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Water Relations in Plants Dominating Phryganic Ecosystems*

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Abstract. The water potential and the osmotic potential in plants which dominate Greek phryganic ecosystems (*Phlomis fruticosa, Sarcopoterium spinosum, Cistus* sp.) were measured from April to Nowember. Water potential decreased considerably reaching a minimum in September. Higher values of osmotic potential than that of water potential were found during dry period (*i.e.* negative values of pressure potential). This interesting fact was confirmed by artificial desiccation.

Mediterranean climatic regions are characterized by wet and mild winters contrasting to dry and hot summers. So, the plants dominating these areas must be capable of surviving during the dry and hot summers.

Among the already known adaptation is seasonal dimorphism (ORSHAN 1972) which is the main adaptive strategy of the plants dominating phryganic ecosystems (synonyms: tomillares — Spain, batha — Israel, gariga — Italy, coastal sage — USA). Because of the seasonal dimorphism phryganic species reduce their transpiring mass during summer. Although the transpiring mass decreases to a 15% fraction (ORSHAN 1954) of the one encountered during the most favourable period (in most cases in mid spring), as the summer drought progresses soil moisture becomes less available to the plants, causing internal water stress. It is well known (HSIAO 1973) that many physiological processes (enzymatic activity, photosynthesis, growth *etc.*) are affected seriously by water stress.

Available data concerning water relations in plants dominating phryganic ecosystems cannot be considered as sufficient, especially for Greece no relevant work has been published. Therefore in this paper I study the water relations of *Phlomis fruticosa, Sarcopoterium spinosum* and *Cistus* sp., which dominate Greek phryganic ecosystems. As an indication of the plant water status I measured water potential which, according to SLATYER (1967) and KRAMER (1969), reflects very well the thermodynamic state of water within the plant, osmotic potential and water saturation deficit.

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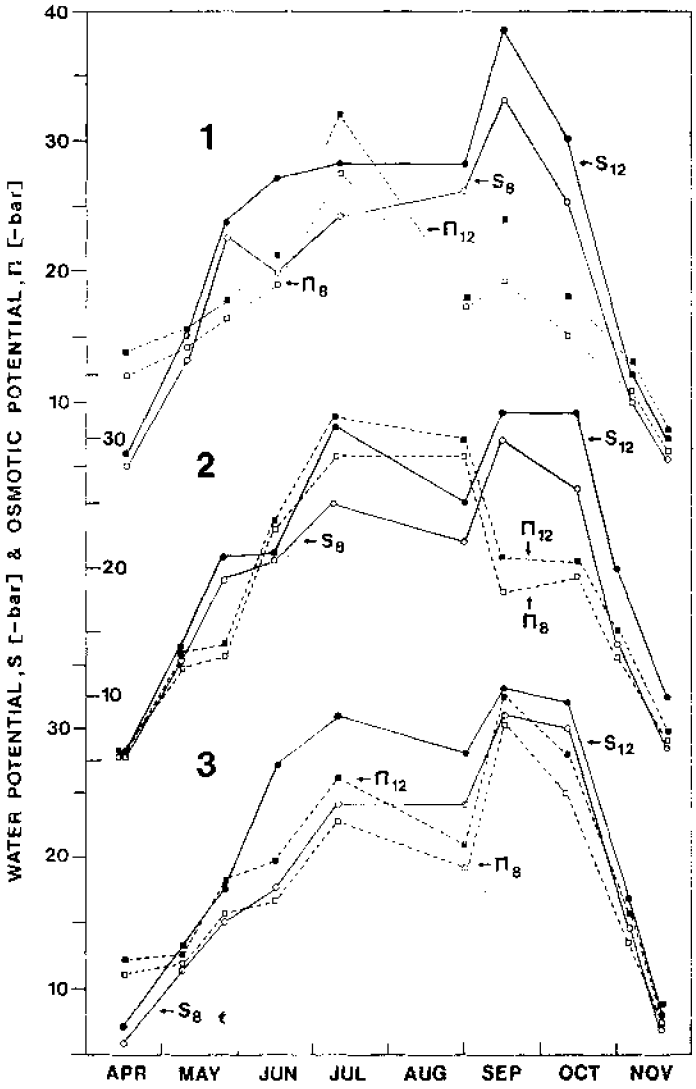
Materials and Methods

Area of Study

The study area was at a height of 400 m above sea level on Mt. Hymettus near Athens, about 2.5 km to the SW of the University campus. The soil is terra-rossa with a depth less than 25 cm. Mechanical analysis shows 31% sand, 37% silt and 32% clay. The rock content is about 50%, the pH 7.9 and the moisture holding capacity 55%.

