

Pollen emission from olive trees and concentrations of airborne pollen in an urban area of North Sardinia

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Abstract

In this study the seasonal and daily variations in olive airborne pollen concentrations were measured in the atmosphere of Sassari (Italy) and the olive pollen emission was monitored in the countryside during the flowering period in 1995 and 1996, in order to detect the patterns of change in the atmosphere. The intensity and the timing of pollination was also studied in relation to phenological stages occurrence. In addition, the influence of the main meteorological parameters on pollen emission and airborne pollen dispersal in the city was assessed. Airborne pollen reached its highest concentration a few days before the peak of pollen emission in 1995 but several days after it in 1996 (6 days). Analysis of hourly concentrations shows that the maximum emission and dispersion recorded during the observation period occurred in the middle of the day. Significant regressions were found between hourly temperature and air humidity values and hourly pollen concentrations recorded in the olive grove for almost every day studied, indicating a negative correlation between humidity and pollen concentration and a positive correlation between pollen concentration and temperature. On the other hand, no significant correlation was observed between the meteorological parameters and pollen concentration recorded in the urban area. © 1997 Published by Elsevier Science Ireland Ltd.

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1. Introduction

The olive tree, a source of allergenic pollen, is cultivated in all Mediterranean countries, particularly in those areas where the climate is generally warmer. In Sardinia the olive has been cultivated since ancient times and has become the main fruit tree crop in the countryside close to urban areas. In the north of the island it accounts for 74% of all cultivated fruit species, covering 3000 ha, mostly concentrated close to the urban area of Sassari. Although the olive tree is economically important owing to the income it provides farmers, it can be considered a risk to human health

because of the well-known allergenicity of olive pollen.

Previous investigations conducted in the Sassari area have shown a very uncommon rate of mono-sensitization to olive pollen, lower even when the pollen concentration was high (Atzei et al., 1993). In the same paper recent studies on clinic and epidemiology of olive pollen allergy have been reviewed and discussed in relation to mono- and poly-sensitization.

A number of earlier studies, have outlined yearly trends and reported the results of accurate monitoring of total airborne pollen flora in the urban atmosphere and the relationship with meteorological factors (Bricchi et al., 1992; Iglesias et al., 1992; Diaz de la Guardia et al., 1995); the incidence of olive pollen concentration has also been documented (Scarpelli et al., 1991; Negrini et al., 1992). However, little is known about the

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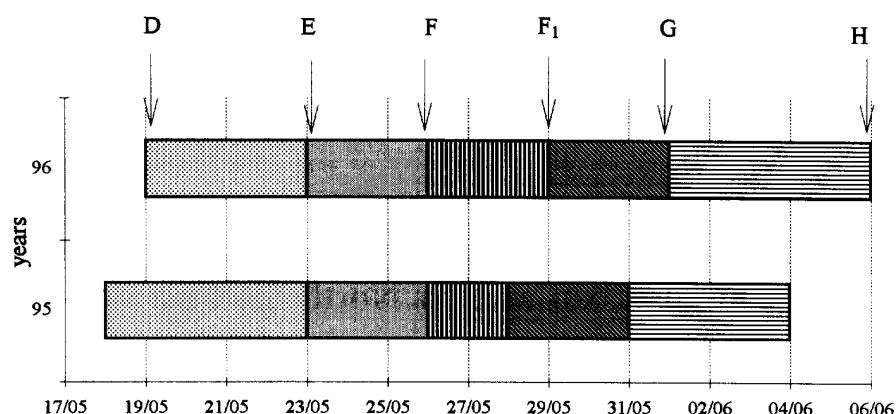


Fig. 1. Phenological stages observed in the olive grove (Sassari, 1995–1996). D = onset of the inflorescence, E = differentiation of the inflorescence, F = beginning of flowering, F1 = full blooming, G = petal falls, H = fruit set.

relation between the olive flowering process and airborne pollen concentrations in urban areas (Frenguelli et al., 1989; Strada et al., 1990).

Floral development is a function of the genome and the microclimate. The olive is characterized by enormous populations of flowers, usually resulting, however, in a low percentage of fruit set and flower abscission in excess of 98%, and by alternate bearing behavior (Martin, 1990). It may be presumed that the intensity and the timing of pollination are strongly affected by these factors. Evidence of the relationship between airborne pollen, monitored in different urban areas of South Italy, and the alternate bearing behavior of this species have been presented by Macchia et al. (1989) and Scarpelli et al. (1991).

