

Plant Response to Stress

Functional Analysis
in Mediterranean Ecosystems

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INTRODUCTION

A great part of the land surface of Greece (approximately 40%) is covered by natural mediterranean type ecosystems. In this area warm and dry summers alternate with mildly cold and wet winters (Aschmann 1973). Rainfall occurs primarily during the late autumn and early winter months. The period of greatest water availability coincides with the period of lowest temperatures. During the dry summer season, temperature are highest and relative humidity is lowest which results in large summer water deficits. Evidence for adaptation to mediterranean climate conditions has been sought through study of both the morphology and the phenology of the mediterranean vegetation. Several phenological studies have been undertaken in mediterranean-type ecosystems of other parts of the world, e.g. California and Chile (Mooney *et al.* 1974; Hoffmann and Hoffmann 1976; Mooney and Kummerow 1977; Montenegro *et al.* 1979; Mooney and Kummerow 1981; Kummerow *et al.* 1981). In all these studies the phenological changes of the species (evergreen sclerophylls or drought-deciduous) have been found to change characteristically in response to seasonal environmental events in the native habitats.

Several studies on the structure and function of the mediterranean-type ecosystems of Greece were started during the last decade. Most of the information collected to date has dealt with phryganic ecosystems, in which seasonally dimorphic plants dominate. The ecology of the Greek maquis ecosystems, where the dominant plant species are evergreen sclerophylls, is less well known. Phenological study is one of the first steps in understanding the function of ecosystems. This is because phenological events reflect the way in which the species (and/or the system) exploit the so-called favourable periods in order to gain carbon and to allocate photosynthetic products for growth and reproduction. This paper reports results of phenological studies in Greek maquis ecosystems obtained during a two-year period in northern Greece.

SITE DESCRIPTION

The site used for this investigation is located in northern Greece, in Stavros-Halkidiki, close to the peninsula of Mount Athos. The site was chosen primarily because of the high density and cover of the species *Quercus coccifera* L. and

Arbutus unedo L., which are considered typical representatives of the evergreen sclerophyll vegetation in Greece. The plants occurred on a north-east facing slope on metamorphic rocks of biotitic gneiss and amphiboles. The slope was less than 10° at 100 m above sea level. Vegetation at the site has not burned for at least 20 to 25 years. No grazing or other human activities occur there at present. The dominant plant species based on biomass are *Quercus coccifera* L. (32%) and *Arbutus unedo* L. (15%). Other woody species occurring in the area are *Phillyrea media* L., *Erica arborea* L., *Quercus ilex* L. and *Cistus* sp.

FIELD PHENOLOGY METHODS

Detailed phenological observations were made between April 1981 and April 1983 at monthly intervals on randomly chosen *Quercus coccifera* and *Arbutus unedo* individuals. On each plant, one representative branch was labeled with a permanent nylon ribbon for the phenology census. Each branch was monitored throughout the year for the following.

- 1) Total number of leaves on the branch
- 2) Total length of the main branch and the lateral branches
- 3) Time of leaf emergence and leaf fall
- 4) Presence of flower buds, flowers, or fruits

RESULTS AND DISCUSSION

The characteristic seasonal changes in daily air temperature and rainfall at the site are shown for the two-year study period in Fig. 1. Temperature increased during the growing season (spring to early summer) along with photoperiod. Rainfall in general decreased by late spring. Occasional summer thunderstorms occurred during both 1981 and 1982. As far as seasonal fluctuations in factors which drive phenological events, such as light, water, and heat energy, are concerned, water availability is the most unpredictable. Incident radiation and, to a somewhat lesser extent, mean air temperature fluctuated with a fairly predictable seasonal pattern.

Plant phenological responses to the physical environment were not synchronous for the two species studied. This is assumed to occur because the species utilize resources differently in this multispecies community. *Quercus coccifera* flowers in spring and *Arbutus unedo* flowers from October to early spring (April or March). In *Arbutus unedo* flower bud differentiation occurred almost 12 months before flowering (Fig. 2, lower part). These buds remained on the branches from October 1981 until the flowers formed in October 1982. In *Q. coccifera*, the flower buds differentiated between October and March. Development continued on through anthesis during a 4 to 5 month period in spring and early summer. The timing of flowering in *A. unedo* in the fall may depend on time of

