Water Relations of Windbreak Trees under Desert Conditions

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With 6 Figures

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In the desert regions some windbreak trees grow successfully. These plants are used for protection of orchards, for the control of movement of sand dunes and for other purposes. Since these plants are cultivated in desert regions where the water supply is limited, it is of particular interest to study their water relations.

The present investigation comprises the study of the transpiration and osmotic pressure of the windbreaks planted in the desert region at Burg El Arab. The windbreaks included in the desert region are *Tamarix* sp., *Cupressus sempervirens, Casuarina equisetifolia* and *Acacia* saligna. This study is of prime importance for extending the plantation of these windbreaks in the proper sites according to their water economy.

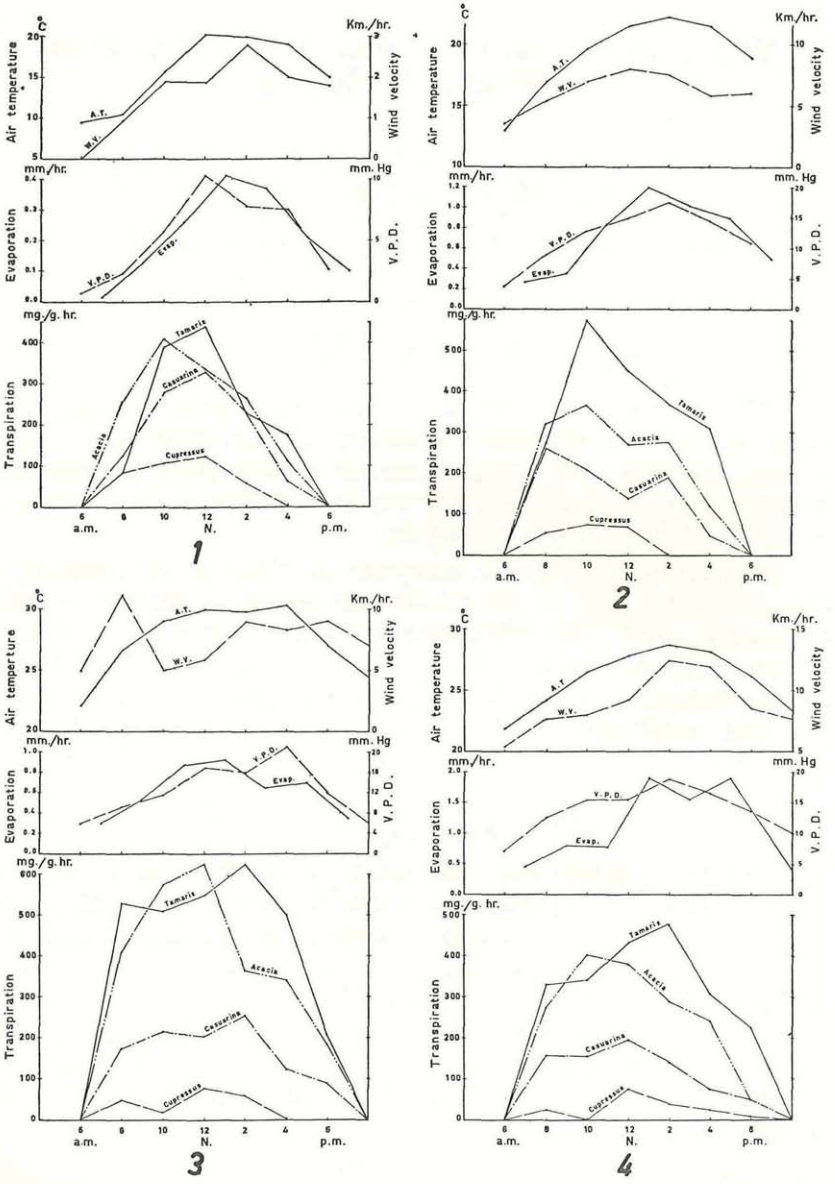
Transpiration

The transpiration rate was measured by the method of rapid weighing of detached parts. Measurements were taken monthly for a period of one year. The diurnal fluctuations of the transpiration rate of the different species in four months were taken as representatives of the different seasons, (Figs. 1, 2, 3 and 4).