The present study has been carried out based on the following main purposes:

- to evaluate the incidence and timing of olive pollen emission monitoring the atmosphere in the middle of pollen source;
- to investigate the relationship between pollen emission and airborne concentrations in the urban area;
- to determine the influence of the main meteorological parameters on pollen emission and airborne pollen dispersion.

2. Materials and methods

Olive pollen emission was monitored in the countryside during the flowering period, and seasonal and daily variations in olive airborne pollen concentrations were measured in an urban area of North Sardinia (Sassari) in order to detect the patterns of olive pollination. In addition, the influence of the main meteorological parameters on pollen released from the plant and airborne pollen dispersal in the city was assessed.

Olea europaea pollen distribution in the atmosphere was recorded hourly throughout the flowering seasons, from the third week in May to mid June 1995 and 1996. Two trials were conducted: in the first, the pollen concentration in an olive grove was measured soon after dehiscence; in the second, data on the airborne pollen concentration in the urban environment of Sassari were collected. Two Burkard 7-day recording volumetric traps were used to perform pollen counts. One was placed at 1.5 m above ground level in the middle of an olive grove located near the city and the second was positioned on the roof (9 m above ground level) of the Aerobiological Observatory inside the city.

The grove was chosen 10 km from the city (Lat. N 40° 45', Long. E 8° 29', h 170 a.s.l., NW exposure), in the surrounding area where olive is the main crop extensively cultivated for oil production. Some common features are predominant in the area: the cultivar 'Bosana' is largely spread, the soil is calcareous, the dominant wind blows from NW, similar orchard management techniques are used. Differences in tree behavior are mainly related to the microclimate within single groves resulting from various factors related to plant age and architecture, presence or absence of windbreak, exposure and soil characteristics (depth, texture and pH).

Ten branches/plants on ten trees were chosen and the following phenological stages were recorded every 2 days from April to June: onset of the inflorescence (D), differentiation of the inflorescence (E), beginning of flowering (F), full blooming (F1), petal falls (G), fruit set (H).

During the flowering season the pollen grains captured hourly in the spore traps were stained with basic fuchsin and then counted by optical microscopy.

Data of hourly pollen concentrations were grouped into six classes and the hourly frequency of each class was calculated in both olive grove and city for 1995 and

