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Study of the incidence of meteorological parameters on the flowering of *Quercus* by means of its pollen production

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SUMMARY - The period of pollination of *Quercus* in Extremadura was analyzed over four years, monitoring atmospheric pollen levels. There were clear interannual differences in both recorded concentrations and phenology. Significant correlations were found with temperatures between January and May, rainfall from February to April, and the date of the last frost, which would explain the aforementioned differences.

Key words: Extremadura, *Quercus*, aeropalinology, phenology.

RESUME *- "Etude des effets des paramètres météorologiques sur la floraison de* Quercus *à travers sa production de pollen". On a analysé la période de pollinisation de* Quercus *dans l'Estrémadure pendant quatre années moyennant la suite des concentrations de son pollen dans l'atmosphère. On a mis en évidence l'existence de différences interannuelles, dans les concentrations enregistrées et dans sa phénologie, et on a obtenu des corrélations significatives avec les paramètres des températures entre janvier et mai, des précipitations de février à avril, et de la date de la dernière gelée, lesquelles pourraient expliquer les variations mentionnées.*

Mots-clés*: Estrémadure,* Quercus*, aerpalinologie, phénologie.*

Introduction

Extremadura is one of the regions where the cultivation and maintenance of *Quercus* species has greatest importance because of the use made of them in dehesa regimes. One of the main aspects of their cultivation is acorn production for livestock consumption. Early knowledge of the year's yield of acorns and the factors which may affect it is, therefore, of great importance in the region.

In the case of anemophile species, aeropalinological techniques have been of great use in forecasting crops, since Cour and Van Campo (1980) made the first studies on vineyards, olive groves, cereals, and orchards, and showed the high value of pollen levels as a predictive parameter of the subsequent agricultural output. Later studies have refuted these results for vineyards and olives (Besselat and Cour, 1989; González and Candau, 1995; Candau and González, 1997).

Annual yields of acorns are poorly accounted for in farming statistics, however, since they are consumed at the base of the tree, so that a study of this type based on indirect parameters of livestock output would require a series of years longer than the four presented here. The scope of the present work is therefore to lay out the bases for more prolonged studies, showing the variations that *Quercus* pollination might undergo, and some hypotheses concerning the incidence of the parameters on its flowering.

Material and methods

The evolution of *Quercus* pollen levels was monitored over four years, 1994, 1995, 1996, 1997, using a Burkard model volumetric trap. This device, using the analytical methodology described in Silva (1996), allows the hourly pollen levels of *Quercus* to be recorded, and from these raw data the daily means to be established. The trap was located in the grounds of the Agricultural Engineering School of the University of Extremadura (Badajoz) at a height of 6 m above the ground.

For the study of the incidence of the meteorological parameters, we used data supplied by the Territorial Meteorological Centre of Extremadura, which were submitted to a study of correlations calculated with the program NCSS (Number Cruncher Statistical System).

Results

Table 1 shows the results obtained for *Quercus* pollen levels during the pollination months of this genus, from March to May (Silva, 1996). One observes the different degree of pollination in the four years of the study. There exist variations between 1996 (the period's mean level was 59.0 grains m^{-3}) and 1997 (mean level 430.1 grains m^{-3}). One also observes that the month of greatest concentration also varies, being March in 1994 and 1997, and April in 1995 and 1996: the peak of pollinization is delayed by more than 20 days in these latter two years compared with the former.

Table 1. Mean pollen levels and means of some of the meteorological parameters studied. Both the day of greatest concentration and the last frost are referred to as days since 1 January.

	Concentrations (grains m^{-3})			Mean	Maximum day
	III	IV	V		
1994	176.7	136.9	67.2	126.8	83
1995	166.5	585.6	79.2	273.8	104
1996	9.6	110.6	58.5	59.0	106
1997	980.4	255.9	48.4	430.1	80

	Mean temperatures (°C)					Mean	Last frost	Rainfall (mm) II-IV
	I	II	III	IV	V			
1994	8.5	9.0	14.5	14.2	18.0	12.84	44	93.7
1995	9.4	11.4	13.4	16.7	20.8	13.34	68	44.0
1996	10.3	8.7	12.2	15.6	17.1	12.78	76	97.8
1997	9.3	12.0	15.7	17.9	17.6	14.50	6	25.8

With respect to the meteorological parameters listed in the same table, one observes that 1994 and 1995 were the coolest regarding the January to May mean temperature, and the warmest was 1997. The date of the last frost was earliest in 1997 (6 January), and latest in 1995 and 1996 (9 and 17 March, respectively).