The climate of the area belongs to the mediterranean type with a wet and



Figs. 1 to 3. Water potential, S, and osmotic potential, π, during the period from April to November in *Sarcopoterium spinosum* (Fig. 1), in *Phlomis fruticosa* (Fig. 2), and in *Cistus* sp. (Fig. 3).

mild winter contrasting to a hot and dry summer with very high evaporation rates (Table 1).

Three woody species characteristic of the sub-shrub were studied: *Phlomis fruticosa* L., *Sarcopoterium spinosum* (*Poterium spinosum* L.) and *Cistus* sp. They were selected because their abundance made it possible to sample them easily.

Water Potential

was determined by the "equilibrium with osmotic solutions" method according to SHARDAKOV (1948), as described by SLAVÍK (1974).

Osmotic Potential

was determined by cryoscopy. The cell sap was extracted according to KOZINKA (1960) by adding 0.5 ml chloroform to 10—15 g fresh weight of the samples and storing in air-tight bottles for 24 h at 0 °C. Loss of semipermeability forces cell sap to run out from a hypodermic syringe when a small pressure is applied.

Water Saturation Deficit

was calculated from (STOCKER 1928, SLAVÍK 1974):

$$\mathrm{WSD} = \frac{\text{saturated weight} - \text{initial (fresh) weight}}{\text{saturated weight} - \text{dry weight}} \times 100 .$$

TABLE 1
Some climatic characteristics of Athens

	Air temperature [°C]		
	Maximum*	Minimum*	Mean**
January	12.2	5.9	9.0
February	13.2	6.2	9.5
March	15.7	8.0	11.5
April	19.8	11.1	15.2
May	24.7	15.4	19.7
June	29.3	19.6	24.1
July	32.5	22.5	27.2
August	32.2	22.4	27.0
September	28.6	19.2	23.4
October	23.5	15.5	19.0
November	18.0	11.4	14.6
December	14.0	7.9	11.0
Annual average	22.0	13.8	17.6
Annual total			

* Average for the years 1861—1950; ** average for the years 1901—1950; + year 1973.

Results and Discussion

Fig. 1 presents data on the changes in water potential and osmotic potential in the leaves of the plant *Sarcopoterium spinosum* during the period from April to November. The given values are means of at least 10 daily measurements, day by day, obtained at 08.00 h and at 12.00 h.

It must be noted that:

1. Water potential values at noon are lower (by 1 to 7 bar) as compared with the morning ones.
2. As dry period progresses water potential values decrease considerably reaching a minimum (−44 bar) in the middle of September.
3. As far as concerns osmotic potential it is worth noting that during a dry period values measured are higher than water potential ones (*i.e.* negative pressure potential values). A similar situation has been observed by KYRIAKOPOULOS and LARCHER (1975) in leaves of *Quercus ilex* submitted to artificial desiccation.

Analogous information for the leaves of *Phlomis fruticosa* and *Cistus* sp. is given by Figs. 2 and 3, respectively. The remarks made on *Sarcopoterium spinosum* also apply here, the only difference being that water potential reaches values about 20% higher during the driest months. This might be attributed to the different leaf structure (higher mass per leaf area).

A comparison of my data with those reported for coastal sage species in California (POOLE and MILLER 1975) shows closer agreement with *Salvia* sp. (which attains a minimum water potential of −40 bar) and less close with *Artemisia* sp. (−65 bar). In addition a recent work from Spain (MERINO *et al.* 1976) presents values lower than mine.

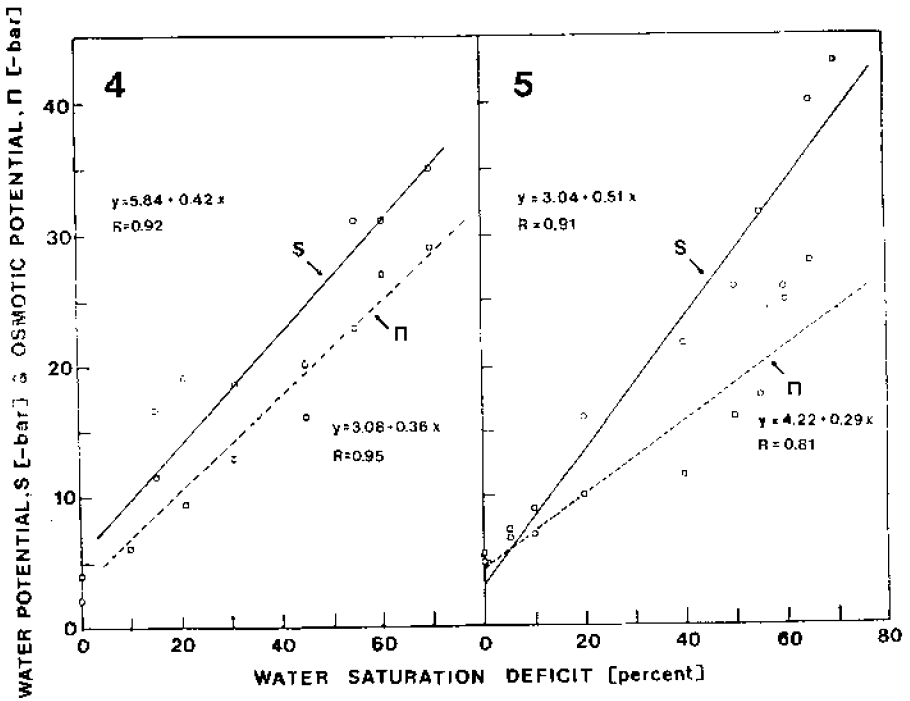
The interesting fact that pressure potential reaches negative values was