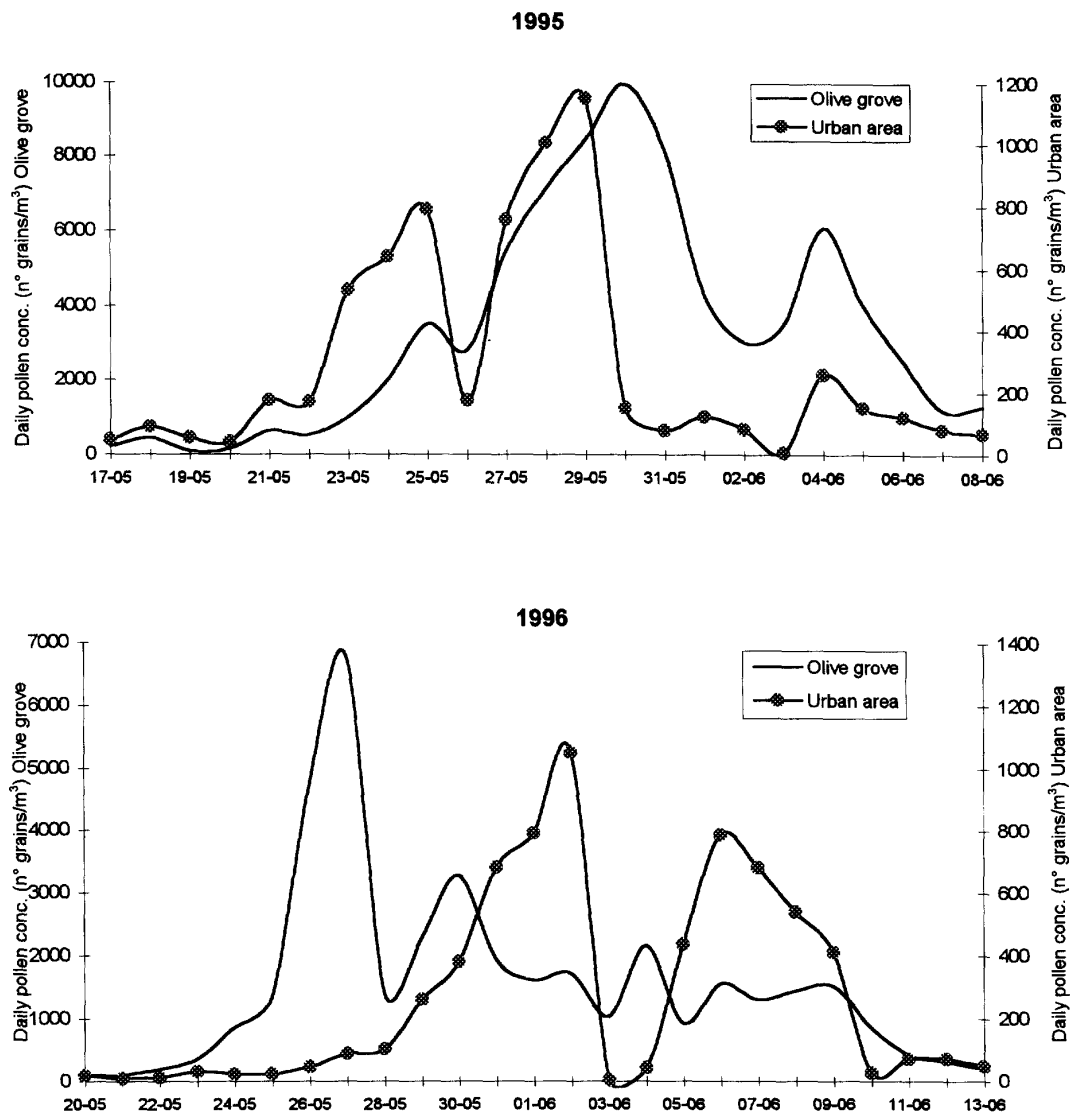


Fig. 2. Seasonal trend in the olive pollen daily concentration in the urban area of Sassari and in an olive grove recorded in 1995 (top) and 1996 (bottom).

only in the olive grove for 1996. The magnitude of the classes was defined for each year and for each area depending on the pollen concentration observed. In 1995, for instance, in the olive grove the highest hourly pollen amount (more than 1200 grains/m³) was recorded and the following six classes of frequency were identified (< 100, 101–300, 301–500, 501–800, 801–1200, > 1200 grains/m³).

During the flowering season the air temperature and humidity as well as rainfall were recorded at the two sites, by standard weather stations positioned near the spore traps. The influence of the meteorological parameters was determined in both trials by simple

regressions of hourly temperature and relative humidity on hourly pollen concentrations monitored both in the olive grove and in the urban area of Sassari. The trend shown by the data of pollen count recorded in the olive grove follows a distribution in which three phases were identified. Therefore the following division have been adopted: from May 17 to 22 in 1995 and from May 20 to 25 in 1996, the period consistent to the rising phase; from May 27 to 31 in 1995 and from May 26 to June 2 in 1996, the period of peak occurrence; from June 1 to 8 in 1995 and from June 5 to 13 in 1996, the decreasing phase. In order to define more clearly the pollen emission process in relation to environment,

