

The importance of cultivated land for spreading of allergenic plants in Italy

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Abstract We studied the ecological characteristics of the plants of Italian cultivated land that cause allergies in sensitized individuals. Differences between the allergenic flora of annual and perennial cultivations were found. Prevalence of annual therophytes was found in seasonal and annual crops subjected to soil tillage and to strong human disturbance. Plants growing in stable, moderately disturbed cultivations (citrus and olive groves, vineyards) were more often perennials. Allergenic species dispersed by wind and those endowed with multiple dispersal strategies (polychory) were well represented in seasonal and annual crops. The moderate height of these cultivations facilitates circulation of air, favouring the diffusion of anemochoric plants, which explains the abundance of the *Poaceae* and the *Asteraceae* families. The spreading of some allochthonous invasive allergenic species was ascertained. The entrance of allergenic plants from surrounding natural ecosystems increases the overall allergenicity of Italian cultivations. The results obtained pointed out a strong relationship between allergenic flora, human impact, and the structure of the cultivations. They point out the importance of knowledge about the ecological characteristics of the allergenic flora

infesting the cultivations, which enables efficacious control of the diffusion of the most dangerous species.

Keywords Allergenic plants · Ecology · Pollen morphology · Cultivated land · Italy

1 Introduction

In the last five centuries the flora of cultivated land in Europe has undergone notable changes caused by new farming techniques and by contact with new territories. After the discovery of America, the establishment of neophytes began, a process affected by many factors, among them historical and cultural (Kowarik 2003). Even though the various species each followed their own historical and environmental itinerary, some colonized new crops (for example maize, sunflowers, oilseed rape).

A number of contributions report the results of different studies on the Italian flora and vegetation infesting cultivations (Allegrezza and Hruska 1992; Baldoni 1995; Poldini et al. 1998; Covarelli 2002). On entering the respiratory tract of sensitized subjects, particularly in some categories of workers, for example ground keepers and florists, the pollen of some plants provokes a set of reactions (nasal discharge, sneezing, and itchy, watery eyes) termed

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“pollinosis” or “hay fever” (D’Amato et al. 2007). These reactions can also be provoked by pollen of cultivated species (Fornaciari et al. 2000). Atmospheric pollutants accentuate the phenomenon (Riera et al. 2002), and cross reactions between pollen and foods, for example fruit and vegetables, are becoming increasingly frequent (Sampson 2004). Although aerobiological and allergological aspects of these manifestations are fairly well understood, little is known to date about the ecological characteristics of the plants infesting the cultivated areas that produce allergenic pollen. The need for an interdisciplinary approach involving aerobiology and ecology has just been noted by some researchers (Edmonds 1979; Linskens and Cresti 2000).

This paper was written with the intention of supplementing the lack of work in this field and elucidating the relationship between the allergenic flora of cultivated land and human impact. The phytoallergenic contingent studied in this paper is formed prevalently by plants which release allergenic pollen grain into the atmosphere, and by those which cause cross reactions with food or contact allergy (Weber 2007). Because cross reactivity is an allergic phenomenon which is currently being studied, and needs to be examined more closely, the allergenic flora infesting the Italian cultivations examined in this paper, was treated as a whole. The research is considered as the initial step toward knowledge of the allergenic flora infesting cultivated land and examines this flora without aerobiological monitoring, which seems very complicated in this case, because of the geographical extent of the territory considered.

This issue is fairly complex, considering the heterogeneous origins of the vascular flora that infests this territory. We supposed that weed management could affect the ecological characteristics of allergenic species infesting the cultivations, favouring their spreading. Utilizing data obtained in this work we will seek to answer the following questions:

- 1) What are the ecological characteristics of the species infesting Italian cultivations which provoke allergic effects on human health?
- 2) Does cultivated land, exposed to various types of human disturbance, promote the spreading of allergenic plants?

We hoped the results obtained would confirm the importance of knowledge of the ecology of allergenic

flora and stimulate further investigations on the most dangerous species in order to ensure better protection of the pollen-sensitive population.

