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FLORISTIC ANALYSIS OF THE WEED COMMUNITIES IN WHEAT AND CORN CROPS: A CASE STUDY IN WESTERN-CENTRAL ITALY

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Abstract – Since a large area of Italy is lacking of updated informations about weed flora, we carried out a field survey in wheat and corn crops in western-central Italy (Lazio), by phytosociological approach, to update data, making comparisons and diachronic observations with literature. Relevés were carried out in 62 wheat crops, 50 corn ones. Totally 149 vascular units and 36 families were recorded; Poaceae and Asteraceae are prevailing. In wheat fields 113 units were observed: Dicots *s.l.* are 77,88% and Monocots 22,12%; in corn fields 78 units were observed. Floristic composition of relevés is very variable. In both cultivations Therophytes, Mediterranean and wide distribution *taxa* dominate. Among wheat weeds one alien species was observed; greater (11%) was the occurrence of non-native *taxa* in corn crops. The comparison of the surveys in 1981 and in 2011-2012 showed the prevailing of Asteraceae, Fabaceae, Brassicaceae, Poaceae, even if in different percentages. A strong increase of Therophytes and Mediterraneaneans is detected. Wheat crops weed flora has a higher value than that in corn crops, because of species richness and mostly native *taxa* presence. The prevailing of Dicots, not resistent to herbicides, can be considered an indicator of good conservation status of agro-ecosystems.

Keywords: Agroecosystem, Arable fields, Lazio, Biodiversity, Weed management, Vascular flora

Introduction

Weed communities on arable fields are known as a highly dynamic component of European vegetation (Lososová et al., 2004), depending on the different management practices; this is related to the definition of weed species as plants adapted to man-made habitats, interfering with human activities (Holzner, 1978). Weeds are recognized to be an important component of biological diversity and an essential trophic resource for pollinators, phytophagous insects, granivorous birds and herbivores (Storkey, 2006). Organic agriculture favours wild flora and fauna and the composition of the seedbank is dependent on the management practiced through the whole rotation (Andreasen & Stryhn, 2008).
Weeds may occur in three vegetation types: as segetal in arable land, as ruderals in one of the possible ruderal sites, in natural vegetation from which they originated or into which they have been able to invade (Holzner, 1978). In the last years it was recognized that in agro-ecosystems biodiversity performs ecosystem services beyond production of food, including recycling of nutrients, regulation of microclimate and hydrological processes, detoxification of chemicals and suppression of undesirable organisms (Altieri, 1999).
A lot of political initiatives have been implemented in Europe to meet growing concerns about negative effects of the intensification of land-use practice over the past decades, causing a biodiversity loss. In order to assess the overall effect on wild flora of the changing management of arable land, first of all surveys at different scales are necessary (Andreasen & Stryhn, l.c.).
To evaluate the biodiversity and the conservation status of the different habitats inside the rural landscape for the management of agro-ecosystems, a floristic-vegetational indexes system was recently designed, using as index of

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floristic biodiversity the number of species present in a phytosociological relevé (Taffetani & Rismondo, 2009; Rismondo et al., 2011).
In Italy the most widespread crops on arable fields are wheat and corn; wheat crops cover 1,961,980 ha, that means ca 1/9 of the Used Agricultural Area (UAA), a decreasing value as compared with last decades one. Other cereals, covering 767,260 ha, are on the contrary increasing; corn crops, in particular, occupy wide areas because economically supported by EU. Organic agriculture represents 5.97% of the UAA, constantly increasing (Data ISTAT, http://www.istat.it, last access 28/02/1/2013, A.A.V.V., 2011).
Since a large area of Italy is lacking of detailed updated information about weed flora and vegetation, useful to individuate their changing in time and their management in the next future, we carried out a large field survey in wheat and corn crops in some areas in western-central Italy, for which only a few published relevés are available (Blasi et al., 1981; Fanelli, 2002). The objectives of this paper were to: i) update data about the weed flora on arable fields in central Italy, focusing on the value of the floristic information carried out by means of the phytosociological method, ii) compare our floristic data with literature ones concerning the whole central Italy to define the conservation status of weed flora in the investigated sites, iii) make diachronic observations analysing the oldest literature relevés available for some of the investigated areas.

Material and Methods

Study area and sampling

The study sites are located in the Lazio region, a very heterogenous area in terms of lithology, climate, soil types, land use, consequently hosting a very rich vascular flora consisting of 3,330 units (species and subspecies) and 3,146 species, divided into 150 families and 896 genera.(Anzalone et al., 2010).
As concern land use, nowadays in the region wheat crops cover 66,248 ha, other cereals 25,221 ha; it was detected a good increasing of organic agriculture, nowadays extending on 84,713 ha (A.A.V.V., 2011).
The floristic data come from an ongoing phytosociological study (Abbate et al., in prep.). Field relevés (period 2011-2012) were carried out in 112 crops, in the same phenological phase, at an altitude range of 50-350 mt a.s.l.: 62 are wheat fields (releved surface range of 100-250 mt^2), 50 are corn ones (releved surface range of 100-400 mt^2). The bioclimate of the study sites is referable to the Transitional Mediterranean Region or to the Transitional Temperate Region (Blasi, Michetti, 2007).
The collected *exsiccata* are preserved in the Herbarium RO (code according to Thiers, 2011).
Species identification was made using European Flora (Tutin et al., 1964-1980), Italian Floras (Fiori, 1923-1929; Pignatti, 1982) and specific works for some critical genera (e. g. Iamonico, 2012 for *Amaranthus* L.).
Nomenclature follows the recent Flora of Lazio by Anzalone et al. (2010).
Life forms come from Pignatti (1982), while chorotypes follow both Pignatti (1982) and Abbate et al. (2009).