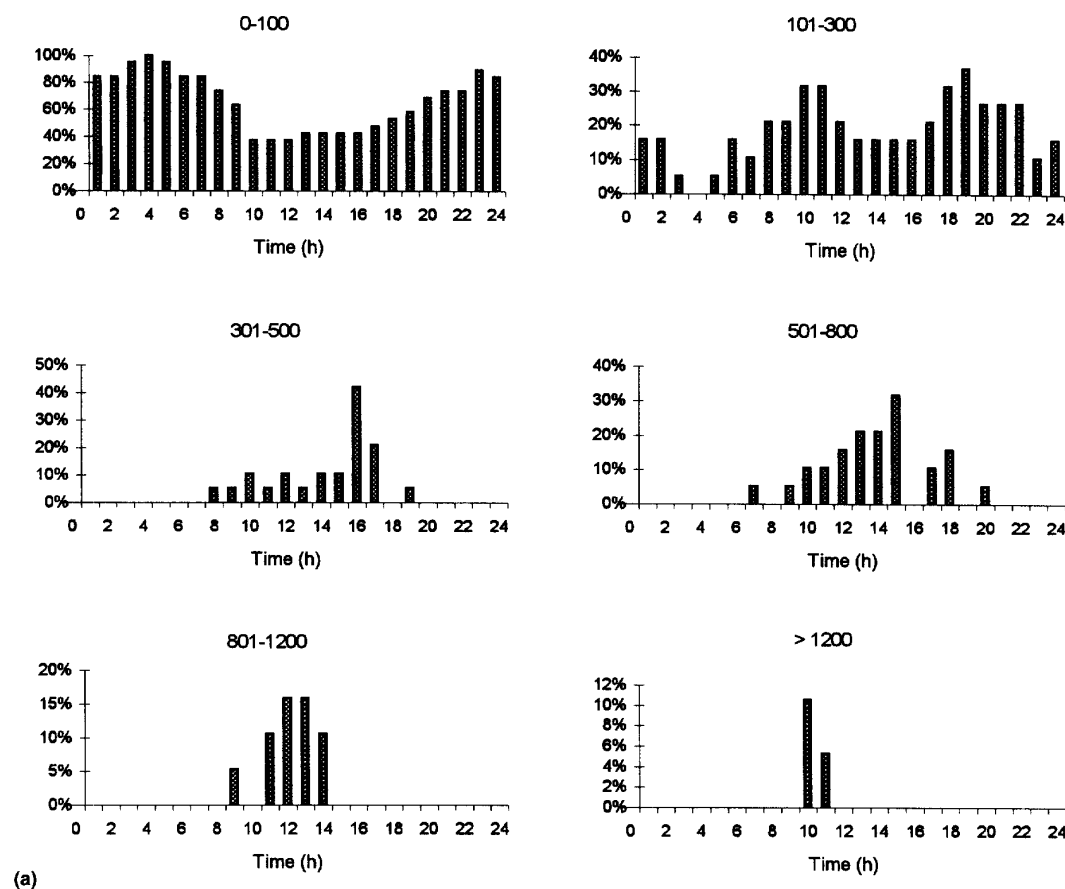


Fig. 3. (a) Distribution of hourly pollen concentration observed in the olive grove into defined frequency classes (Sassari, 1995). (b) Distribution of hourly pollen concentration observed in the olive grove into defined frequency classes (Sassari, 1996). (c) Distribution of hourly pollen concentration observed in the urban area into defined frequency classes (Sassari, 1995).