The diurnal march of the transpiration rate exhibits three distinct levels in the different species. The highest level of transpiration rate was shown by *Tamarix* and *Acacia,* the median level by *Casuarina* and the lowest level by *Cupressus.*

In all the species, the transpiration rate was nearly nil before sunrise and after sunset in the different seasons. The maximum transpiration rate was attained early before the maximum of the evaporating factors of the atmosphere. The early attainment of the maximum

transpiration rate was reported by a number of investigations (HAMMOUDA 1954, MIGAHID & ABD EL RAHMAN 1953, ZOHARY 1961, STOCKER 1961 und ABD EL RAHMAN & BATANOUNY 1965 a).



Figs. 1—4: Daily march of the transpiration rate of windbreak trees and climatic factors — in January, 1961 (Fig. 1) — in March, 1961 (Fig. 2) — in June, 1961 (Fig. 3) — in September, 1961 (Fig. 4).

The maximum transpiration rate attained in January was 439 mg./g. h. in *Tamarix* sp., 408 in *Acacia*, 330 in *Casuarina* and 123 in *Cupressus* (Fig. 1). In March the maximum transpiration rate reached was 572 mg./g. h. in *Tamarix*, 365 in *Acacia*, 263 in *Casuarina* and 72 in *Cupressus* (Fig. 2). The highest transpiration rate attained in June was 626 mg./g. h. in *Tamarix*, 625 in *Acacia*, 257 in Casuarina and 78 in *Cupressus* (Fig. 3). In September the maximum transpiration rate was 478 mg./g. h. in *Tamarix*, 401 in *Acacia*, 194 in *Casuarina* and 76 in *Cupressus* (Fig. 4).

This comparison demonstrates the great difference in the transpiration intensity of the different species. This is confirmed by comparison of the mean, maximum and minimum transpiration intensity in the whole year (1961). Examination of Fig. 5 reveals that the transpiration intensity in *Tamarix* ranged between 93 and 245 mg./g. h. in the whole year with a mean of 160 mg./g. h. In *Acacia* it varied between 102 and 209 mg./g. h. with a mean of 139 mg. The transpiration intensity ranged between 46 and 89 mg./g. h. in *Casuarina* with a mean of 73 mg./g. h. In *Cupressus* the transpiration intensity fluctuated between 0 and 47 mg./g. h. with a mean of 18 mg.

It is evident from the above comparison that the mean transpiration intensity of *Tamarix* in the whole year was sightly higher than that of *Acacia*, more than double that of *Casuarina* and about 10 times that of *Cupressus*.

Osmotic Pressure

The osmotic pressure of plant sap is of utmost importance in the water economy of plants. WALTER 1955 stated that the osmotic value may serve as a very exact indicator of the water balance, and therefore the total water economy of the plants.

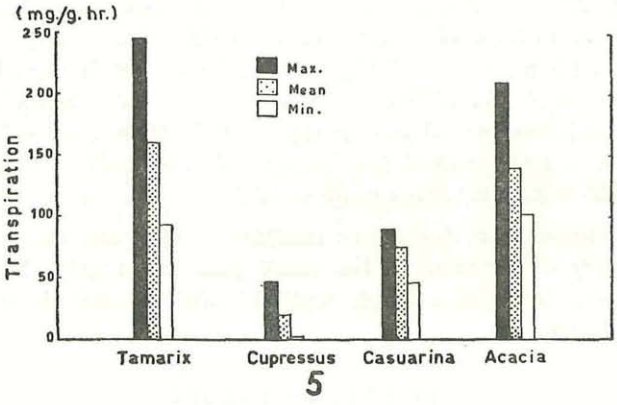
The osmotic pressure of plant sap was measured by using the cryoscopic method. Measurements were achieved in the different months covering the different seasons. The maximum, mean and minimum osmotic pressure of the plant sap of the different species recorded in the different seasons are illustrated in Fig. 6.

