



Grana

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/sgra20>

Relationship between pollen emission and fruit production in olive (*Olea europaea* L.)

Fabio Orlandi Corresp. Author, Bruno Romano & Marco Fornaciari

^a Department of Plant Biology and Agro-environmental Biotechnology, University of Perugia, Borgo XX Giugno, 74 - 06121 Perugia, Italy

Available online: 18 Feb 2007

To cite this article: Fabio Orlandi Corresp. Author, Bruno Romano & Marco Fornaciari (2005): Relationship between pollen emission and fruit production in olive (*Olea europaea* L.), Grana, 44:2, 98-103

To link to this article: <http://dx.doi.org/10.1080/00173130510010440>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Relationship between pollen emission and fruit production in olive (*Olea europaea* L.)

FABIO ORLANDI, BRUNO ROMANO and MARCO FORNACIARI

Orlandi, F., Romano, B. & Fornaciari, M. 2005. Relationship between pollen emission and fruit production in olive (*Olea europaea* L.). – Grana 44: 98–103. ISSN 0017-3134.

Aerobiological data of pollen emission concentrations is used to predict fruit production. The principal aim of this work was to study the relationship between pollen emission patterns, emission homogeneity and fruit production in olive (*Olea europaea* L.). Data of daily pollen concentrations in the atmosphere during the flowering period, collected over a 20-year period in Perugia (Central Italy), and the corresponding fruit production data were analysed. Correlation and regression analyses on the partial pollen amounts (subdivisions of the whole flowering period), their statistical variability (expressed as coefficients of variation of the daily pollen concentration), and the production values in the different years demonstrate that pollen emission, during the seven to ten day period immediately preceding the maximum pollen emission day, appears to be most closely related to fruit production. Moreover, the pollen emission homogeneity (minimal variability in daily pollen concentrations) during the “critical” flowering period is very important for fertilization.

Fabio Orlandi*, Bruno Romano & Marco Fornaciari, Department of Plant Biology and Agro-environmental Biotechnology, University of Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy.

*Corresp. Author

E-mail: fabor@unipg.it

(Manuscript received 22 January 2004; accepted 29 October 2004)

A recent study has clearly shown the importance of accurately estimating pollen emissions in anemophilous species to predict future fruit production (Fornaciari et al. 2002). Since the 1980's, different methods have been used to forecast crop yields for agriculturally important species. In most cases, meteorological and biological variables were used (agro-meteorological models).

Some multi-year studies on olive and grape have demonstrated that there is a close relationship between the quantity of pollen released during flowering and fruit production (Besselat 1992, Cour & Richard 1992, Fornaciari et al. 1998, Minero et al. 1998). The pollen variable was almost always defined as the yearly pollen index (Ip) that is the summation of the daily pollen concentration values (average number of pollen grains/m³ of air) during the whole pollen emission period.

The aim of the present study was to initially identify the most predictive relationship between pollen emission in olive (*Olea europaea* L.) and yearly crop yield, considering partial flowering periods. A second objective was to determine if the eventual relationship between the concentration of pollen emitted during the subdivided periods and fruit production is related to pollen emission variability in the same periods. In other words, an attempt was made to understand if the pollen data of the most predictable pollination sub-periods also includes variability information about daily pollen concentrations and how the “pollen-production” relationships are influenced by this variability.

The second aspect is important because if there are different olive cultivars in an olive grove, a heterogeneous pollen emission could lead to the reproductive processes

being out-of-synchrony which would probably result in reduced inter-fertilization.

Pollen emission was studied in olive groves in the Province of Perugia (central Italy). The groves had different cultivars of olive (*Olea europaea* L.), almost all of which are local varieties that have problems with self-sterility. This self-sterility is frequently due to pollen tube growth being inhibited immediately after crossing the stigmatic surface. Olive has a gametophytic incompatibility that conserves a certain degree of heterozygosis. Natural selection occurs on the basis of the growth rate of the gametophyte through the pistil.

MATERIAL AND METHODS

The olive pollen emission was determined by using a pollen trap (VPPS 2000 Lanzoni model) with an estimated range of action of 30 km that was situated on the roof of the College of Agriculture at the University of Perugia (Fig. 1 & Table I). Annual olive production data for the period 1982–2001 were obtained from the Age Control S.p.A. database (Agency for the Control of the Italian Crop Production), and are expressed as total olive production for the Province of Perugia (tons of milled olives).