Data analysis

The statistical analyses were performed by means of the softwares Microsoft Excel for Windows (univariate analysis, using histograms) and NCSS 2007 [multivariate analysis, using clustering and PCA (Principal Component Analysis)].
A comparison of our data with those concerning the whole Central Italy (Covarelli, 2002) was made selecting the more frequently observed units (presence in more than 20% of the relevés) since Covarelli (l.c.) has not provided data for occasional species.
A diachronic analysis was carried out using the oldest available literature relevés from Blasi et al. (1981), carried out in the Treja Basin in Northern Lazio.

Results

Analysis of the present weed flora

A total of 149 vascular units (species and subspecies), belonging to 36 families, was observed in wheat and corn crops weed communities in Lazio (Tab. 1). 42 units of which are common to the two vegetation types; among the most frequent ones we mention *Convolvolus arvensis*, *Glebonis segetum*, *Papaver rhoeas* subsp. *rhoeas*, *Avena sativa* subsp. *sativa*. The comparison between families presence in the two cultivations highlights the predominance of Poaceae and Asteraceae which, together, represent ca 30% of the observed *taxa* in each type (Fig. 1).

Tab.1. Observed frequency (%) of all the weed units (species and subspecies) in the relevés carried out in wheat and corn crops. For each units minimum and maximum cover indexes, assigned in the relevés according the Braun-Blanquet scale, are reported. Nomenclature follows Anzalone et al.(2010).

UNITS	**WHEAT CROPS**		**CORN CROPS**	
	%	**min/max index**	**%**	**min/max index**
Convolvulus arvensis	74.2	+/4	56.0	+/4
Papaver rhoeas subsp. *rhoeas*	61.3	+/3	10.0	+/4
Lolium multiflorum	37.1	+/1	4.0	+
Fumaria officinalis	30.6	+/1	8.0	+/1
Lolium perenne	30.6	+/3	8.0	+/2
Glebonis segetum	29.0	+/3	30.0	+/1
Raphanus raphanistrum	29.0	+/2	8.0	+/2
Anthemis arvensis subsp. *arvensis*	27.4	+/3	10.0	+/1
Avena sativa subsp. *sativa*	19.4	+	20.0	+
Elymus repens	19.4	+/2	8.0	+/2
Legousia speculum-veneris	14.5	+/2	4.0	+
Borago officinalis	11.3	+	2.0	1
Rumex acetosa subsp. *acetosa*	9.7	+/1	6.0	+/1
Daucus carota	8.1	+/1	6.0	+
Trifolium campestre	8.1	+	4.0	+
Cichorium intybus	8.1	+/1	2.0	+/2
Galium aparine	8.1	+/1	2.0	+/1
Vicia sativa sativa	6.5	+/1	2.0	1
Capsella bursa-pastoris subsp. *bursa-pastoris*	4.8	+	4.0	+
Dasypyrum villosum	4.8	+/1	4.0	+
Anagallis foemina	4.8	+	2.0	+
Linaria vulgaris subsp. *vulgaris*	4.8	+	2.0	1
Trifolium nigrescens subsp. *nigrescens*	4.8	+/3	2.0	+/2
Mentha sp.	4.8	+/1	1.0	+
Rumex crispus	3.2	+	12.0	3
Coleostephus myconis	3.2	1/2	4.0	+
Equisetum ramosissimum	3.2	1	4.0	1/3
Chenopodium opulifolium	3.2	+	2.0	+/2
Potentilla reptans	1.6	+	34.0	1
Rapistrum rugosum	1.6	+	10.0	+
Silene latifolia subsp. *alba*	1.6	+	10.0	+
Sinapis alba	1.6	+	8.0	+
Dactylis glomerata	1.6	+	6.0	1/3
Ammi majus	1.6	r	4.0	+/3
Geranium columbinum	1.6	1	4.0	+
Holcus lanatus	1.6	+	4.0	1/2
Rumex obtusifolius subsp. *obtusifolius*	1.6	2	4.0	1/2
Veronica persica	1.6	+	4.0	+
Digitaria sanguinalis	1.6	1	2.0	+/5
Echinochloa crus-galli	1.6	1	2.0	+/3
Polygonum aviculare	1.6	2	2.0	1/4
Reseda phyteuma subsp. *phyteuma*	1.6	1	2.0	+/1
Avena barbata	22.6	+	0	.
Avena sterilis subsp. *sterilis*	12.9	+/2	0	.