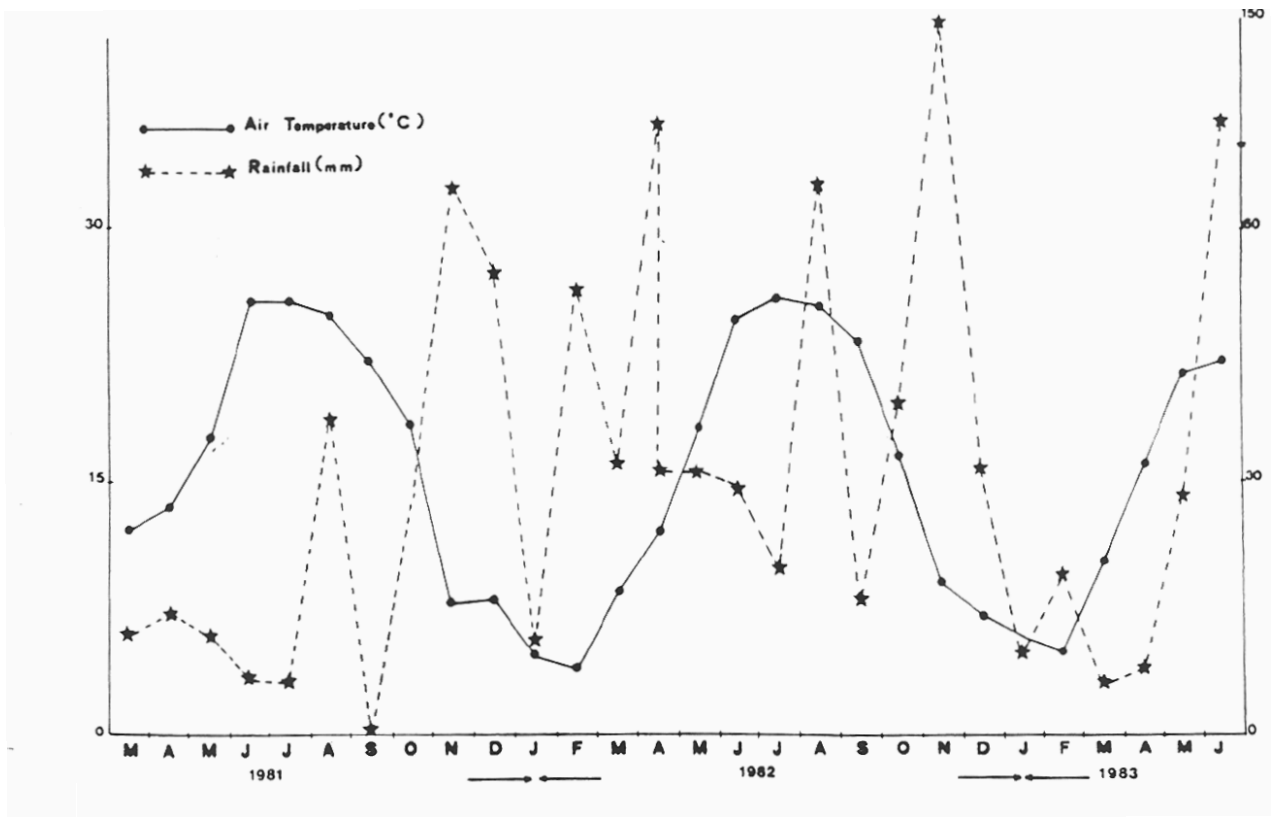


Fig. 1. Climate diagram of the area where the experimental site is located

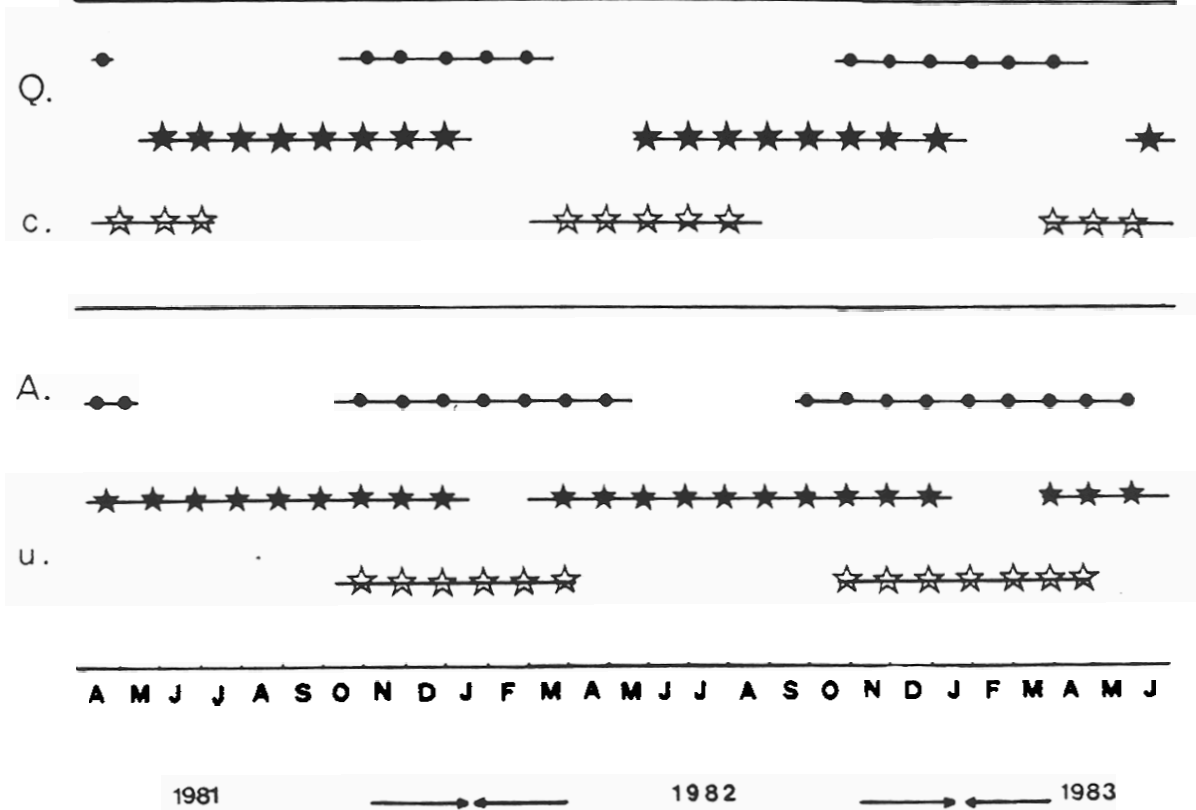


Fig. 2. Periods during which bud formation (•), fruit formation (blackened stars), and flowering (open stars) occurred in *Quercus coccifera* and *Arbutus unedo*

occurrence of autumn rains and subsequent increase in water availability. A somewhat similar but even more complicated situation was reported by Kummerow *et al.* (1981) for two of the dominant species of the California chaparral. Flower development in *Adenostoma fasciculatum* depended on moisture availability just preceding flowering in April and May. Flowering in *Arctostaphylos glauca* was affected by water availability during springtime one year before.

Formation of fruits in *Quercus coccifera* started late in the spring. Fruit ripening occurred over a period of 3-4 months. Fruits began dropping in late summer and early autumn but many continued expanding until spring. In 1981, 88% of the fruits were shed between November and February, while in 1982, 63% of the total were shed between September and October. The difference may have been related to changes in water availability, since during the summer months of 1981 rainfall was lower than in 1982 (Fig. 1) and rainfall may induce the stimulus for fruit abscission. In *Arbutus unedo*, fruits are formed in early spring. The maturation of these fruits occurs over more than one year. Fruits start to fall in late autumn. The majority, 97% in 1981 and 90% in 1982, were shed between December and January.