2 Methods

2.1 Study area

The study was carried out in various locations from the Northern (47°05'N) to the Southern part (35°29'S) of the Italian peninsula. Our research included various types of cultivated land whose altitude ranges from 20 to 1,200 m a.s.l. The geographical distribution of the stations studied is reported in Table 1. Sampling was done prevalently at lower altitudes of the hilly belt, where numerous areas of cultivated land were present. The highest sampled site was at 1,200 m a.s.l.

2.2 Data collection and analysis

Sampling of flora infesting Italian cultivated land was carried out in the years 1995–2008. The plots of approximately 100 m² standard size were selected in 14 different crop types, preferably not recently treated with herbicides. They are: wheat, rye, barley, lentil, maize-beet (fields of maize with the beet situated on the edges or in alternate rows), vegetables (leek, sweet fennel, onion, etc.), maize, root crops (rape, beet, or potatoes), olive groves, fodder, citrus

Table 1 Geographical position, and the number of the plots of the cultivated land in Italy where the allergenic flora was studied

Region	Number of plots
Trentino-Alto Adige	37
Veneto	25
Friuli	27
Emilia-Romagna	80
Toscana	45
Marche	120
Umbria	85
Lazio	51
Puglia	28
Campania	32
Sicilia	71

groves, resting crops (or fallow land), stubble, and vineyards. Total number of plots sampled was 601. Vascular flora was recorded in every cultivated plot during one vegetative period at least. When possible, and in relation to frequent changes of the types of cultivation in the same plot, the observations were repeated during the subsequent years of the period indicated before. Uniting data on the spontaneous vascular flora identified in the same type of crop, we obtained species lists, from which we extrapolated the allergenic plants, identified using the Allergome database (2009). The cover of every allergenic species was checked using the Braun-Blanquet scale (Westhoff and van den Maarel 1978). For every single plant present in a determinate crop type the mean percentage cover value is reported, obtained from the ratio of its cover to the total number of observations in the crop. Crop plants with allergenic pollen were excluded from the data sets. The total number of allergophytes was 189 species. This number includes all the allergenic species, those with the allergenic pollen grain together with plants responsible for cross reactions; either the species which produce pollen grain in abundance or those with moderate production and weakly allergenic pollen. The last group, noted locally in luxuriant populations, produces in some areas a notable quantity of pollen. Contributing to the total amount of pollen released in atmosphere, these species could be considered sensu D'Amato et al. (2007) equally responsible for the allergenic reactions in sensitized persons. Taxonomic nomenclature of the species follows Conti et al. (2005). Grouping them in appropriate partial lists concerning different types of crops considered, these data sets were then used to identify the biological traits of the individual species, following the Raunkiaer classification (1934) and to conduct the ecological analysis of allergenic flora. The morphological data on the pollen were drawn from Erdtman (1971) and Grant Smith (1990).

One-way ANOVA was used to compare the allergenic weed flora present in 14 different crop types and to search for significant differences in the distribution of allergophytes in the crop types studied. The threshold for statistical significance was set at $P \leq 0.05$. To identify the overall variation patterns in species composition correspondence analysis was employed, using computational routines of PAL-STAT software (Ryan et al. 1994).

For the dispersion strategies of the allergenic flora infesting cultivated fields, Bullock et al. (2002) was used. We wanted to verify the relationship between life forms and human disturbance performing a regression analysis on the T/H quotient according to Sokal and Rohlf (1995). To clarify the relationship between the dispersal strategies of allergenic flora and the structure of different crop types the height of the cultivations was checked, uniting them in four main groups according to the mean value of their height (50, 100, 150, or 200 cm).

3 Results

3.1 Ecological analysis

Table 2 reports the list of the most frequent allergenic plants in Italy infesting cultivated land. As regards the taxonomical position (Table 3) the presence of *Poaceae* and *Asteraceae* do not change significantly in either annual or perennial crops. The species of the *Rosaceae* family, instead, are more common in stable cultivations, suggesting contact with shrubberies and woodland edges. Sporadically present and scarcely abundant is a group of allergophytes belonging to 13 different families (*Plantaginaceae*, *Chenopodiaceae*, *Solanaceae*, *Amaranthaceae*, among others).