segue →

UNITS	**WHEAT CROPS**		**CORN CROPS**	
	%	**min/max index**	**%**	**min/max index**
Phalaris aquatica	11.3	+/2	0	.
Poa sp.	9.7	+/1	0	.
Adonis microcarpa subsp. *microcarpa*	6.5	r/1	0	.
Anacyclus radiatus subsp. *radiatus*	6.5	+/1	0	.
Anagallis arvensis subsp. *arvensis*	6.5	+	0	.
Stellaria media subsp. *media*	6.5	+/1	0	.
Sylibum marianum	6.5	+	0	.
Viola arvensis	6.5	+/1	0	.
Bromus hordeaceus subsp. *hordeaceus*	4.8	+/1	0	.
Matricaria chamomilla	4.8	+/3	0	.
Phalaris coerulescens	4.8	+/1	0	.
Trifolium arvense	4.8	+	0	.
Vicia villosa varia	4.8	+	0	.
Calendula arvensis	3.2	+	0	.
Diplotaxis muralis	3.2	+	0	.
Euphorbia helioscopia subsp. *helioscopia*	3.2	+	0	.
Gladiolus communis subsp. *communis*	3.2	+	0	.
Knautia integrifolia subsp. *integrifolia*	3.2	+	0	.
Medicago sativa	3.2	+	0	.
Myosotis arvensis subsp. *arvensis*	3.2	+	0	.
Plantago lanceolata	3.2	+/2	0	.
Ranunculus arvensis	3.2	+/1	0	.
Ranunculus bulbosus	3.2	+	0	.
Rumex acetosella	3.2	+	0	.
Sherardia arvensis	3.2	1	0	.
Sixalis atropurpurea	3.2	1	0	.
Vicia sativa s.l.	3.2	+/2	0	.
Allium sphaerocephalon	1.6	+	0	.
Anchusa undulata subsp. *hybrida*	1.6	1	0	.
Bifora radians	1.6	+	0	.
Brassica napus subsp. *napus*	1.6	+	0	.
Brassica nigra	1.6	+	0	.
Briza minor	1.6	+	0	.
Bunias erucago	1.6	1	0	.
Campanula rapunculus	1.6	+	0	.
Cerastium glomeratum	1.6	1	0	.
Cerastium sp.	1.6	2	0	.
Chenopodium album subsp. *album*	1.6	2	0	.
Crepis sp. 1	1.6	1	0	.
Crepis sp. 2	1.6	r	0	.
Diplotaxis viminea	1.6	1	0	.
Erigeron sumatrensis	1.6	+	0	.
Eupatorium cannabinum subsp. *cannabinum*	1.6	2	0	.
Euphorbia segetalis	1.6	+	0	.
Fallopia convolvulus	1.6	+	0	.
Galega officinalis	1.6	+	0	.
Galium mollugo subsp. *erectum*	1.6	+	0	.
Gaudinia fragilis	1.6	+	0	.

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UNITS	WHEAT CROPS		CORN CROPS	
	%	min/max index	%	min/max index
Gladiolus communis subsp. *byzantinus*	1.6	1	0	.
Helminthotheca echioides	1.6	1	0	.
Hordeum murinum subsp. *leporinum*	1.6	+	0	.
Lepidium draba	1.6	1	0	.
Lolium sp.	1.6	1	0	.
Muscari comosum	1.6	+	0	.
Poa annua	1.6	+	0	.
Polygonum arenastrum subsp. *arenastrum*	1.6	3	0	.
Ptilostemon strictus	1.6	1	0	.
Ranunculus lanuginosus	1.6	+	0	.
Ranunculus parviflorus	1.6	+	0	.
Ranunculus sardous	1.6	+	0	.
Raphanus sativus	1.6	1	0	.
Rumex bucephalophorus subsp. *bucephalophorus*	1.6	2	0	.
Securigera securidaca	1.6	+	0	.
Silene gallica	1.6	+	0	.
Trifolium ochroleucum	1.6	+	0	.
Trifolium resupinatum	1.6	+	0	.
Trisetaria panicea	1.6	+	0	.
Veronica arvensis	1.6	1	0	.
Vicia narbonensis	1.6	+	0	.
Cynodon dactylon	0	.	38.0	+/5
Setaria viridis viridis	0	.	24.0	+/3
Xanthium spinosum	0	.	22.0	+/5
Abutilon theophrasti	0	.	20.0	+/3
Persicaria maculosa	0	.	20.0	+/4
Portulaca oleracea	0	.	18.0	+/3
Chenopodium album	0	.	12.0	+/2
Amaranthus sp.	0	.	8.0	+/3
Avena fatua	0	.	8.0	+/3
Datura stramonium subsp. *stramonium*	0	.	8.0	+/2
Amaranthus blitum subsp. *blitum*	0	.	6.0	1
Amaranthus hybridus	0	.	6.0	1/2
Cyperus rotundus	0	.	6.0	1/3
Chamaesice prostrata	0	.	4.0	+
Cucurbita pepo	0	.	4.0	+/2
Heliotropium europaeum	0	.	4.0	+
Setaria verticillata	0	.	4.0	+
Solanum nigrum subsp. *nigrum*	0	.	4.0	1/2
Verbascum sinuatum	0	.	4.0	+
Xanthium orientale subsp. *italicum*	0	.	4.0	1
Amaranthus blitoides	0	.	2.0	3
Astragalus sp.	0	.	2.0	+
Calystegia sepium subsp. *sepium*	0	.	2.0	1
Chenopodium sp.	0	.	2.0	1
Hibiscus trionum	0	.	2.0	2
Hypericum calycinum	0	.	2.0	1
Origanum vulgare subsp. *vulgare*	0	.	2.0	+
Phalaris minor	0	.	2.0	+
Picris hieracioides	0	.	2.0	+
Pteridium aquilinum subsp.*aquilinum*	0	.	2.0	1
Reichardia picroides	0	.	2.0	+
Rubus cfr. *caesius*	0	.	2.0	1
Rubus ulmifolius	0	.	2.0	+
Sorghum halepense	0	.	2.0	+
Verbena officinalis	0	.	2.0	+
Vicia ervilia	0	.	2.0	1