Seasonal changes in shoot elongation of *Q. coccifera* and *A. unedo* were studied between April 1981 and June 1983 at the Stavros-Halkidiki site. Growth was initiated in the spring in both species. 40-45% in *A. unedo* and 45-50% in *Q. coccifera* of the total yearly shoot elongation occurred in spring. A very small amount of growth (<10% of annual elongation) was observed during the autumn months. Mean leaf sizes of *Q. coccifera* and *A. unedo* are shown in Table 1.

Table 1. Leaf Dimensions of *Q. coccifera* and *A. unedo*.

| Species | Length cm | Width cm | Surface cm ² | Size Class |
|---------------------|--------------|-------------|----------------------------|------------|
| <i>Q. coccifera</i> | 5.00 | 2.50 | 12.50 | maximum |
| | 3.00 | 2.00 | 6.00 | mean |
| | 0.50 | 0.30 | 0.15 | minimum |
| <i>A. unedo</i> | 10.00 | 4.80 | 48.00 | maximum |
| | 6.80 | 3.40 | 23.12 | mean |
| | 2.00 | 1.00 | 2.00 | minimum |

Cambial activity in stems of *A. unedo* and *Q. coccifera* does not occur at the same time as stem elongation (Arianoutsou-Faraggitaki *et al.* 1984). In the former

species, cambial activity occurs between October and December, while in the latter species, it is initiated in June and completed by the end of August. Cambial activity of *Q. coccifera* appears less affected by moisture availability. Avila *et al.* (1975) state that in both Californian and Chilean evergreen species, cambial activity of shrub species occurs throughout the year, with a maximum observed either in spring or in early summer.

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