Correspondence analysis revealed difference between the species composition of different crop types (Fig. 1). Three groups of allergenic plants can be observed: the first (group A) growing with the cereals (wheat, rye and barley; maize cultivations excluded), the second (group B) in root crop fields (vegetable, beet and potatoes), and the third (group C) present in perennial, stable cultivations (olive groves, vineyards, citrus groves, among others). The ordination diagram shows similarity in the gradients connected with the changes of human management and with environmental conditions. The first axis indicates that human disturbance affects the species composition during the vegetation period (from spring to summer/autumn). The second axis can be correlated with environmental conditions in which the mean annual temperature and precipitation are probably the most important variables.

Comparing the ecological characteristics of the allergenic flora of different crop types, species growing in annual or seasonal crops have a short

Table 2 The most important allergenic plants in the 14 different crop types in Italy

Abbreviations	No of crop type	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No of plots	65														
Crop type	Wheat	Rye	Barley	Lentil	Maize-beet	Vegetable	Maize	Root crops	Olive groves	Fodder	Citrus groves	Resting crops	Stubble	Vineyards	
Species															
Al.pr	<i>Alopecurus pratensis</i>	40													81
Am.al	<i>Amaranthus albus</i>				100	60									
Am.gr	<i>Amaranthus graecizans</i>				29		26				20				32
Am.re	<i>Amaranthus retroflexus</i>				44	31	42	100			45				
Am.ar	<i>Ambrosia artemisiifolia</i>				15		39						13		
An.ar	<i>Anthemis arvensis</i>	59	15	15	75							14			
An.od	<i>Anthoxanthum odoratum</i>								15	90	12	15			
Ar.el	<i>Arrhenatherum elatius</i>	10				10			12	85	29		10		
Ar.al	<i>Artemisia alba</i>							23				32			30
Ar.vu	<i>Artemisia vulgaris</i>	10						15				33			41
Av.fa	<i>Avena fatua</i>	10	20					19		20					10
Av.st	<i>Avena sterilis</i>										20				
Be.pe	<i>Bellis perennis</i>								32	38				20	26
Br.ni	<i>Brassica nigra</i>										60	30			
Br.di	<i>Bromus diandrus</i>	21	60											15	
Br.er	<i>Bromus erectus</i>									25		32	25	15	25
Br.st	<i>Bromus sterilis</i>							10				15	10		
Br.ar	<i>Bromus arvensis</i>	80	10			10	15					80			15
Ch.al	<i>Chenopodium album</i>	15				100	23	35	100		20	45			21
Ch.po	<i>Chenopodium polyspermum</i>	10				20			35						15
Ci.in	<i>Cichorium intybus</i>						10						80		
Cy.da	<i>Cynodon dactylon</i>						15	15	20		15	15	10	10	
Cy.ro	<i>Cyperus rotundus</i>					10					20				15
Da.gl	<i>Dactylis glomerata</i>				15					85		10		25	15
Daca	<i>Daucus carota</i>	10			10				95	30		21	30		95
Di.sa	<i>Digitaria sanguinalis</i>					21	40	65	20						

