07NS	0.20NS	-0.01NS	**0.35** **	-0.14NS

Conclusion

Thus, species showed different strategies to withstand drought. *P. pseudostrobus* was identified as a species with isohydric water status regulation, while *J. flaccida* and *Q.canbyi* presented water potential patterns typical for anisohydric species. Isohydric behaviour is of advantage during severe but short periods of drought, while anisohydric water status regulation is favourable during long-term drought conditions of minor intensity. Detailed knowledge about the type of water status regulation may be a critical factor for plant survival and mortality in the context of climate change.

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