12A.2 OLIVE FLOWERING PHENOPHASE: A MULTIREGIONAL POLLEN MONITORING NETWORK

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A pollen monitoring investigation was carried out in the most important southern Italian olive-growing regions (Sicily, Puglia, Calabria and Campania) to analyse the olive (Olea europaea L.) pollination, continuously over a 3-year period (1999-2001). Volumetric pollen traps that aspirate known quantities of air in a certain period of time were used to determine pollen release (daily pollen concentrations) and flowering trends in the olive groves. Pollen monitoring was also considered to be a valuable source of information about flowering phenology considering that olive reproduction starts with a massive pollen emission. The principal aim of this study was to investigate the relationships between thermal trends and reproductive development in olive and the consequent olive fruit production. Numerous studies on different species have investigated the relationship between climate and flowering phases and they have shown the importance of the accumulated heat requirements on the consequent phases of pollen maturation and release (Fornaciari et al. 1998, Lechowicz 1995). Another important aim was to investigate the influence of meteorological variables during the main olive flowering period in order to gain more information about pollen dispersion in the atmosphere. Spring temperatures expressed as Growing Degree Hours (GDH) and the flowering phases (pollination) defined as the anthesis period in olive were analysed to evaluate the cultivars that are best adapted to the particular areas and to interpret the biological response of the olive trees to more or less marked climatic variations. The main characteristics of the olive flowering phenomena in the study areas have also been identified (flowering period and concentration, annual trends). The close relationship between the meteorological variables, heat accumulation and flowering event is also shown. Extensive, geographically-distant areas (macro-areas) have been identified in which flowering was conditioned by the same meteorological variables, particularly the presence/absence of a dry climate with respect to a humid climate. Fourteen olive monitoring stations were located in olive-growing provinces (Tab. 1).

The pollen trap (VPPS 2000 Lanzoni model),

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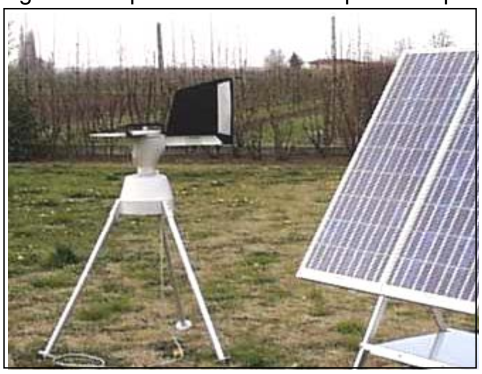
Tab. 1. Olive grove areas and principal olive cultivars in each area.

Region	Olive areas	Olive cultivars
Sicily	Agrigento	Biancolilla
	Messina	Minuta
	Trapani	Biancolilla, Giarraffa
Puglia	Bari	Coratina, Ogliarola
	Brindisi	Coratina, Ogliarola
	Foggia	Peranzana
	Lecce	Cellina di Nardò, Carolea
	Taranto	Cellina di Nardò, Carolea
Calabria	Catanzaro	Carolea
	Cosenza	Leccino, Coratina
	Reggio C.	Leccino, Coratina
Campania	Avellino	Leccino, Olivella
	Benevento	Ortolana, Auliviello
	Salerno	Frantoio, Rotondella

developed from the Hirst model (Hirst 1952) is made up of two parts: a lower, fixed part, and an upper, mobile part (Fig. 1). By knowing the aspirated volume of air, the concentration of particles/m^3 can be expressed for hourly, daily or weekly intervals (Fornaciari et al. 2002; Gagnon and Comtois 1992).

Fig.1. Solar-powered volumetric pollen trap.