Table 2 continued

Abbreviations	No of crop type	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No of plots	Crop type	Wheat	Rye	Barley	Lentil	Maize-beet	Vegetable	Maize	Root crops	Olive groves	Fodder	Citrus groves	Resting crops	Stubble	Vineyards
Species															
Di.er	<i>Diplotaxis erucoides</i>	10					45		30		35	20	25	30	
Ec.cr	<i>Echinochloa crus-galli</i>	25					95		80				100		
El.re	<i>Elymus repens</i>	10										80	85		
Er.bo.	<i>Erigeron bonariensis</i>						25						15		
Fe.pr	<i>Festuca pratensis</i>										85	10	20	20	
Fo.vu	<i>Foeniculum vulgare</i>								25			20	25	15	
Gl.se	<i>Glebionis segetum</i>	10		50								50	20		
Ho.la	<i>Holcus lanatus</i>										65			10	
Le.vu	<i>Leucanthemum vulgare</i>	15									45	25			
Lo.mu	<i>Lolium multiflorum</i>	90	25	90											
Lo.pe	<i>Lolium perenne</i>	10				10			15	95	40	95	32		95
Ma.ca	<i>Matricaria chamomilla</i>	40		35					25				60		60
Me.sa	<i>Medicago sativa</i>				10				15				75	25	
Me.an	<i>Mercurialis annua</i>				10			20	80				20	15	
Mo.ar	<i>Moricandia arvensis</i>	20	10	15	10										
Pa.rh	<i>Papaver rhoeas</i>	100	50		30	15					20	15			10
Ph.pr	<i>Phleum pratense</i>	10			23						60			35	
Pl.la	<i>Plantago lanceolata</i>		15	21	10		10	10			65	65		20	15
Pl.ma	<i>Plantago major</i>			10		15	10				21	20			
Po.an	<i>Poa annua</i>		10	15		15			25	15					
Po.pr	<i>Poa pratensis</i>									23	80		21	25	15
Po.tr	<i>Poa trivialis</i>			15							75		10	22	19
Pr.sp	<i>Prunus spinosa</i>												23	34	15
Ro.ca	<i>Rosa canina</i>												31		29
Ru.ca	<i>Rubus caesius</i>											20			15
Ru.cr	<i>Rumex crispus</i>	15							20			15	10	10	21
Sa.eb	<i>Sambucus ebulus</i>													20	
Se.vi	<i>Setaria viridis</i>					45	40	10		10					30
Si.ar	<i>Sinapis arvensis</i>	70		23	70							15			

Table 2 continued

Abbreviations	No of crop type	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No of plots	Crop type	65	20	25	30	25	38	65	50	70	35	51	25	32	70
Species		Wheat	Rye	Barley	Lentil	Maize-beet	Vegetable	Maize	Root crops	Olive groves	Fodder	Citrus groves	Resting crops	Stubble	Vineyards
So.ni	<i>Solanum nigrum</i>					20	25	30				25			
So.ha	<i>Sorghum halepense</i>						35	29	40						
Sy.sq	<i>Symphoricarichum squamatum</i>						30	33							27
Ta.of	<i>Taraxacum officinale</i>										60			60	
Ul.mi	<i>Ulmus minor</i>					10	10					20			
Vi.sa	<i>Vicia sativa</i>		10	15				19	20			35	15		
Xa.sp	<i>Xanthium spinosum</i>					10		25	30				10		

The presence of allergenic species is evaluated using the Braun-Blanquet's scale (according to Westhoff and van den Maarel 1978) and expressed as a mean cover value for every species when present in determinate crop type; species with less than 10% cover are not included in the list. The column on the left reports the species abbreviations used during the computational elaborations of the data. The second row in the head of the table points out the number of plots studied for every crop type

Table 3 Principal characteristics of the allergenic flora of the cultivated land in Italy ($\pm$ standard deviation, *SD*; only the most important species traits are reported)

Characteristics	Allergophytes	
	Annual crops	Stable groves
Taxonomic groups		
Poaceae	63.2 $\pm$ 51	37.3 $\pm$ 6.6
Asteraceae	19.6 $\pm$ 1.7	21.3 $\pm$ 3.2
Rosaceae	4.2 $\pm$ 1.9	15.3 $\pm$ 8.2
Others	3.9 $\pm$ 0.4	6.3 $\pm$ 1.8
Life cycle		
Annuals	85.0 $\pm$ 1.1	49.3 $\pm$ 3.2
Perennials	2.9 $\pm$ 0.7	29.5 $\pm$ 1.2
Life forms		
Therophyte	54.5 $\pm$ 3.9	25.7 $\pm$ 2.9
Hemicryptophyte	45.1 $\pm$ 2.7	67.4 $\pm$ 4.1
Geophyte	1.7 $\pm$ 0.5	4.3 $\pm$ 0.9
Dispersal mode		
Anemochory	55.1 $\pm$ 7.2	39.1 $\pm$ 12.1
Polychory	25.3 $\pm$ 1.9	19.9 $\pm$ 1.7
Myrmecochory	6.4 $\pm$ 0.7	4.7 $\pm$ 4.3
Anthropochory	3.1 $\pm$ 0.4	2.6 $\pm$ 1.7