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In wheat fields Fabaceae, Polygonaceae and Brassicaceae are as well important components of weeds; the dominance of Poaceae, Asteraceae and Fabaceae was observed in the past by Blasi et al. (1981) and Fanelli (2002) in the same kind of cultivation in Lazio region. The most represented genus results to be *Rumex* (5 units), *Ranunculus* (5) and *Trifolium* (5), followed by *Vicia* (4), *Lolium* (3) and *Avena* (3). In all, 113 units were observed, where Dicots, in the traditional sense, are 88 (77,88%) and Monocots 25 (22,12%). The units number in each relevé is very variable, being comprise in the range 1-24; the mean is 7,29. The most frequent units are: *Convolvolus arvensis*, *Papaver rhoeas* subsp. *rhoeas*, *Lolium multiflorum*, *L. perenne*, *Fumaria officinalis*, *Glebonis segetum*, *Raphanus raphanistrum* (Tab. 1); only some of them reach high cover value, such as *Convolvolus arvensis*, *Papaver rhoeas* subsp. *rhoeas*, *Lolium perenne*, *Anthemis arvensis* subsp. *arvensis*, and locally *Trifolium nigrescens* subsp. *nigrescens*. That means Dicots currently represent the prevealing component of the wheat weeds also in cover.

In corn fields the most substantial families are Amaranthaceae and Polygonaceae with three genus overrepresented (Tab. 1): *Amaranthus* (4 species), *Chenopodium* (3 species) and *Rumex* (3 species). In all 78 units were observed, where Dicots are 60 (76,92%), Monocots 16 (20,51%) and Pteridophytes 2 (2,57%). The units number in each relevé is very variable, being comprised in the range 1-23; the mean is 5,6. The most frequent and abundant *taxa* are: *Cynodon dactylon*, *Setaria viridis* subsp. *viridis*, *Xanthium spinosum*, *Abutilon theophrasti*, *Persicaria maculosa*, *Portulaca oleracea*. The Tribe Paniceae of Poaceae, known as resistant to atrazine (an herbicide utilized in Italy until 1992), is represented by the genus *Setaria*, *Digitaria*, *Echinochloa*, but only *Setaria* results to be very frequent.

The Principal Component Analysis clearly shows a great variability in the floristic composition of the relevés (Fig. 2), underlined by clustering too (not shown). Even if the relevés are very dispersed, two groups are recognizable: one including weed communities in corn crops and one including those in wheat ones. This variability is likely linked to the different environmental, agricultural and management factors, here not analysed. As concern wheat crops, although