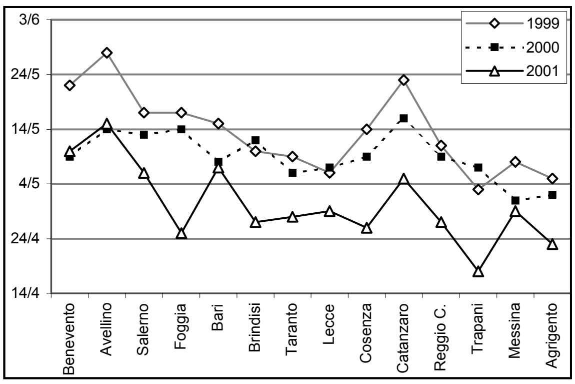


For each geographic area, the day on which the first olive pollen emission was recorded was considered to coincide with flower initiation (Chuine et al. 1999). The daily heat amount value was calculated using the GDH formula. For each station, yearly heat amounts were calculated from January 1 to the first day of pollination. To calculate the GDH values, temperature data were collected at the 14 weather stations of the National Agro-meteorological Network located near the respective pollen monitoring sites. To verify if the GDH formula expresses a close relationship between heat amount and pollen release, two-way Analyses of Variance (ANOVA) were performed, considering the heat summations calculated in the 3 years. With this kind of statistical analysis we were able to determine if the 3 study years (factor 1) and the different monitoring stations (factor 2) affect the calculated heat amounts. Moreover a correlation matrix was carried out to study the relationship between the principal meteorological variables (min. and max. temperatures, rain and relative humidity) and the daily pollen concentrations. Pollination in the olive species in southern Italy began from the last days of April to the first days of May, while the end of this important phenological phase was recorded sometime in June depending on the climatic conditions (Fig. 2). Flowering began first in the southern-most study sites in Sicily, followed by the southern part of Puglia and then by the rest of the sites in Puglia, Calabria and Campania.

The ANOVA results are reported in the upper part of Table 2 where all of the monitoring stations were pooled.

Fig. 2. Starting days of pollination.

Pollination onset in the olive areas



In the lower portion of Table 2 the results of another series of two-way ANOVA analyses regarding the effects of factors 1 and 2 on the heat amounts are reported. For these analyses the monitoring stations were grouped according to the region in which they were located.

Tab. 2. ANOVA results for GDH in the 4 regions.

		Df	Sum of Sq	Mean Sq	F Value	Pr(F)
14 stations	years	2	367466	183733	8.0400	0.0020
	stations	13	731837	562951	24.6400	0.0000
	Residuals	26	593911	228427		
CAMPANIA	years	2	4705863	2352931	10.6904	*0.0248*
	stations	2	7690577	3845288	17.4709	*0.0105*
	Residuals	4	880385	220096		
PUGLIA	years	2	7097396	3548698	0.7403	*0.5069*
	stations	4	55752564	13938141	2.9078	*0.0929*
	Residuals	8	38346559	4793320		
CALABRIA	years	2	3584794	1792397	2.3284	*0.2134*
	stations	2	119153948	59576974	77.3944	0.0006
	Residuals	4	3079135	769784		
SICILY	years	2	28519708	14259854	14.1050	*0.0154*
	stations	2	189492904	94746452	93.7181	0.0004
	Residuals	4	4043891	1010973		

The results of the first ANOVA were significant ($p>0.01$) when the data from the monitoring stations of each region were analysed. If the data from all the monitoring stations were pooled, the results of the ANOVA were not significant.

In particular, the p-values relative to factor 2 (monitoring stations) were only significant for Puglia (p-value 0.09) and Campania (p-value 0.01).

The yearly correlation values between daily pollen concentrations and meteorological data calculated at each monitoring area are reported in Table 3. The significant values ($r > 0.5$) are highlighted and indicate the close relationship between climatic trends and corresponding pollen emission values.

Max. temperature was the most important variable. In particular, considering correlations as absolute values, some areas were mostly affected by thermal variables, others by humidity and for others, the effects were small and contrasting (Fig. 3).