Different taxonomic positions, life cycles, life forms and dispersal strategies of the allergenic flora of annual and stable cultivations can be observed

life cycle and are often annuals and therophytes (Table 3). Allergenic plants typical of stable groves are more often perennials and hemicryptophytes. Regression analysis performed on the therophyte/hemicryptophyte quotient obtained for the crop types studied (Fig. 2) shows a significant relationship between life form and human management.

Differences between dispersal strategies of annual and perennial crops were significant (Table 3). Comparing dispersal mode with the height of cultivated plants, the abundant presence of anemochoric allergophytes, which use the wind as the dispersal vector, in low, annual, and seasonal crops was ascertained (Fig. 3). Polychory, however, i.e. the possibility of adapting the mode of dispersal to the ecological conditions of the determinate area by utilizing various vectors (wind, humans, animals, among others), is present rather equally in all the cultivations and is more favoured in those exposed to frequent changes as a result of management (vegetables, maize-beet, among others). Myrmecochorous dispersal mode,

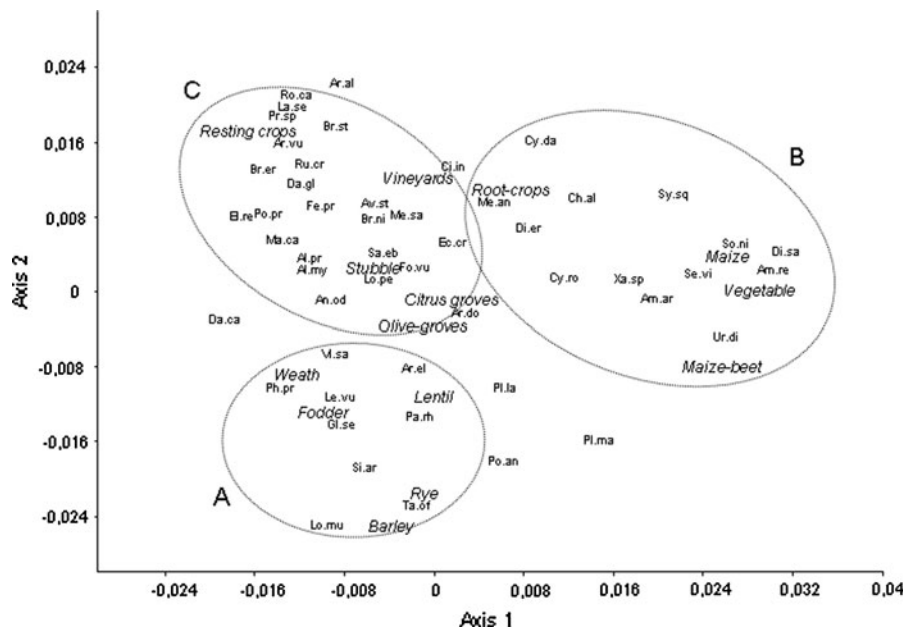


Fig. 1 Ordination diagram of canonical correspondence analysis (CCA) of Italian allergenic flora of the cultivations studied. Abbreviations of the species are as given in Table 2. Three groups of allergenic plants can be observed: the first (group A) growing with the cereals (wheat, rye, and barley), the second (group B) in root-crop fields (vegetables, beet, and potatoes), the third (group C) present in perennial, stable

cultivations (olive groves, vineyards, citrus groves, among others). The *first axis* indicates the human disturbance which affects species composition during the same vegetation period (from spring to summer/autumn). This explains the position of the maize fields among the root crops. The *second axis* can be correlated with environmental variables (probably with temperature and precipitation as the most important factors)