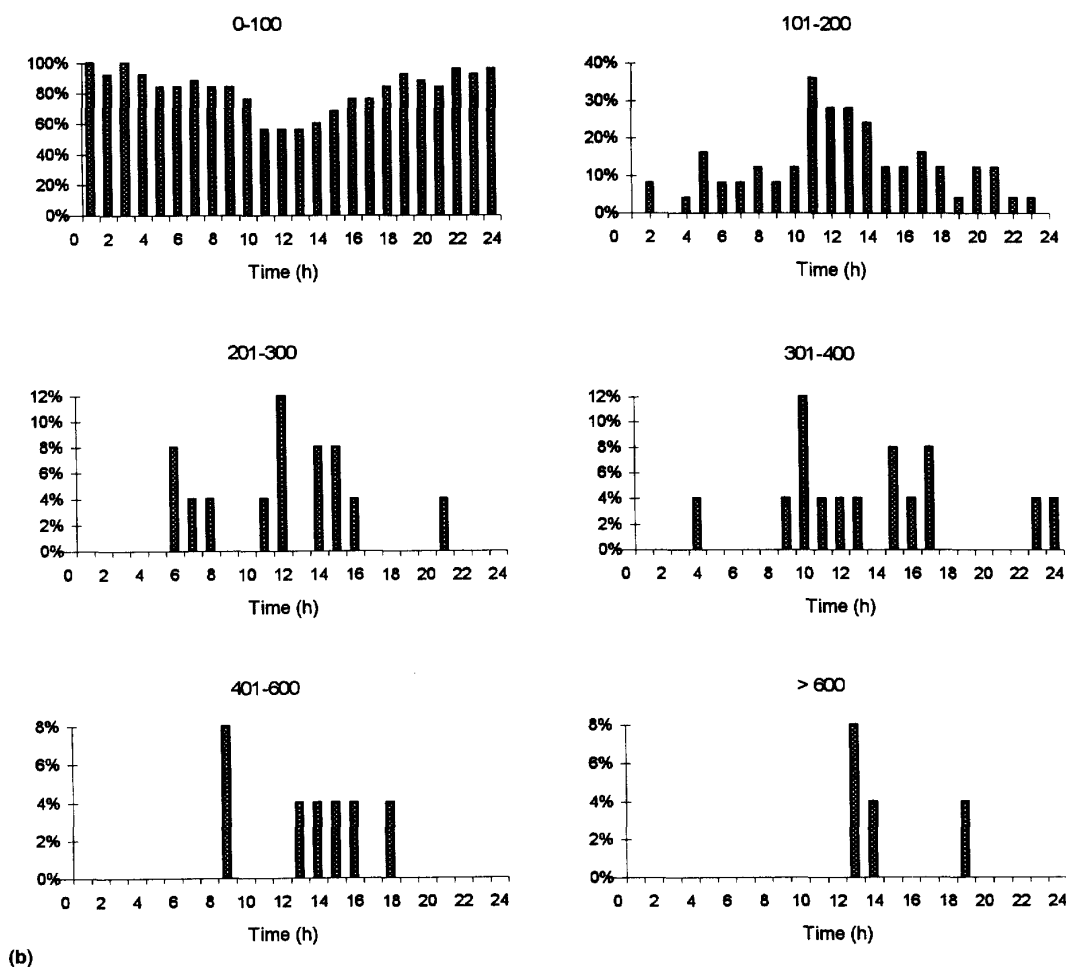
hourly pollen concentrations (% of daily total) of each period was correlated to relative meteorological data. Simple regression on air hourly temperature and humidity separately for each year were calculated, while multiple regression between hourly pollen concentration, hourly temperature and hourly relative humidity was measured combining data recorded during the flowering periods of both years.

3. Results

As shown in the phenogram (Fig. 1), olive trees sampled showed inflorescence onset (D) on May 18 in 1995 and on May 19 in 1996. This phenological phase and the following of inflorescence differentiation (E) ended on May 26 in both years, while flowering phases (F and F1) lasted 5 days in 1995 and 6 days in 1996. Although this short period of the anthesis process, almost contemporaneous within trees in the same

grove, pollen was recorded in the grove and in the urban atmosphere for a longer period, because phenological phases occurrence was graded in relation to the biological behavior of the cultivar Bosana. Moreover, pollination could have been also influenced by the unnecessarily coincident flowering period in the area of olive groves.

The highest incidence of pollen emission in the olive grove was recorded on May 30 in 1995, and on May 27 in 1996 (Fig. 2), when almost all the trees were in the flowering stage. A second peak was monitored a few days later, followed by a decrease in pollen counts. Peak levels of airborne pollen were recorded in the city area in 1995 on May 25 and 29; in 1996 a first peak was observed on June 2 and a second on June 6. A sharp decrease in airborne pollen was recorded on June 3 and 4, 1996, which can be related to a 21-h rainfall that occurred on those days. Therefore, airborne pollen reached its highest concentration only 2 days before the peak of pollen emission in 1995 but several days after it in 1996 (6 days).



(b)

Fig. 3. (Continued)

Pollen concentrations reached levels from six to eight times higher in the rural area than in the city atmosphere and almost 50% greater in 1995, in account of the alternate bearing. This peculiar character of the species influenced also pollen trapping in the urban area, but at a lower extent.

Analysis of hourly concentrations in the grove shows the maximum emission in the middle of the day and pollen grains presence in the atmosphere during all day. From 18 p.m. to 9 a.m., hourly concentration reached 300 grains/m³ in 1995 and 200 grains/m³ in 1996 (Fig. 3a, b). A similar trend was observed in the urban area (Fig. 3c).

In 1995 and 1996 significant regressions were found between hourly temperature and air humidity values and hourly pollen concentrations recorded in the olive grove, indicating a negative correlation between humidity and pollen concentration and a positive correlation between pollen concentration and temperature (Tables

1 and 2). On the other hand, no significant correlation was observed between the meteorological parameters and pollen count recorded at the observatory in 1995 (Table 3) and 1996 (data not shown).