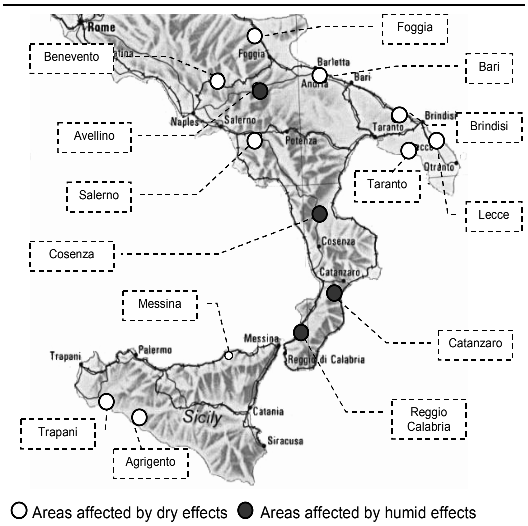
The results of the ANOVA carried out on the data from each region, show that there was a non-random relationship between heat amount and flowering during the three years of study. The differences among the monitoring stations were not statistically significant in Puglia and Campania because, the bio-climatic relationships in these areas are quite homogeneous.

These results reflect the fairly modern olive cultivation practices in Puglia in which the typical alternation of yearly olive production has been reduced.

Tab. 3. Correlation results (pollen emission-climatic variables).

	T° Min	T° Max	Prec	U.R.		T° Min	T° Max	Prec	U.R.
Avellino	0.12	0.14	-0.14	-0.23	Messina	-0.13	-0.04	-0.04	-0.02
	0.27	0.05	-0.12	-0.15		-0.12	-0.03	-0.05	-0.17
	0.17	0.20	-0.20	-0.35		-0.17	-0.08	-0.04	0.06
Benevento	-0.29	0.10	0.19	0.06	Trapani	-0.34	-0.39	-0.10	0.44
	-0.40	**-0.57**	-0.12	-0.10		-0.19	-0.08	-0.14	-0.19
	-0.25	-0.33	0.22	0.14		-0.16	0.21	-0.05	-0.09
Salerno	**-0.57**	**-0.69**	0.03	-0.09	Bari	-0.31	-0.25	-0.15	0.03
	0.34	-0.07	-0.21	0.11		-0.46	-0.21	-0.12	-0.08
	0.59	**0.53**	0.03	-0.29		-0.41	0.12	-0.04	0.05
Catanzaro	-0.08	-0.22	-0.17	0.30	Brindisi	-0.48	**-0.60**	0.14	**0.51**
	0.19	-0.32	-0.24	0.26		-0.27	-0.05	-0.01	-0.20
	0.28	0.12	-0.03	-0.19		-0.36	-0.42	-0.02	0.14
Cosenza	-0.43	-0.38	0.37	0.34	Foggia	**-0.67**	-0.32	0.14	-0.05
	0.08	0.11	-0.15	-0.33		0.04	0.16	0.46	-0.15
	-0.37	-0.37	-0.05	0.12		-0.20	-0.21	-0.03	-0.03
R. Calabria	-0.11	**-0.69**	0.12	**0.69**	Lecce	0.06	-0.37	-0.04	0.27
	0.04	0.18	0.03	-0.28		-0.38	-0.42	0.07	0.02
	0.27	0.29	0.29	-0.30		0.06	-0.05	0.08	-0.05
Agrigento	0.11	0.40	-0.15	-0.12	Taranto	-0.17	0.00	0.02	-0.02
	0.16	0.18	**0.60**	0.31		0.25	**0.67**	0.28	-0.48
	-0.39	**-0.62**	0.32	-0.02		0.07	-0.16	0.16	0.21

Fig. 3. Correlation results between climatic variables and pollen concentrations (dry and humid influences).



On the other hand, the correlation results for the different monitoring areas showed the distinct influence of climatic variables on the olive plants. A typical behaviour was recorded at 4 monitoring stations located inland near the Apennine mountain chain. These stations with similar climatic conditions were mostly affected by the relative humidity variable ("humid" climate). Moreover, nine stations, located near the sea, were mostly affected by thermal conditions ("dry" climate).

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