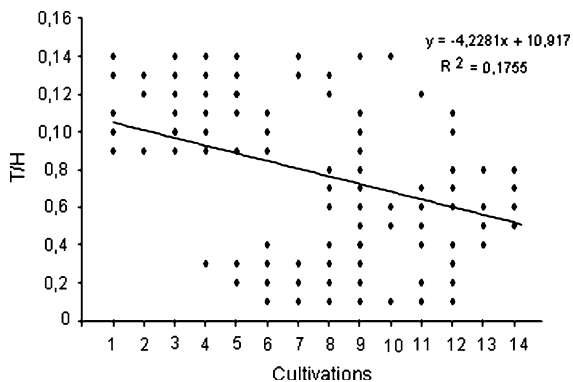


Fig. 2 Results of regression analysis on the quotient Therophytes/Hemicryptophytes of the allergenic flora of the cultivations studied. A significant relationship between life form and human management can be observed. Annual crops are exposed to the frequent changes as a result of management (hoeing, ploughing), which favour growth of annual or seasonal therophytes with short life cycles. In the stable groves, where human disturbance is moderate and constantly repeated in the same way, the perennial hemicryptophytes are more common

with ants as dispersal vectors, was more frequent in the root crops, indicating the affinity of the ants for the disturbed habitats with disturbed soil.

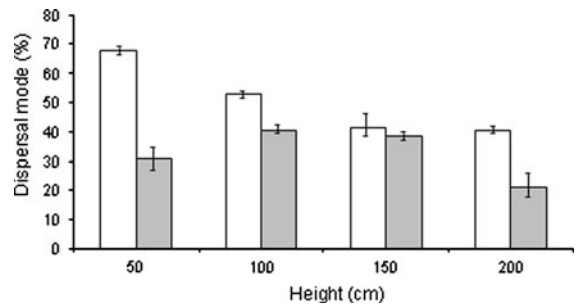


Fig. 3 Relationship between the height of cultivations and the mode of dispersal of Italian allergenic flora infesting cultivated land (anemochory = white columns, polychory = grey columns). The abundant presence of anemochoric, wind-dispersed allergophytes in low, annual, and seasonal crops can be observed. Polychory, i.e. the possibility of changing the mode of dispersal in response to the ecological conditions of the environment, is weakly related to the height of cultivation

The difference between cereal fields and other types of cultivation is confirmed by ANOVA (Table 4). Considering the changes in species composition across 14 crop types studied, the allergenic flora of the wheat fields shows a positive correlation

Table 4 Results of ANOVA for the allergenic plants present in the crop types studied ($P \leq 0.05$). Numbering of the cultivations studied follows Table 2

Crop type	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	n.s.		n.s.		$F = 0.88$	$F = 2.85$	$F = 1.57$	$F = 0.05$	$F = 0.05$	$F = 1.20$	$F = 0.08$	$F = 0.07$	$F = 0.19$	$F = 0.44$
2			$F = 0.10$	$F = 0.001$	$F = 2.59$	$F = 1.29$	$F = 2.10$	n.s.	$F = 0.17$	n.s.	n.s.	n.s.	n.s.	n.s.
3				$F = 0.07$	$F = 1.64$	$F = 0.55$	$F = 1.18$	n.s.	$F = 0.02$	n.s.	n.s.	n.s.	n.s.	n.s.
4					$F = 2.26$	$F = 1.02$	$F = 1.76$	n.s.	$F = 0.13$	n.s.	n.s.	n.s.	n.s.	n.s.
5						$F = 0.47$	$F = 0.08$	$F = 0.51$	$F = 1.17$	n.s.	$F = 0.55$	$F = 1.59$	$F = 2.08$	$F = 2.82$
6							$F = 0.18$	$F = 2.08$	$F = 0.28$	n.s.	$F = 2.56$	n.s.	n.s.	n.s.
7								$F = 1.03$	$F = 0.76$	n.s.	$F = 1.19$	$F = 2.58$	$F = 3.23$	n.s.
8									$F = 3.09$	$F = 1.71$	$F = 0.002$	$F = 0.26$	$F = 0.46$	$F = 0.82$
9										n.s.	$F = 3.73$	n.s.	n.s.	n.s.
10											$F = 2.07$	$F = 0.77$	$F = 0.53$	$F = 0.28$
11												$F = 0.37$	$F = 0.63$	$F = 1.08$
12													$F = 0.03$	$F = 0.16$
13														$F = 0.06$
14														