To investigate the factors that might affect these different behaviours in this preliminary study, given that for conclusions to be drawn, a more prolonged study would be necessary, we opted to display in Fig. 1 the monthly variations of the parameters analyzed. Then a statistical analysis was made of the possible correlations between the meteorological parameters and the pollen variables. The said analysis was performed using the monthly means independently and in several forms of grouping. Table 2 lists the correlations which were found to be significant at the 95% ($p<0.005$) level. It is clear that the pollen concentrations are influenced by the mean temperatures recorded between January and April. Respecting rainfall, only that which occurred between February and April was found to be significant ($r=0.9742$, $p=0.026$).

Analysis of the relationship between the date of the last frost and the peak of flowering resulted in a correlation which was significant at 90% ($r=0.9089$, $p=0.091$).

Discussion

The results show firstly that *Quercus* pollinization undergoes interannual variations, alternating years of low yield (1994, 1996) with years of high yield (1995, 1997). The mean concentration values also present a high degree of variation (126.8, 273.8, 59.0, 430.1 grains m^{3}), which could directly influence the variation of the annual yield of acorns. As well as variation in pollinization the phenology also varies, with the greatest mean monthly value and the peak of pollinization occurring in March in two years (1994, 1997), and in April in the other two years (1995, 1996).

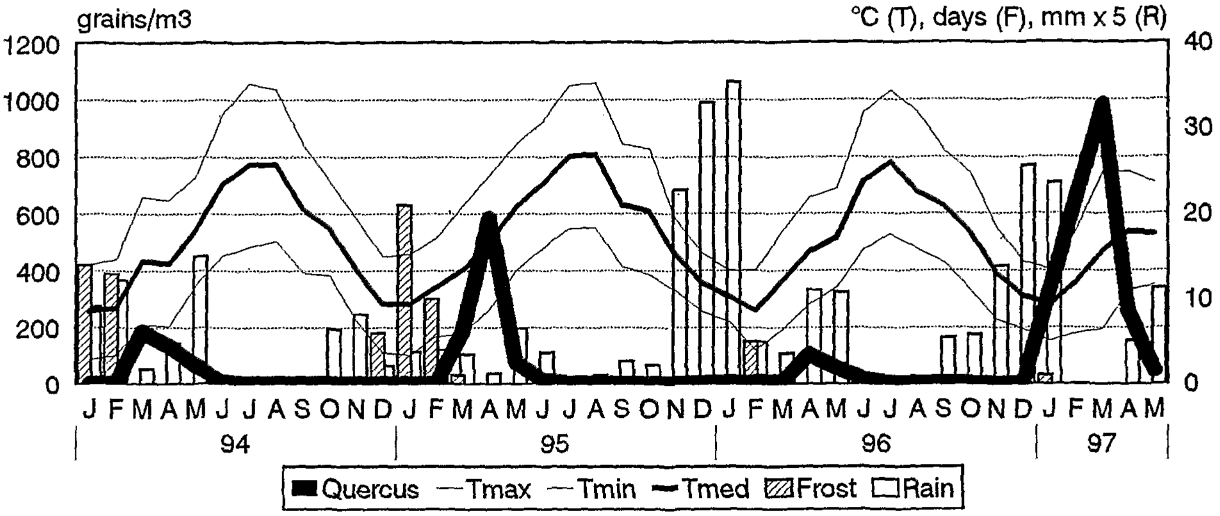

Fig. 1. Variations in mean monthly atmospheric concentrations of *Quercus* pollen content (in grains m^{-3}) in the years 1994, 1995, 1996, 1997, represented together with the monthly averages of maximum, mean, and minimum temperatures (in °C), monthly rainfall (in mm), and the dates of frost.

Table 2. Pearson correlation (r) and probability (p) of r=0 between the mean temperature and the rainfall and the mean *Quercus* pollen concentration during March, April, and May

Temperatures	r	p
February	0.9638	0.036
February-March	0.9743	0.026
March-April	0.9804	0.020
January-March	0.9984	0.002
February-April	0.9983	0.002
Rainfall		
February-April	-0.9742	0.026

Temperatures preceding flowering seem to be the factor triggering a greater or lesser output of pollen in these species (Fig. 2). This would be in agreement with the data obtained by Andersen (1980) and Käpylä (1984) studying *Q. robur*, although the former of these authors observed a greater importance of the effect of summer temperatures (June and September) for this species. The influence of temperature can be explained as affecting physiological processes and in the negative effect that frosts can have on sprouts, buds, and the flowers themselves. The phenology of flowering seems to be influenced by the duration of the periods of frost (Fig. 2).

Nevertheless, the greater or lesser degree of pollen production is also affected by rainfall recorded during pollinization (Fig. 2), doubtless because of its effect of washing the atmosphere clean, increasing interannual variations, and hindering the effectiveness of pollinization since although a great quantity of pollen is produced, the number of grains capable of reaching the stigma is fewer.