The simple regressions, calculated separately for each phase (rising, peak and falling), show also that in this case temperature and air humidity inversely affect the pollen concentrations, as reported for the single days (Table 4). Analysis of variance shows that regression is highly significant ($P > 0.01$) for all three pollination periods and for both years. In particular, the highest values of the coefficient of regression refer to the period of peak emission in 1995, in which 54% of concentration variability is explained by temperature and 43% by humidity.

Similar results are obtained calculating the multiple regression for hourly temperature and humidity variables and pollen concentration, relating period divisions and combining data of the 2 years (Table 5). The

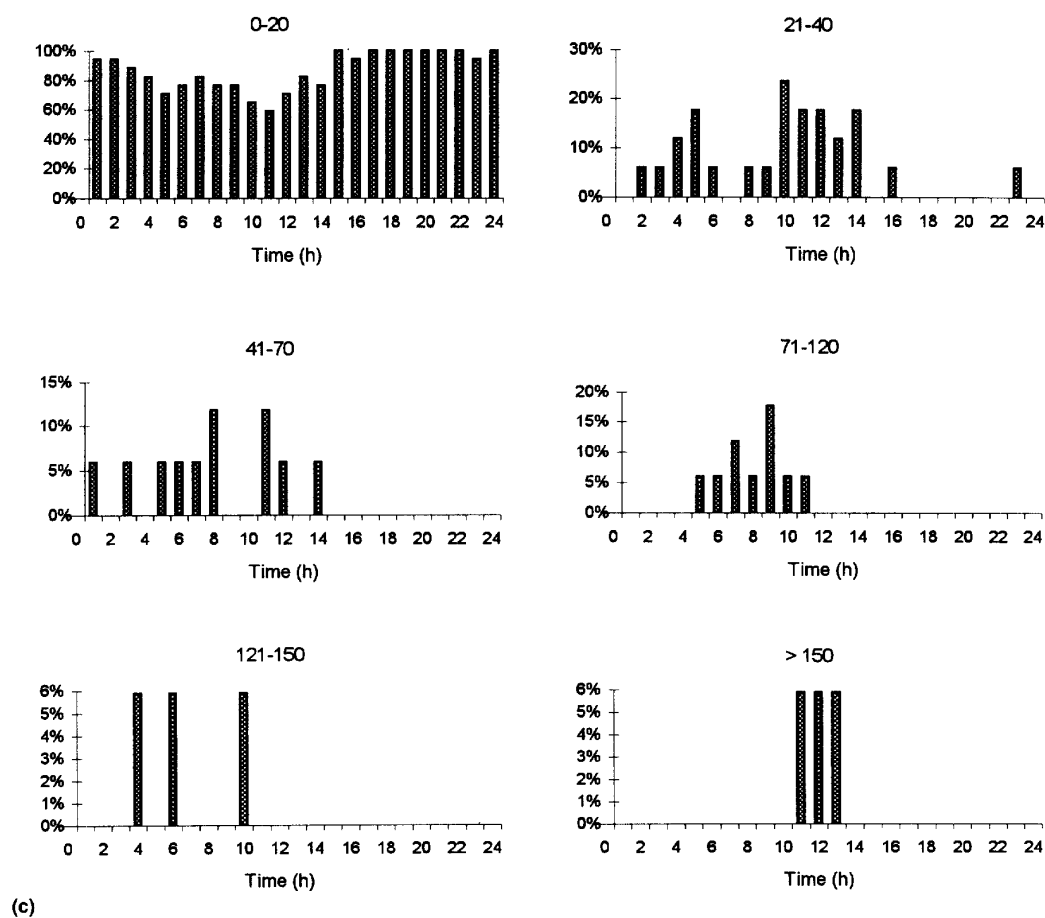


Fig. 3. (Continued)

analysis of variance shows that regression was highly significant and that 31% of concentration variability is determined by the regression equation which includes the two variables.

4. Discussion and conclusions

The results indicate that pollen emission and dispersion, although aspects of the same phenomenon, are influenced by different factors. Variability in concentration trend and amount of olive pollen found among and between olive grove and city atmospheres, as well as between years of observations may be attributed to the biological behavior of the plant (phenological phases pattern and alternate bearing), but meteorological factors play also an important role.

The relationship found between flowering process developmental stages in olive tree and aerobiological data, have underlined how pollen emission from the plants and pollen dispersal are two distinct phenomena.