The allergenic flora of the wheat fields shows a positive correlation with other cereals ($F = 0.1$). The root crops have a marginally significant positive correlation with the allergenic flora of the wheat fields ($F = 2.59$). The stable groves group is not significantly (n.s.) correlated with other crop types

$F = 3.902$, $\alpha = 0.05$

with other cereals ($F = 0.1$). Some root crops have a marginally significant positive correlation with the wheat fields ($F = 2.59$). The correlation between cereal fields and root crops is rather heterogeneous, suggesting the effect of the human management. The group of stable groves shows non-significant (n.s.) correlation with other crop types.

3.2 Pollen morphology

Our studies, conducted according to the classification of Erdtman (1971) and Grant Smith (1990), have revealed a fairly uniform palynologic spectrum (Fig. 4), with prevalence of species of the *Poaceae*, followed by those of the *Asteraceae* and *Apiaceae*. The importance of the *Poaceae* family for pollen production was confirmed by Prieto Baena et al. (2003). The abundance of the *Poaceae* family in the pollen flora of the cultivated land can be associated with an incidence of allergies in ground keepers and other workers (Emberlin 1997; Esch 1999). Pollen production by the species belonging to this family could be connected also with the climatic conditions of the single area as suggested by Norris-Hill (1997). The uniformity of the pollen morphology suggests the importance of the human management on the crops, which selects the allergenic species most capable of adapting their life strategies to the ecological conditions of the cultivations. However, additional research is needed to ascertain this hypothesis. It

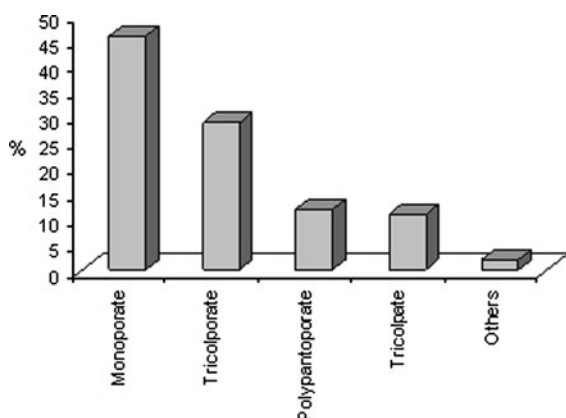


Fig. 4 Pollen morphology of the Italian allergenic flora infesting the cultivations. The uniformity of this diagram confirms the role of the human management on the crops, which selects the allergenic species most capable of adapting their strategies to the ecological conditions of the cultivations

would be very interesting to obtain data on variations in the abundance of the pollen of some of the most dangerous species as suggested by the research performed in Spain (Sanches-Mesa et al. 2003) and in some areas of western Europe (Emberlin et al. 2000).

4 Discussion and conclusions

4.1 Ecological strategies

The analysis of the composition of allergenic flora infesting Italian cultivations showed that the type of human disturbance has a significant effect, grouping together the species of annual crops and those of stable crops. A poorly articulated biological spectrum with prevalence of annual therophytes was found in the seasonal and annual crops subjected to soil tillage and to human disturbance several times every year. This accords with the strategies proposed by Grime (2001) and with the results obtained for the vegetation of cultivated fields in central Europe (Lososová et al. 2008). In stable settings (vineyards, and olive and citrus groves) perennial hemicryptophytes were well represented, and geophytes slightly less so. Patterns related to life forms change along the gradient of human disturbance. The decrease of the T/H quotient from annual to perennial cultivation also confirms the importance of human disturbance regimes on the life forms. The type of human impact and frequent changes of agricultural management during the same vegetative period (hoeing, uprooting, among others) affects, in some cultivations (for example root crops, maize, or mixed cultivations of maize and beet), the selection of the allergenic flora infesting these fields. This explains the collocation of the maize fields by mean of computational methods.