The highest osmotic pressure of 68.3 atm. was attained by *Tamarix*. This recorded value is comparable with that attained by the common halophytes inhabiting saline areas. This indicates the high salt tolerance in *Tamarix*. The maximum value recorded in *Cupressus* was 43.6 atm. Although this value was much less than that attained by *Tamarix*, yet it is higher than that recorded in many of the common xerophytes. The range of osmotic pressure of desert plants growing in different habitats, lies between 12.1 and 37.8 atm. as recorded by TADROS 1936, MIGAHID

& ABD EL RAHMAN 1953, MIGAHID & SHAFEI 1953 and ABD EL RAHMAN & BATANOUNY 1965 b.

The high osmotic pressure exhibited by *Cupressus* is a good criterion for the ability of the plant to withdraw water from a soil poor in moisture content. SLATYER 1957 stated that the osmotic pressure of the plant leaves is fundamentally the factor determining the point at which permanent wilting occurs.

The maximum osmotic pressure reached in *Casuarina* was 31.1 atm. This value is comparable with those recorded in many of the common xerophytes. The lowest maximum value of 21.6 atm. was recorded in *Acacia*.



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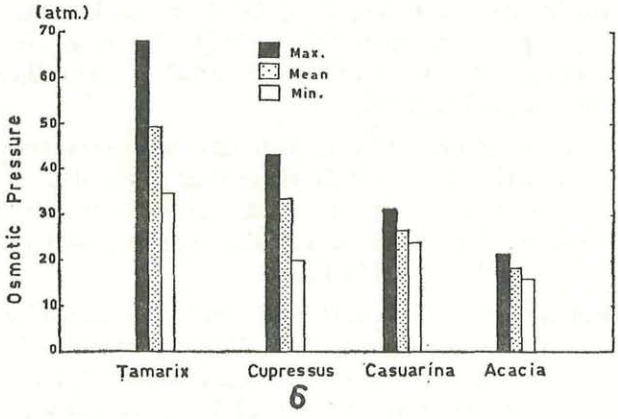

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Fig. 5: Comparison of the maximum, mean and minimum transpiration intensity of the different species of windbreak trees.

Fig. 6: Comparison of the maximum, mean and minimum osmotic pressure of the different windbreak trees.

General Discussion

From the above results it is evident that *Cupressus* has extremely low transpiration intensity which is even lower than that of the common xerophytes living under extremely arid conditions. Moreover it has a fairly high osmotic pressure which enables the plant to withdraw water from a soil with low moisture content.

Casuarina comes next to *Cupressus* in its water economy. It has a higher transpiration intensity and a lower osmotic pressure. But still the transpiration intensity and osmotic pressure of *Casuarina* are comparable with those of the common xerophytes.

It is convenient to plant *Cupressus* and *Casuarina* in desert regions with limited rainfall since they are drought resistant plants. They are proper windbreaks which can be used for the protection of orchards in the desert regions.

Tamarix has a very high osmotic pressure up to 68 atm. It is a highly salt accumulating plant. ABD EL RAHMAN 1965 reported that the partial osmotic pressure of chlorides in *Tamarix* constitutes about 47% of the total osmotic pressure. The degree of salt accumulation in *Tamarix* is higher than in many of the common halophytes inhabiting saline areas.

The extremely high osmotic pressure displayed by *Tamarix* enables it to grow successfully in wet saline areas which are widely distributed in the lowlands of the desert regions, extending along the Mediterranean littoral west of Alexandria. The lowlands are catchment areas where the rain water accumulates by runoff. A huge amount of water is lost through percolation in the saline soil of the lowlands. One cannot benefit from the water accumulating in these saline areas since the crops and fruit trees cannot stand the high osmotic pressure of the soil solution.