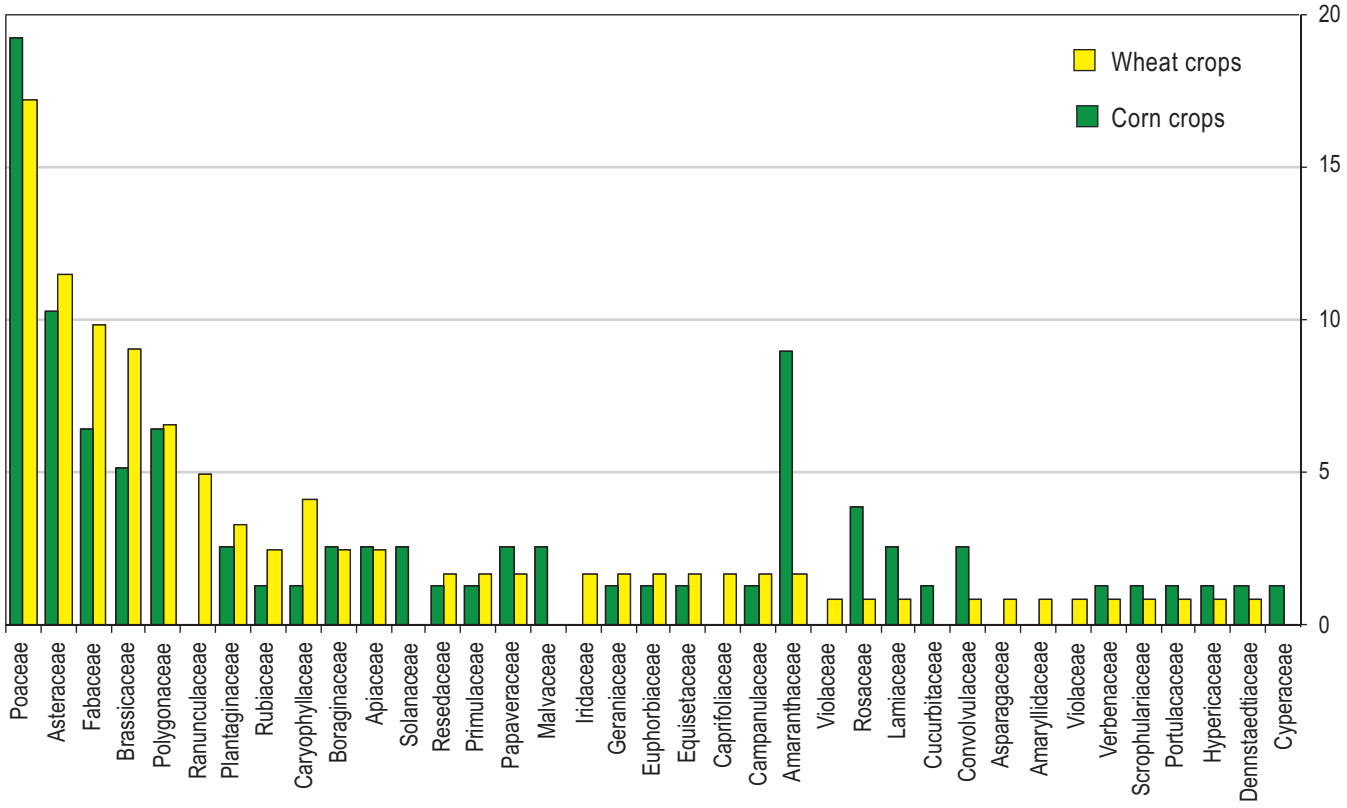


Fig. 1. Percentage composition in families of the weed flora observed in wheat and corn crops.

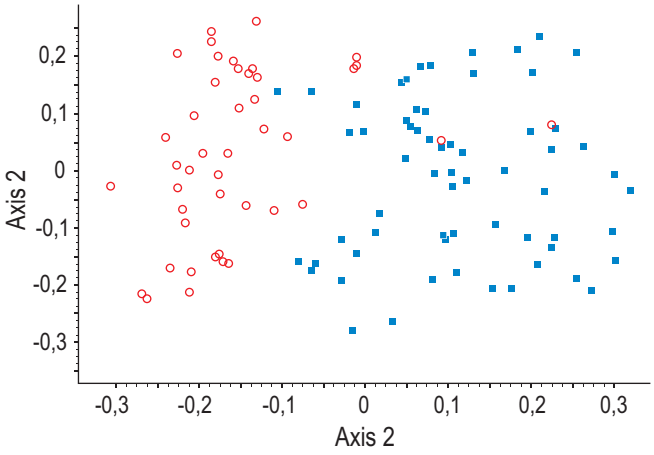


Fig. 2. Principal Component Analysis: scatterplot of the relevés against PC1 and PC2 (binary data). Relevés in corn crops (circle) and in wheat crops ones (square).

a low correlation has been detected between number of units *per* relevé and wheat plants height (R2=0,03), a general trend can be observed: the number of weeds *per* relevé decreases with the wheat plants height. A possible interpretation is that the high plants cause a reduction of the light propagation toward the substrate and, as a consequence, a less richness of weeds is observed. It is important to remark that wheat height is very different in the most frequently cultivated varieties in Italy (Fig. 3).

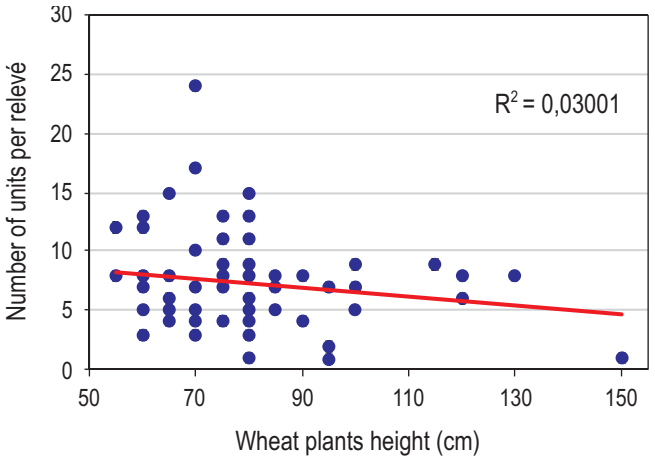


Fig. 3. Regression between number of units per relevé and wheat plants height (cm).

The life form spectra computed for the weed flora observed in wheat and corn crops show a great homogeneity and confirm the dominance of the scapous Therophytes; although

the two vegetation types are characterized by different phenological and agronomic features (Fig. 4).