The trap is made up of two parts: a lower fixed part, and an upper mobile part which has a small aperture through which the airborne material enters, sucked in by a constant air flow volume (10 l/min). Using the pollen trap, we were able to sample the pollen content in the atmosphere. Through microscopic analyses of the olive pollen grains we determined the pollen concentration per cubic metre of air expressed as hourly, daily or weekly concentrations (Fornaciari et al. 1998, Gagnon & Comtois 1992, Tomas et al. 1997).

Once the daily pollen concentrations in the atmosphere were

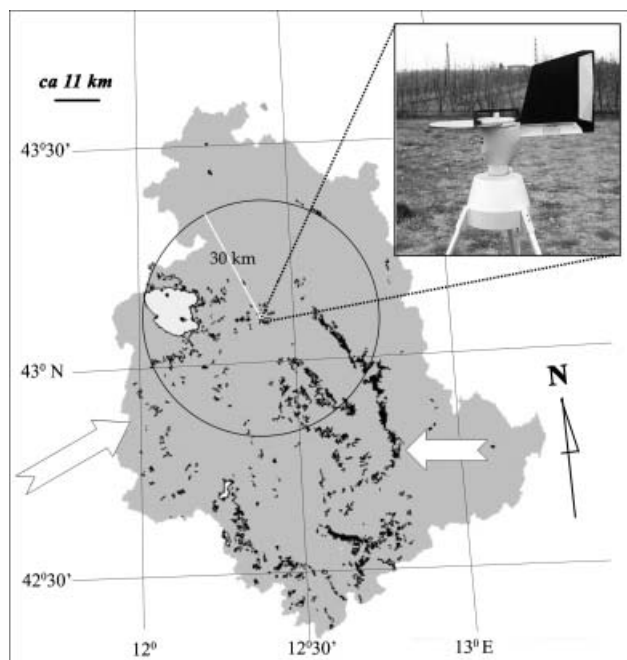


Fig. 1. Study region of Umbria. Pollen trap station in Perugia, black areas indicate the presence of olive groves and the aerobiological monitoring area is delimited by the circle surrounding the pollen trap. The olive cultivars found in the area nearby the pollen trap are listed in Table I.

calculated, the sum of the values were then used to determine the yearly Pollen indexes (Fornaciari et al. 1997); our database contains continuous Pollen index values (Ip) for nearly twenty years (1982–2001). The yearly pollination periods were subdivided into 79 “sub-periods” of varying length (from two to ten days, Table II) starting from the first monitoring day. The sub-periods were calculated in such a way that the total of all the sub-periods of the same duration (e.g. all the two-day sub-periods) was equal to the entire flowering period, which on the average, lasts 40 days.

In order to determine the most predictive relationship between pollen emission and fruit production a correlation analysis of the total sums of the pollen concentrations, in the 79 sub-periods, and the yearly olive production was made. Subsequently, the shorter sub-periods (calculated on a two to three day basis) were linked to identify “critical” pollination periods that could be adequately used for the statistical analyses, and justified from a physiological

Table II. Breakdown of the total pollination period (TPP) into 79 sub-periods.

Flowering Period	Sub-periods length (Days)								
	10	9	8	7	6	5	4	3	2
1	1	5	10	15	21	28	36	46	60
2									61
3									
4									62
5									
6									63
7									
8									64
9									
10									2
11	66								
12									
13	67								
14									
15	68								
16									
17	69								
18									
19	3	7	12	17	23	30	39	50	
20									71
21									
22									72
23									
24									73
25									
26									74
27									
28									75
29									
30	4	8	13	18	24	31	40	51	76
31									77
32									
33									78
34									
35									79
36									
37									80
38									
39									
40									

Table I. Olive cultivars in the study area and their self-sterility condition.