The use of both phenological and meteorological data has been suggested by Bricchi et al. (1992) to detect the pattern of Gramineae pollination.

The alternate bearing influence on airborne olive pollen in urban area has been also reported by Macchia et al. (1989) and Scarpelli et al. (1991). The results of the observations here reported have shown fluctuations year by year clearly related to the plant physiology, mainly when grains were collected closely to the emission source.

The influence of temperature and humidity of the air on the amount of olive pollen emission was evident both over the period of a single day, when the greatest amount of pollen was released in the middle of the day and during the pollen season, as shown by analysis of lines of regression. Pollen concentration in the urban atmosphere proved to be of more complex reading, and regression data were not always significant. Probably other physical and meteorological factors influencing air trajectory and speed (not considered here) affect the behavior of air masses containing pollen.

Table 1

Simple regression between hourly olive pollen concentration, hourly temperature and relative humidity (Sassari, olive grove, 1995)

Date	T			RH%		
	r^2	r	P	r^2	r	P
17/05/95	0.25	0.50	*	0.35	−0.60	**
18/05/95	0.28	0.52	**	0.17	−0.41	*
19/05/95	0.31	0.56	**	0.41	−0.64	**
20/05/95	0.31	0.56	**	0.01	−0.09	n.s.
21/05/95	0.22	0.47	*	0.32	−0.57	**
22/05/95	0.29	0.54	**	0.11	−0.33	n.s.
27/05/95	0.58	0.76	**	0.48	−0.69	**
28/05/95	0.61	0.78	**	0.69	−0.83	**
29/05/95	0.57	0.76	**	0.17	−0.41	*
30/05/95	0.69	0.83	**	0.21	−0.46	*
31/05/95	0.57	0.76	**	0.52	−0.72	**
01/06/95	0.48	0.69	**	0.51	−0.71	**
02/06/95	0.47	0.68	**	0.42	−0.64	**
03/06/95	0.39	0.62	**	0.21	−0.46	*
04/06/95	0.68	0.83	**	0.64	−0.80	**
05/06/95	0.50	0.71	**	0.33	−0.58	**
06/06/95	0.20	0.45	*	0.29	−0.54	**
07/06/95	0.29	0.54	**	0.30	−0.55	**
08/06/95	0.33	0.57	**	0.39	−0.62	**

*95% (>0.4044)

**99% (>0.5151)

Table 2

Simple regression between hourly olive pollen concentration, hourly temperature and relative humidity (Sassari, olive grove, 1996)

Date	T			RH%		
	r^2	r	P	r^2	r	P
20/05/96	0.29	0.54	**	0.49	−0.70	**
21/05/96	0.33	0.57	**	0.21	−0.46	*
22/05/96	0.75	0.87	**	0.65	−0.81	**
23/05/96	0.52	0.72	**	0.53	−0.73	**
24/05/96	0.47	0.68	**	0.52	−0.72	**
25/05/96	0.46	0.68	**	0.37	−0.61	**
26/05/96	0.38	0.62	**	0.41	−0.64	**
27/05/96	0.36	0.60	**	0.47	−0.68	**
28/05/96	0.03	−0.18	n.s.	0.02	0.15	n.s.
29/05/96	0.34	0.59	**	0.34	−0.59	**
30/05/96	0.67	0.82	**	0.16	−0.40	n.s.
31/05/96	0.13	0.36	n.s.	0.01	0.07	**
01/06/96	0.20	0.44	*	0.16	−0.40	*
02/06/96	0.06	0.24	n.s.	0.42	−0.65	**
05/06/96	0.28	0.53	**	0.36	−0.60	**
06/06/96	0.29	0.54	**	0.23	−0.48	*
07/06/96	0.43	0.65	**	0.62	−0.79	**
08/06/96	0.33	0.58	**	0.24	−0.49	*
09/06/96	0.38	0.62	**	0.27	−0.52	**
10/06/96	0.29	0.54	**	0.25	−0.50	*
11/06/96	0.20	0.44	*	0.09	−0.29	n.s.
12/06/96	0.25	0.50	*	0.26	−0.51	*
13/06/96	0.08	0.28	n.s.	0.32	−0.57	**

*95% (>0.4044)

**99% (>0.5151)

Table 3

Simple regression between hourly olive pollen concentration, hourly temperature and relative humidity (Sassari, urban area, 1995)