A slight variability concerns chorological spectra computed on the two floristical lists. In both cultivations, the most represented categories are Mediterranean (especially Eurimediterranean) and wide distribution ones (Fig. 5). It is remarkable that among wheat weeds, just one alien species was observed, *Erigeron sumatrensis*, native of tropical America. Much greater was the occurrence of non-native species in corn crops, which constitute more than 11% of the weed flora, coming from all over the American continent, mostly from tropical and sub-tropical South-America; in particular *Xanthium spinosum* and *Amaranthus* spp. are locally very abundant. In particular wheat crops, the most ancient crops in Italy and Europe, have a less number of weeds against the corn crops. Since corn was introduced in Europe after the Renaissance, it could seem that there is a relationship between the cultivation residence time and the weed flora. Really the different chorological spectra are related to the different management of the two cultivations: wheat crops are not irrigated and consequently weeds are influenced by the local climate, while corn crops are continually irrigated; this creates a humid microclimate, not suitable to Mediterranean species.

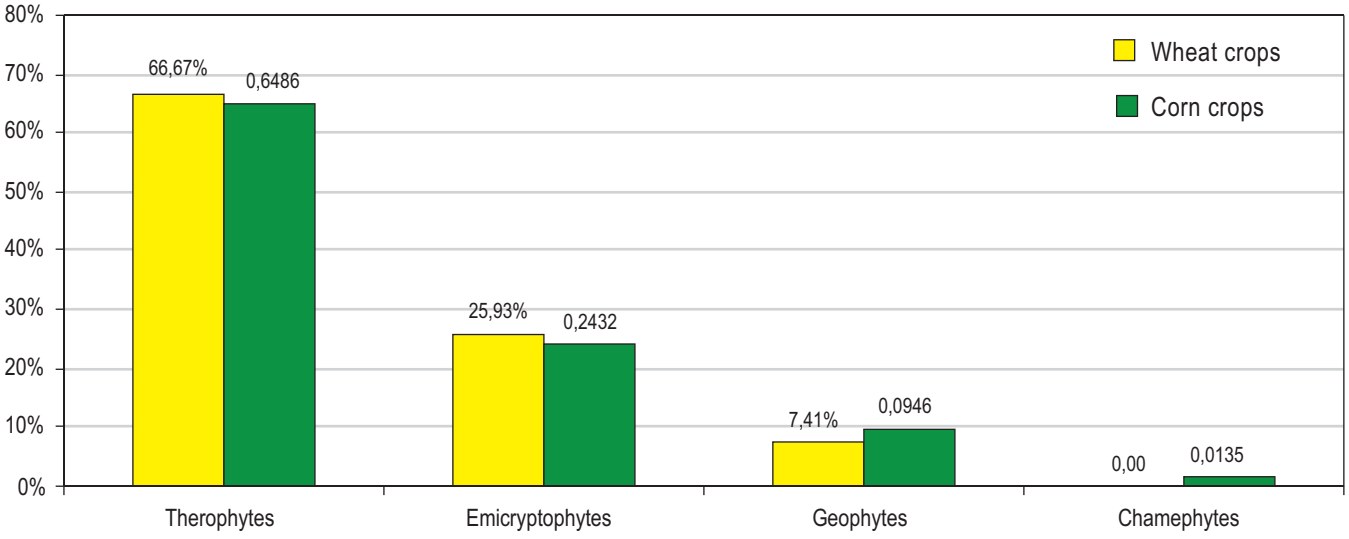


Fig. 4. Life forms spectra of the weed flora observed in wheat and corn crops.

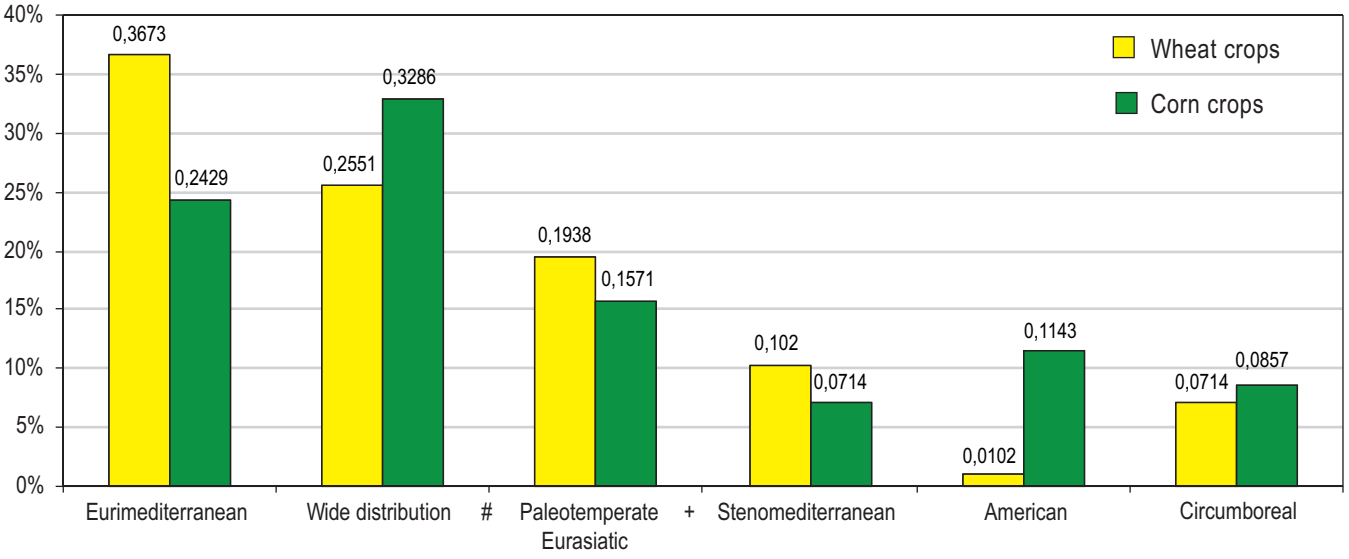


Fig. 5. Chorological spectra of the weed flora observed in wheat and corn crops.