Cultivars	Extensiveness in the area	Characteristics
Dolce Agogia	Predominant	Partially self-sterile
Frantoio	Predominant	Self-sterile but advantaged by cross pollination
Leccino	Predominant	Self-sterile
Moraiolo	Predominant	Self-sterile
		Advantaged by cross pollination
Borgiona	Sporadic	Self-sterile
Bianchella	Sporadic	Self-sterile
Marchigiana	Sporadic	Self-sterile
Nostrale di Rigali	Sporadic	Self-sterile

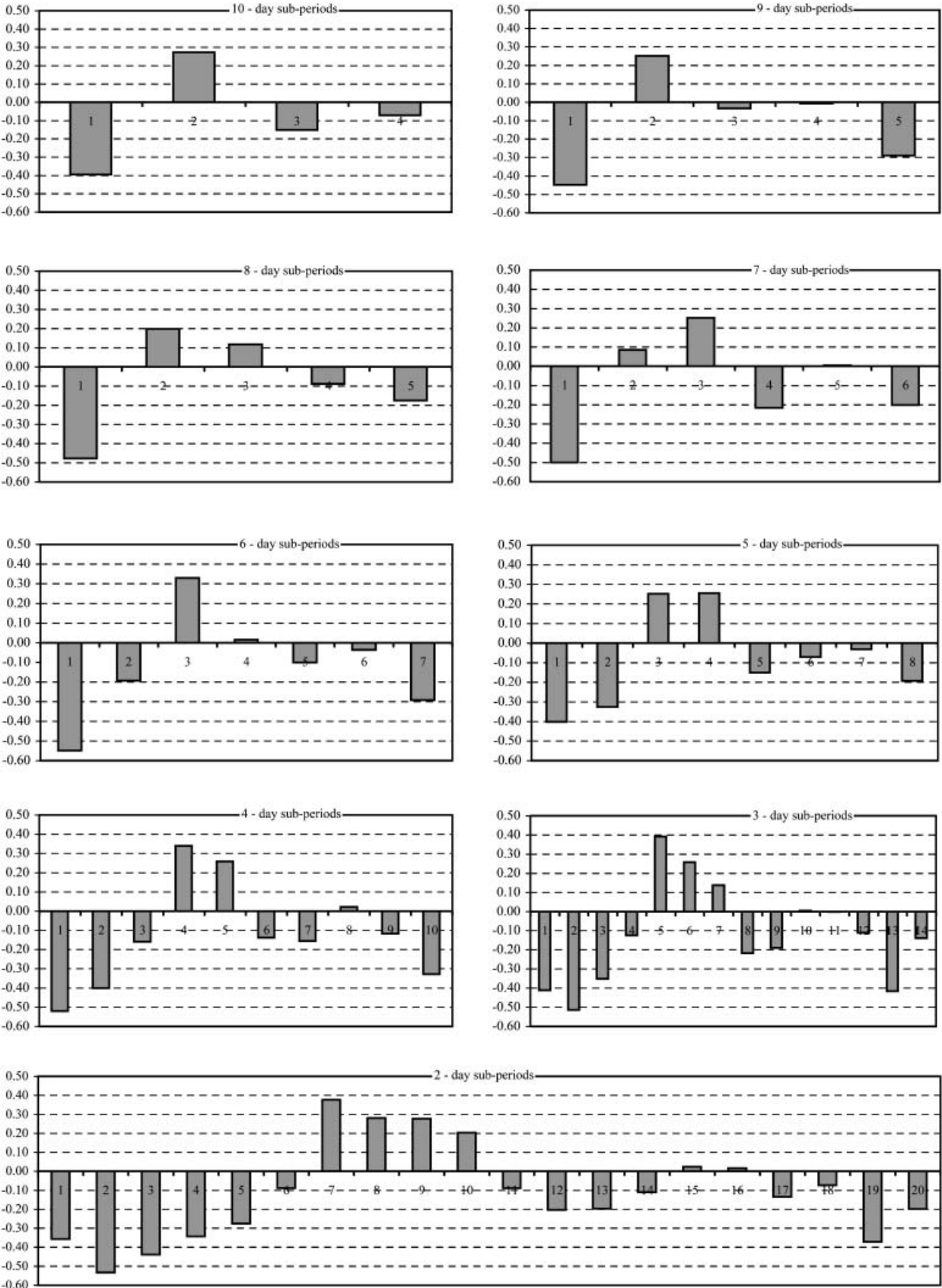


Fig. 2. Correlations between pollen summation in the 79 sub-periods and yearly productions.

point of view based on the biological characteristics of olive flowering.

The relationships between the partial summations of the daily pollen concentrations and their variabilities were evaluated for each "critical" sub-period. The variability of the pollen concentrations was determined by calculating the coefficients of variation (CV) in order to specify the degree of emission homogeneity for each "critical" sub-period. To predict the olive harvest entity, regression analyses were made using the yearly olive production as the dependent variable, with total pollen emission (Ip), the pollen emissions concentrated in the "critical" sub-periods and their coefficients of variation as the predictive variables.