The osmotic pressure of *Tamarix* is comparable with that of the common halophytes spreading in the salt marshes. Thus it can grow successfully under such conditions of high salinity. When the *Tamarix* plants grow they act in trapping the drifted sand in the lowland. Consequently the salt crust at the surface will be covered by the drifted sand, and the land level will rise and become somewhat far from the water table, a condition which prevents capillary rise and accumulation of salts at the surface. Thus in the course of time, the new accumulated soil will become suitable for cultivation of shallaw rooted plants as barley, since it receives enough water from higher surrounding areas and in the meantime the new soil is not saline.

Also the wood of *Tamarix* trees can be used as a fuel by the bedouins inhabiting the desert regions.

It is advisable not to grow *Acacia saligna* in desert regions with limited rainfall, since it has a relatively high transpiration intensity as compared with the other windbreaks, It can be planted on sand dunes

where rain water is stored. Since *Acacia* trees carry many leaves with broad surface, they provide a complete cover on the soil surface. Thus *Acacia saligna* can be used as a proper plant for the control of movement of sand dunes.

Summary

The present investigation comprises the study of the water relations of some windbreaks namely *Tamarix* sp., *Cupressus sempervirens, Casuarina equisetifolia* and *Acacia saligna* growing in the desert region at Bug El Arab. The transpiration intensity varies widely in the different species. The mean annual transpiration intensity was 160 mg/g. h. in *Tamarix,* 139 mg. in *Acacia,* 46 mg. in *Casuarina* and 18 mg. in *Cupressus.* The maximum osmotic pressure which determines the ability of the plant to absorb water from the soil exhibits a wide variation among the different species. It reached 68.3 atm. in *Tamarix,* 43.6 atm. in *Cupressus,* 31.1 atm. in *Casuarina* and 21.6 atm. in *Acaria.*

In the light of the results obtained concerning the water economy of the studied species, it is advisable to plant the drought resistant trees namely *Cupressus* and *Casuarina* as windbreaks protecting the orchard plantations in the desert regions. *Tamarix,* being a highly salt tolerant species can be grown in saline areas found in lowlands distributed in the desert region along the Mediterranean Littoral west of Alexandria. The growing plants act in trapping the drifted sand which covers the salt crust at the soil surface. The new accumulating soil which receives runoff water is favourable for plantations of fruit trees and crops. *Acacia saligna,* with its broad leaves providing a complete cover over the soil surface is a proper tree for the control of movement of sand dunes.

References

Abd El Rahman A. A. 1966. Salt accumulation and its effect on the osmotic pressure of plants. — Bull. Fac. Sci. Cairo Univ., 40: 73—86.

— & Batanouny K. H. 1965 a. Transpiration of Desert Plants under Natural Conditions in Wadi Hoff. U. A. R., — J. Bot. 7: 37—59.

— — 1965 b. Osmotic Pressure of Desert Plants under Different Environmental Conditions. U. A. R. — J. Bot. 7: 95—107.

Hammouda M. A. Studies in the water relations and transpiration of Egyptian desert plants. — Ph. D. Thesis, Fac. Sci. Cairo Univ.

Migahid A. M. & Abd El Rahman, A. A. 1953. Studies in the water economy of Egyptian desert plants. III. Observations on the drought resistance of desert plants. — Bull. Instit. Desert d'Egypte, 3 (1): 58—83.

— & El Shafel M. 1955. Osmotic pressure of plant sap, as related to salinity and water content of the soil. — Bull. Instit. Desert d'Egypte, 5 (1): 57—81.

Slatyer R. O. 1957. The significance of the permanent wilting percentage in studies of plant and soil water relations. — Bot. Rev. 23: 586—636.

STOCKER O. 1961. Contribution to the problem of drought resistance of plants. — Indian J. Plant Phys. 4 (2): 87—102.

TADROS T. M. 1936. Osmotic pressure of Egyptian desert plants in relation to their water supply. — Bull. Fac. Sci. Cairo Univ. 7: 1—35.

WALTER H. 1955. The water economy and hydrature of plants. — Ann. Rev. Plant Physiology: 239—252.

ZOHARY M. 1961. On hydro-ecological relations of the Near East desert vegetation. — UNESCO Arid Zone Research Proceed. Madrid Symposium: 199—212.