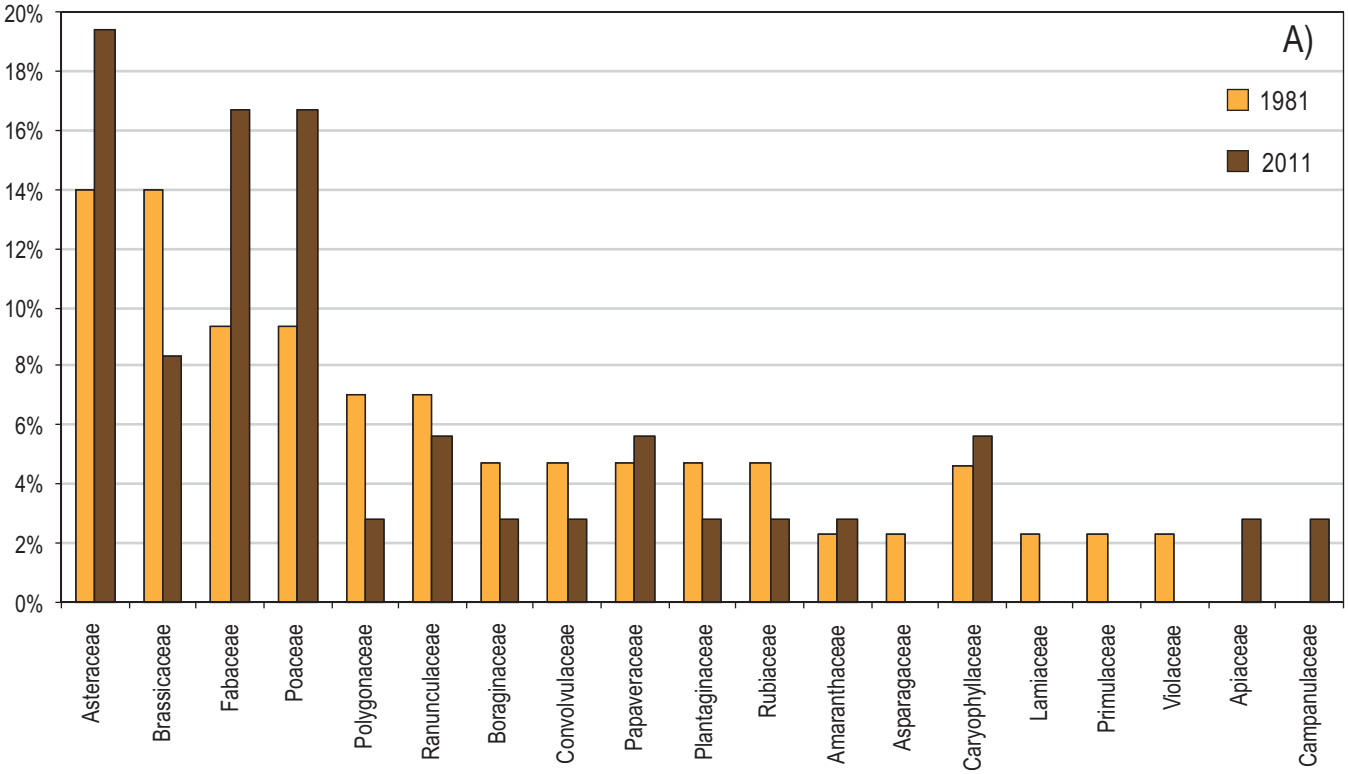


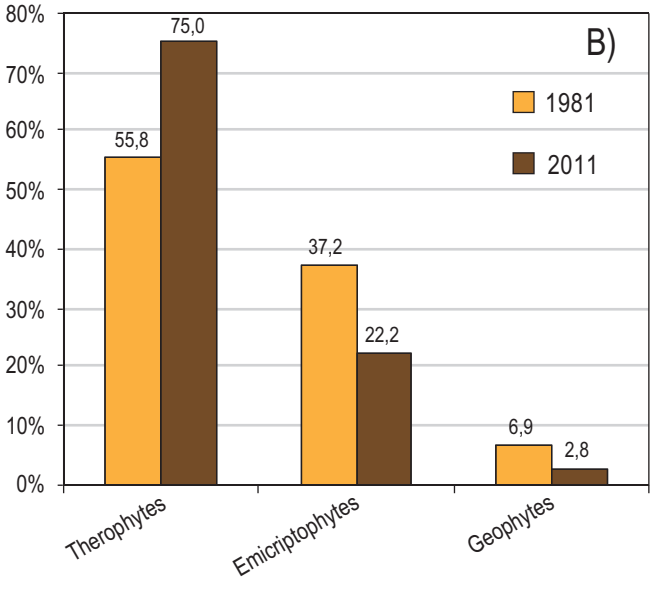
Fig. 6A, B, C. Diachronic comparative analysis for Treja Basin wheat weed flora (time range 1981-2011). A) families, B) life forms spectra, C) chorological spectra.