RESULTS AND DISCUSSION

A detailed analysis, based on the consideration of two to three day linked sub-periods, showed that pollen emission during the first 12 days of flowering was negatively correlated with production, while pollen concentrations during days 13 to 21 were positively correlated (Fig. 2). Therefore within the whole olive flowering phenomena two main "critical" sub-periods of pollen emission were identified (Fig. 2), an "initial" (12 day period) and a "central" (eight-day period). The final part of the entire flowering, (≈ 20 day period), always gave contrasting results with low correlation values. For this reason, the ends of the pollination periods were pooled into a single group called the "final" pollination interval and had little influence on the analysis results.

A correlation matrix among pollen emission summations recorded in the three "critical" pollination sub-periods ("initial", "central" and "final"), and the corresponding CV related to the total pollen emission period and to the three identified sub-periods was calculated (Table III). There is a positive correlation ($r=0.60$) between the coefficient of variation in the first 12 days of pollination ("initial" phase) and the pollen released ("central" phase) during the subsequent eight-day period (Table III). On the other hand, a significant negative correlation ($r=-0.54$) was recorded between the coefficient of variation of the central phase and the corresponding pollen emission summation (Table III). These last correlation results show that the increases in pollen emission during the central phases (correlated with the final production as indicated by the preceding analysis, Fig. 2) correspond to increased pollen variability in the initial phase and to a low variability in the central interval. In the same way, there is a positive, but not significant

Table III. Correlation matrix between Σ of pollen concentrations in the three flowering periods and the corresponding coefficient of variation.

	Σ Pollen emission in interval			
		Initial	Central	Final
Σ Pollen emission in interval	Initial	1.00	0.29	0.05
	Central	0.29	1.00	-0.19
	Final	0.05	-0.19	1.00
C.V. in the emission intervals	Total	0.14	-0.15	-0.19
	Initial	-0.54	-0.11	0.16
	Central	0.60	0.46	-0.47
	Final	0.24	-0.20	0.21

relationship, among the pollen emissions during the initial phases ($r=0.46$) and the final phases ($r=0.21$) with their corresponding coefficient of variation values. This fact demonstrates that pollen emissions concentrated at the beginning and end of the flowering period are associated with high levels of heterogeneity. The inverse and significant relationship ($r=-0.54$) between the "central" phase pollen emission and its CV, indicate that the emission homogeneity may affect its positive relationship with the final fruit production.

The results of the regression analyses are reported considering different variables:– yearly olive production,

- total pollen index (Ip),
- the pollen quantity released during the 8 days of the central phase,
- the coefficient of variation calculated in this last period.

Table IV. Regression data.

■ Production as dependent variable ■ Pollen Index (Ip) as independent variable.				
Coefficients	Value	Std. Error	t value	Pr(> t)
(Intercept)	226978.76	59360.92	3.82	0.00
IP	14.25	11.62	1.23	0.24
Multiple R-Squared: 0.38				
F-statistic: 5.266 on 2 and 17 degrees of freedom, the p-value is 0.01				
■ Production as dependent variable ■ Pollen Index in the "central" interval (Ipr) as independent variable				
Coefficients	Value	Std. Error	t value	Pr(> t)
(Intercept)	221361.79	43285.86	5.11	0.00
Ipr	28.75	13.42	2.14	0.05
Multiple R-Squared: 0.47				
F-statistic: 7.564 on 2 and 17 degrees of freedom, the p-value is 0.00				
■ Production as dependent variable ■ Pollen Index and coefficient of variation in the "central" interval as independent variables (Ipr and CVr).				
Coefficients	Value	Std. Error	t value	Pr(> t)
(Intercept)	438323.79	141800.61	3.09	0.01
Ipr	15.56	15.26	1.02	0.32
CVr	-287971.77	179999.44	-1.60	0.13
Multiple R-Squared: 0.54				
F-statistic: 6.35 on 3 and 16 degrees of freedom, the p-value is 0.00				
■ Production as dependent variable ■ Coefficient of variation in the "central" interval as independent var.				
Coefficients	Value	Std. Error	t value	Pr(> t)
(Intercept)	538494.77	102405.60	5.26	0.00
CVr	-387136.04	151663.44	-2.55	0.02
Multiple R-Squared: 0.51				
F-statistic: 8.99 on 2 and 17 degrees of freedom, the p-value is 0.00				