Rainfall		Evaporation		Total solar radiation*
mm*	% of total	mm**	% of total	[J cm^{-2}]
56.9	14.2	62.9	3.9	20.1
40.1	10.0	65.0	4.1	26.0
35.4	8.8	87.0	5.5	38.9
21.1	5.6	116.7	7.3	59.9
21.2	5.3	155.2	9.8	74.1
14.7	3.7	193.5	12.2	75.8
6.2	1.5	247.6	15.6	75.4
8.7	2.2	237.3	14.9	71.6
15.4	3.8	172.4	10.8	55.7
43.9	11.0	113.3	7.1	37.3
65.8	16.4	75.4	4.7	27.6
70.4	17.6	62.1	3.9	20.1
399.8		1588.4		582.4

1 bar = 10^5 Pa

tested in *Phlomis fruticosa* and *Cistus* sp. by the artificial method, as described by KYRIAKOPOULOS and LARCHER (1975) and according to which measurements of water potential and osmotic potential were taken at different levels of water saturation deficit (WSD).

The results obtained are shown in Figs. 4 and 5. A major observation is that water potential does not rise to zero when leaves are saturated with water but remains at a level of about −5 bar. Also, at relatively small WSD values negative pressure potential ones correspond. The conclusion is that my observations conform well with those of KYRIAKOPOULOS and LARCHER (1975).



Figs. 4 and 5. Cell-water relations in leaves of *Phlomis fruticosa* (Fig. 4) and of *Cistus* sp. (Fig. 5) at increasing water saturation deficit.

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BOOK REVIEW

WARDLAW, I. F., PASSIOURA, J. B. (ed.): **Transport and Transfer Processes in Plants.** — Proceedings of a Symposium held in Canberra, Australia, December 1975. — Academic Press, New York—San Francisco—London 1976. 484 pp. £ 19.50.

The proceedings of a symposium in which 90 participant took part bring 39 papers (chapters) in three sections: Short Distance Transport, Long Distance Transport and Integrating Systems.

The introductory paper by Evans discusses the relation between transport and distribution in plants. In the short-distance-transport section papers on symplastic transport (Gunning and Robards), mass flow (Walker), cytoplasmic streaming (Williamson), transfer cells (O'Brien), movement from host to parasite (Jones), accumulation of starch (Jenner), uptake by roots (Pitman, Cram), symplasmic transport to the xylem (Läuchli), electrophysiology of roots (Anderson), model of potassium influx (Glass), potassium translocation (Dunlop and Tomkins), auxin transport (Newman and Sullivan), IAA lateral transport (Jarvis and Field), phloem loading (Geiger), transfer of sorbitol (Bieleski), metabolite transfer in C_4 plants (Hattersley, Watson and Osmond), transfer to guard cells (Raschke) are included.

Long-distance-transport papers deal with vascular pattern in higher plants (Zimmermann), histochemical approach in translocation (Fisher), P-protein in sieve tube elements (Dempsey, Bullivant and Bieleski), solutes recovered from xylem (Pate), movement of viruses (Helms and Wardlaw), stomatal behaviour and long distance transport (Allaway), water transport through plants (Kaufmann), translocation from source leaf (Christy and Swanson), translocation in leaves (Troughton), sink leaf diffusion equation (Passioura), and mathematical models of Münch pressure flow (Christy).

Papers on integrating systems of translocation were devoted to the control of water movement through plants (Passioura), assimilates partitioning (Wardlaw), distribution of assimilates and sink-source geometry (Cook and Evans), sink, stomatal physiology and photosynthesis (Kriedemann, Loveys, Possinghamand, Saton), transport of regulators in phloem and xylem (King), hormonal-directed transport of metabolites (Patrick), nutrient mobilisation and cycling (Pate), and remobilization of nutrients (Loneragad, Snowball and Robson). A short but stimulating discussion on integrating systems serves as Conclusion.

It was evidently an extremely interesting symposium and the publication of this very comprehensive book is meant to transfer up-to-date knowledge to those who could not take part in it.

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