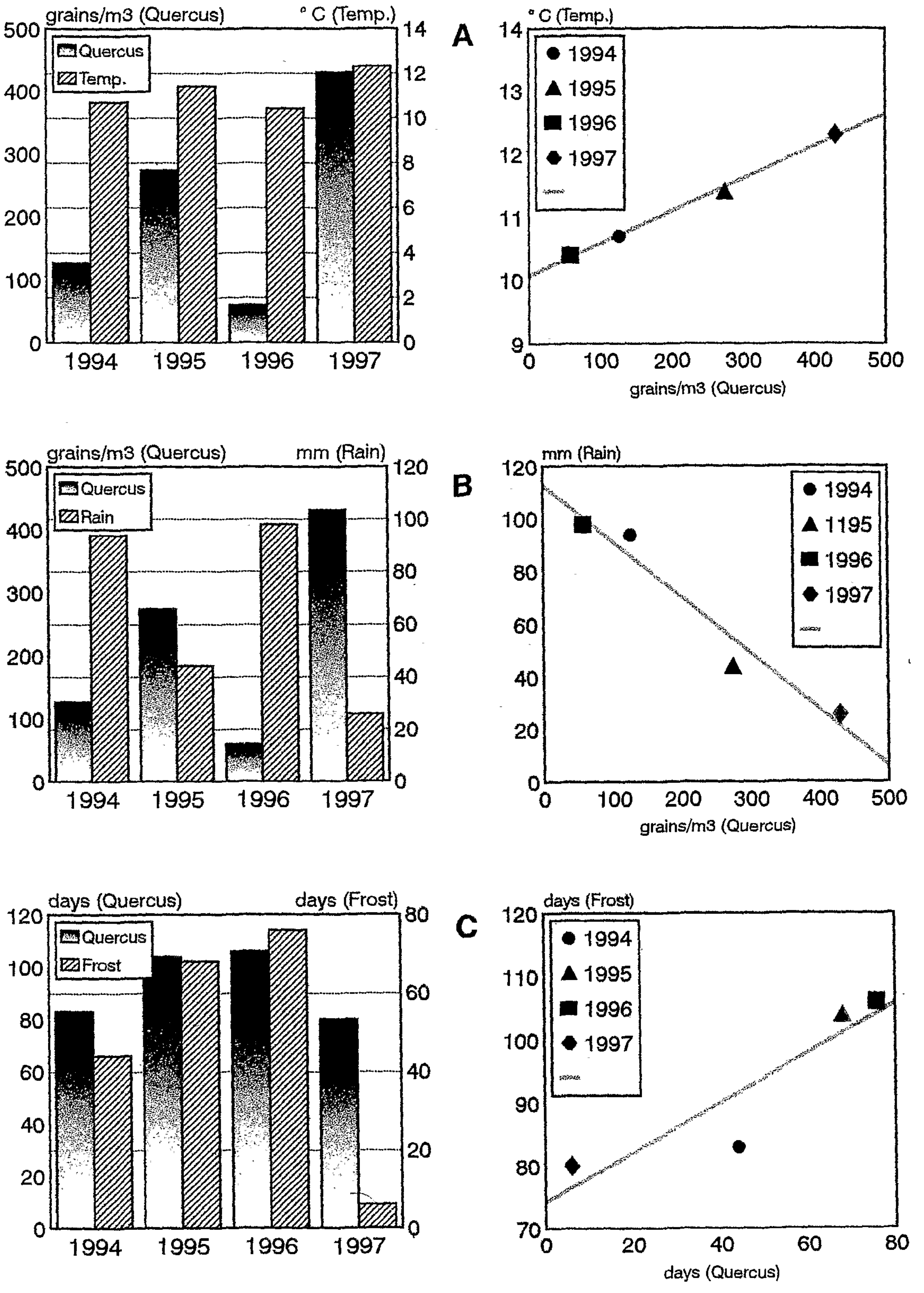

Fig. 2. (A) Histogram of mean annual pollen levels and mean January to March temperatures, together with the calculated regression. (B) Histogram of mean annual pollen levels and February to April rainfall, together with the calculated regression. (C) Linear representation of the peak of pollinization and of the date of the last frost, in days since 1 January, and the calculated regression.

Conclusions

From the present study one can extract the premises for future studies of greater duration on the positive influence of January to April temperatures on *Quercus* pollen yields, and on how the regime of frost and February to April rainfall can affect pollinization, delaying it when the last frosts are late, and washing the pollen out of the atmosphere, respectively.

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