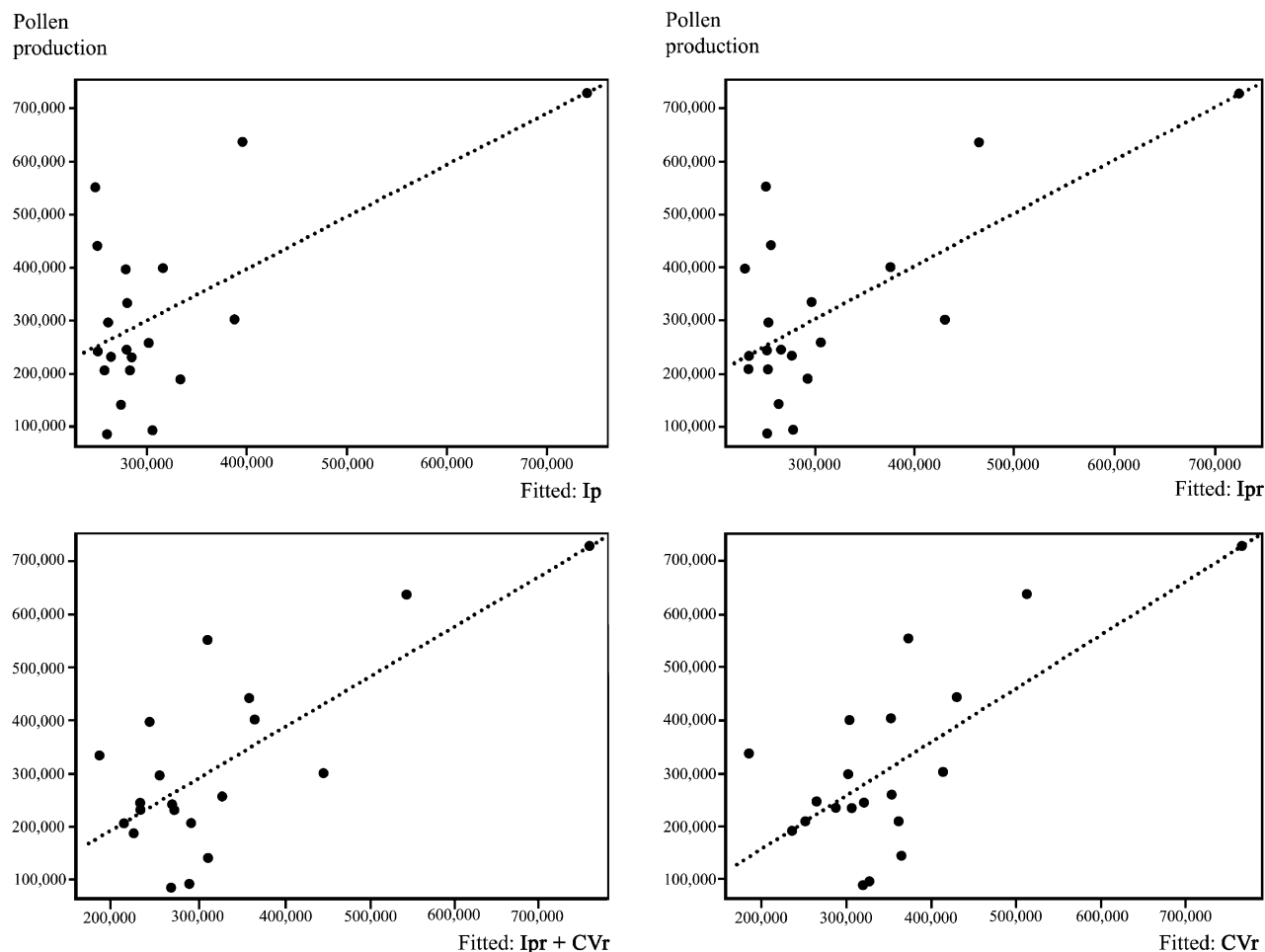


Fig. 3. Regression lines derived from the analyses among Pollen production, Pollen index (Ip), Pollen amount in the “central” flowering period (Ipr) and the Coefficient of variation in this last period (CVr).