The dispersal strategies of the allergenic flora reflect the ecological conditions of the fields, as suggested by Ozinga et al. (2004). Free circulation of masses of air and the openness of arable fields promotes the anemochoric species, whereas stable crops with their canopy of cultivated plants can reduce the effect of wind dispersal. This accords with the results obtained by Tackenberg et al. (2003). Thus the *Poaceae* are more abundant in annual crops; some of these, for example *Lolium perenne*, *Cynodon dactylon*, *Bromus sp. pl.*, and *Poa sp. pl.*, were, in

fact, present in numerous samples processed here. The stable cultivations are frequently in direct contact with various ecotonal habitats (Rastelli et al. 2003), with shrubberies and woodlands.

Landscape complexity positively affects the species diversity of the cultivated land (Gabriel et al. 2005). For this reason the allergenic flora of stable crops is enriched with various environmental species (*Sambucus ebulus*, *Ulmus minor*, among others). The polychoric plants, capable of changing their dispersal strategy in response to ecological conditions, are well represented in vegetables, root crops and mixed crops exposed to frequent disturbances by humans and changes in management. All this confirms again the relationship between allergenic flora and human practices in agricultural landscapes, which directly affects plant diversity, as observed in European cultivated lands by Stoate et al. (2001).

Ants as vectors of the dispersion of allergenic flora were most abundant in moderately disturbed areas (stubble, resting crops, or fallow land). According to Sebastia and Puig (2008) ant-affected areas have higher plant species richness than those exposed to ploughing, supporting the initial successional stages of the vegetation dynamics.

Economic aspects related to the productivity of certain crops have spurred studies on certain species, for example, the olive (*Olea europaea*), the phenological and aeropalynological characteristics of which are well known (Fornaciari et al. 2000; Galán et al. 2004). In contrast, there is a dearth of detailed studies on the pollen morphology of the allergophytes infesting cultivated land in general. The lack of data calls for continued research in this field.

Particular attention is devoted to invasive species. In order to avoid need for successive efforts in eliminating particularly dangerous allergenic plants, efficient prevention of their diffusion is indispensable. This is the case for *Ambrosia artemisiifolia* L., the pollen of which was already recognized as strongly allergenic in its territory of origin (North America). This species colonizes the northern-central Italian maize fields, and transport of the pollen over long distances (Zauli et al. 2006) causes serious health problems in the human population, not only in Italy (Cecchi et al. 2007) but in other parts of Europe also (Puc 2006). This confirms the importance of knowledge of the ecology of the most dangerous allergenic species.

4.2 Outlook for the future

Renewal of the flora of cultivated areas occurs as a result of arrivals from both natural and anthropized sites. Dynamic exchanges between the various ecosystems occur along ecological corridors through mechanisms that are still little understood (Jongman et al. 2005). Allergenic flora probably pass through the ecotonal areas, as observed by Rastelli et al. (2003) in central Italy, where numerous allergenic *Poaceae* from surrounding meadows and fields were noted.

On the basis of data known to date, one can hypothesize that the allergenic plants of cultivated fields will be increasingly subjected to strong selection caused by intensive methods of industrialized management of farmlands. The increasing presence of various invasive allergenic species in Italian cultivations (Staffolani and Hruska 2008) confirms the need for constant control of the allergenic flora of this ecosystem. Because allergenic manifestations also depend on the quantity of pollen produced (D'Amato et al. 2007) and because the abundant populations of some allergenic plants were locally observed, allergy problems for the human population will probably increase, in particular among those who work in contact with crops.

All these considerations confirm, in conclusion, the need for multidisciplinary studies that will integrate environmental, agronomic, and social knowledge (Gross 2002). Future methods to protect human health will need to be based on knowledge of the ecological characteristics of the plant populations that produce notable quantities of allergenic pollen. In order to ensure better protection of the environment and of the quality of life and health of humans, it will be necessary to conduct research capable of integrating plant ecology with population biology and aerobiology.

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