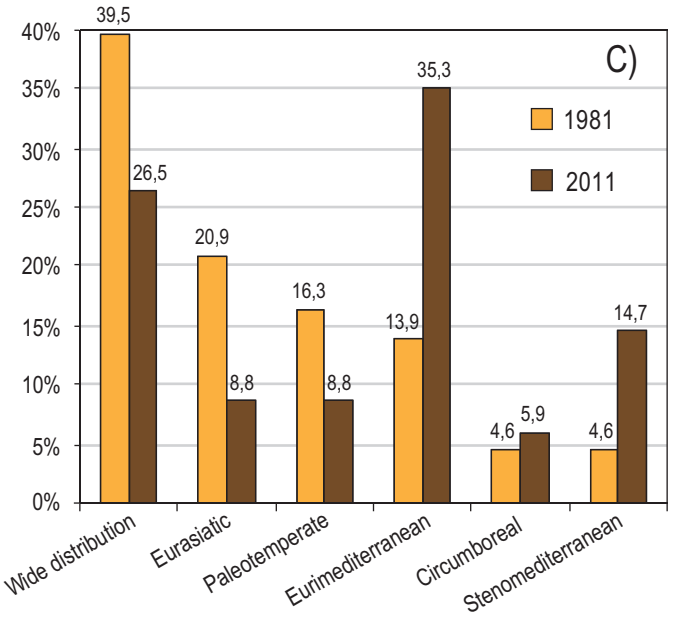
Comparative and diachronic analysis of the weed flora

The comparison between our data and those reported for Central Italy by Covarelli (2002) highlighted a good similarity between frequent weeds in wheat crops; the only exception is represented by the current frequency in Lazio of the Poaceae *Lolium perenne* and *Elymus repens*, not recorded in the past. Even corn crops weed communities result to have a similar floristic composition, having many units in common, though the same author doesn't mention two species actually very frequent in Lazio, that is *Xanthium spinosum* and *Cynodon dactylon*.

As concerns Treja Basin, the comparison of the surveys in 1981 (Blasi et al, 1981) and in 2011-2012 showed that, in both cases, the most represented families are Asteraceae, Fabaceae, Brassicaceae and Poaceae, even if in different percentages in the two periods (Fig. 6A). In 1981 surveys the most represented families were Asteraceae and Bassicaceae; in 2011 Asteraceae and Poaceae were considerably more abundant than before. In any case during the three decades native Dicots are strongly prevailing. In the three decades there was a reduction in the total number of families, with the disappearance of Iridaceae, Violaceae, Primulaceae and Lamiaceae. Some of the observed species are rare or very rare in Lazio, namely *Ranunculus parviflorus* and *Bifora radians* recently observed (Anzalone et al., 2010) and *Adonis aestivalis* in the past (Blasi et al., 1981).

About life forms a strong increase of Therophytes, especially scapous ones, is detected (Fig. 6B); consistently Mediterranean units rise to ca 50%; in 1981 they were only ca 20% (Fig. 6C).





DISCUSSION

The field survey carried out by means of the phytosiological approach in the last two years, let us to detect a very rich weed flora in the wheat and corn crops widely distributed in Lazio region, in very heterogeneous environments.

The detected number of units results to be higher than that observed in the past decades by other authors for Italy, even if this comparison is quite difficult as the two studies were carried out using different sampling approaches. Montemurro et al. (2000), in fact, for the autumn-winter cereals (wheat and barley) reported only 93 species in the entire country, of which 43 in Lazio; these values are very low maybe because deriving from an experimental design based on standard grids. The same authors reported that *Conyza canadensis*, *Calendula officinalis* and *Geranium dissectum* were widely spreading in Lazio, but actually we never observed them.

Our data confirm the rise of annual species (Therophytes) and Poaceae in last decades, as already affirmed by Covarelli (2002) and Montemurro et al. (l.c.), likely as a consequence of the increasing organic agriculture (crop rotation, compost and biological pest control).

Weed communities in wheat crops risult to have a higher floristic value as compared with those in corn crops, because of their species richness and, in chorological terms, of the presence of mostly native *taxa*.

On the whole the present prevailing of Dicots on Monocots can be considered as an indicator of a good conservation status of the investigated agro-ecosystem, being Dicots not resistent to herbicides; that means that the traditional management and organic agriculture well preserve semi-natural plant diversity, as already observed in other countries (Andreasen & Stryhn, 2008; Bellanger et al., 2012).

In perspective of the future Commun Agriculture Policy, for which one of the main objectives is a sustainable management of natural resources, and in order to assess the overall effect on wild flora of the changing management of arable land, frequent surveys on weed flora and vegetation will be necessary.

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