By introducing the summation of the daily pollen concentrations during the eight-day period, as a restricted pollen index (Ipr), the statistical results improved with respect to those obtained with the original pollen index (the multiple R^2 increased from 0.38 to 0.47 and the significance level of the variable also increased). By introducing the variable related to the statistical variability degree within the “central” pollen emission period, the results improved even further (Table IV). However, the most interesting data were obtained by using only this latter variable in the regression analysis. In this manner, the highest statistical significance of the variable was obtained and the degree of explained variability by the productive event was greater than 50%. This result is notable because a single biological variable such as pollen used in the statistical models for predicting production (agrometeorological models, time trend analyses, etc.) rarely reaches values higher than this (Fornaciari et al. 2002, Kaufmann & Snell 1997).

Data from 1982 to 2001 were used in the regression analyses but a dummy variable was introduced to compensate for the outlier value related to the olive production in 2000 (Fig. 3). This was necessary in order to remove the distortion effect in the statistical analysis.

CONCLUSIONS

The results of this study show that pollen concentrations during the second ten days of the flowering period in olive are directly correlated with the future fruit production. This demonstrates the need to identify the quantity of pollen emitted, as well as the exact period in which this emission occurs. Pollen emission trends provide an indication of the future fruit production (Fornaciari et al. 1997).

The analyses regarding the homogeneity of pollen emissions during the considered intervals showed a link between pollen emission during the eight day “central” period and the daily variability during this period. This allowed us to interpret the positive correlation between fruit production and pollen release in this sub-period as the correlation between production and the same variability.

From a biological point of view, a greater homogeneity of pollen emission corresponds to a greater possibility of cross-pollination between different self-sterile cultivars. An increase in the percentage of successful pollination processes between pollinator and no pollinated plants, is strictly correlated with successful fertilization and consequently, with higher total production values.

ACKNOWLEDGEMENTS

The Authors thank Dr. Nancy Hutchinson for critically reading and revising the English version of the manuscript.

The research is supported by the C. N. R. funds for "Biodiversity".

REFERENCES

- Besselat, B. 1992. La prévision du potentiel de récolte a l'aide de la technique du dosage pollinique de l'atmosphère. – In: Méthodes aéropalynologiques, phénologie de la floraison et prévision de rendements. Int. Conf. Bordeaux 1992. Proc. (ed. Org. Comm.), pp. 9–12. – CEMAGREF, Bordeaux.
- Cour, P. & Richard, P. 1992. Les méthodes aéropalynologiques: un inventaire des domaines d'applications en agriculture, en biogéographie et en bioclimatologie. – In: Méthodes aéropalynologiques, phénologie de la floraison et prévision de rendements. Int. Conf. Bordeaux 1992. Proc. (ed. Org. Comm.), pp. 13–14. – CEMAGREF, Bordeaux.
- Fornaciari, M., Pieroni, L., Ciuchi, P. & Romano, B. 1997. A statistical model of airborne pollen grains and some meteorological parameters (*Olea europaea* L.). – *Agricolt. Mediterr.* 127: 134–137.
- Fornaciari, M., Pieroni, L., Ciuchi, P. & Romano, B. 1998. A regression model for the start of the pollen season in *Olea europaea* L. – *Grana* 37: 110–113.
- Fornaciari, M., Pieroni, L., Orlandi, F. & Romano, B. 2002. A new approach to consider the pollen variable in forecasting yield models. – *Econ. Bot.* 56: 66–72.
- Gagnon, L. & Comtois, P. 1992. Peut-on comparer les résultats de différents types de capteurs polliniques? – *Grana* 31: 125–130.
- Kaufmann, R. K. & Snell, S. E. 1997. A biophysical model of corn yield: integrating climatic and social determinants. – *Am. J. Agr. Econ.* 79: 178–190.
- Minero, F. J. G., Candau, P., Morales, J. & Tomas, C. 1998. Forecasting olive crop production based on ten consecutive years of monitoring airborne pollen in Andalusia (Southern Spain). – *Agricult. Ecosyst. Environ.* 69: 201–215.
- Tomas, C., Candau, P. & Gonzalez Minero, F. J. 1997. A comparative study of atmospheric pollen concentrations collected with Burkard and Cour samplers, Seville (Spain), 1992–1994. – *Grana* 36: 122–128.