Date	T			RH%		
	r^2	r	P	r^2	r	P
17/05/95	0.004	0.06	n.s.	0.03	−0.16	n.s.
18/05/95	0.09	−0.31	n.s.	0.01	0.08	n.s.
19/05/95	0.26	0.51	*	0.38	−0.62	**
20/05/95	0.04	−0.19	n.s.	0.23	0.48	*
21/05/95	0.35	0.59	**	0.29	−0.54	**
22/05/95	0.07	0.27	n.s.	0.02	0.14	n.s.
24/05/95	0.01	−0.08	n.s.	0.19	−0.08	n.s.
25/05/95	0.18	−0.42	*	0.14	0.37	n.s.
26/05/95	0.00002	0.0046	n.s.	0.01	0.08	n.s.
27/05/95	0.06	0.24	n.s.	0.11	−0.33	n.s.
28/05/95	0.31	0.56	**	0.46	−0.68	**
30/05/95	0.40	0.63	**	0.17	0.41	*
31/05/95	0.06	−0.24	n.s.	0.09	−0.31	n.s.
01/06/95	0.09	0.30	n.s.	0.16	0.40	n.s.
02/06/95	0.24	0.49	*	0.20	0.45	*
03/06/95	0.06	0.25	n.s.	0.10	0.32	n.s.
04/06/95	0.34	0.58	**	0.14	0.37	n.s.

*95% (>0.4044)

**99% (>0.5151)

As reported by Bricchi et al. (1992) for Gramineae, it appears that the influence of meteorological factors on olive pollen concentration in the air is somewhat indirect as regards the link between temperature and the onset of each phenological stage, and more direct in that temperature and humidity affect the process of dehiscence of the anthers.

The possibility of using knowledge on the phenological behavior of the plant as an investigative tool for aerobiological studies is preliminary evidenced in the present study. A wider research program is conducted in order to achieve more information on the phenology of olive tree and meteorological factors role, useful to a better understanding of all phenomena associated to the fluctuation pattern of this allergenic pollen.

Thus, studies on the allergenicity of pollens should more comprehensively investigate all phenomena related to the physiology and biology of plant releasing pollen, the micro-meteorology in the source area, the processes of pollen dispersal and the influence of meteorological parameters.

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Table 4

Simple regression between hourly olive pollen concentration, hourly temperature and relative humidity in three different periods of emission (rising, peak and decreasing phases)—Data recorded in the olive grove in 1995 and 1996

	Period	Linear regression	N	r	r ²	P	F	P
1995								
T	I	$y = -8.17 + 0.78 x$	144	0.49	0.24	**	44.40	**
	II	$y = -15.09 + 1.26 x$	120	0.74	0.54	**	140.24	**
	III	$y = -5.26 + 0.53 x$	192	0.51	0.27	**	68.40	**
RH%	I	$y = 13.23 - 0.13 x$	144	-0.44	0.20	**	34.31	**
	II	$y = 18.71 - 0.19 x$	120	-0.65	0.43	**	87.81	**
	III	$y = 12.49 - 0.11 x$	192	-0.51	0.26	**	65.16	**
1996								
T	I	$y = -4.99 + 0.6 x$	144	0.62	0.39	**	89.99	**
	II	$y = -1.6 + 0.33 x$	192	0.47	0.22	**	54.80	**
	III	$y = -3.6 + 0.39 x$	216	0.47	0.22	**	60.79	**
RH%	I	$y = 14.47 - 0.13 x$	144	-0.63	0.39	**	91.86	**
	II	$y = 8.03 - 0.06 x$	192	-0.37	0.14	**	29.87	**
	III	$y = 12.1 - 0.11 x$	216	-0.48	0.23	**	65.23	**

Table 5

Multiple regression between hourly pollen concentration, hourly temperature and relative humidity in three different periods of emission (rising, peak and decreasing phases)

Period	Multiple regression	N	r	r ²	P
I	$y = 1.6 + 0.44 x_1 - 0.056 x_2$	288	0.55	0.3	**
II	$y = -0.85 + 0.43 x_1 - 0.03 x_2$	312	0.56	0.31	**
III	$y = 6.3 + 0.17 x_1 - 0.07 x_2$	408	0.5	0.25	**

The regression equations were obtained combining data recorded in the olive grove over the whole flowering periods in 1995–1996.

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