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Effects of weed management on phytoseiid populations in vineyards of Lombardy (Italy)

Abstract - The role of weeds present in the vineyards as refuges for phytoseiid mites and the impact of cultural practices on the floristic composition and on the population of mites was investigated. The experiment was carried out in two vineyards of Lombardy, one was abandoned and the other was cultivated normally. The structure of the herbaceous community was defined. The observations on the mite fauna were carried out by collecting samples of leaves of the most common plant species. The vegetation was much more complex in the abandoned vineyard. Even the composition in the abandoned field was influenced by a greater presence of Dicotyledons, both in number of species and in abundance. The vegetation cover was much greater in conditions of naturalness than on the cultivated field. The phytoseiids were abundant in the abandoned vineyard, and they were even absent on the grass in the other field. In semi-natural conditions five species were collected. Phytoseiids were never found on Monocotyledons. The investigations show the great ecological importance of the herbaceous cover for the upkeep of the phytoseiid populations, for which it is possible to hypothesise a flow from and towards the cultivation. Nevertheleess, the remarkable negative influence of the common cultural practices seemed just as evident on the floristic composition as on the phytoseiids.

Riassunto - *Effetti dell'inerbimento sulle popolazioni di acari fitoseidi nei vigneti lombardi.*

Si è voluto verificare il ruolo delle erbe presenti nel vigneto quale rifugio per gli Acari Fitoseidi e gli effetti delle pratiche colturali sulla composizione floristica e sulle popolazioni acarine. La sperimentazione è stata condotta in due vigneti lombardi, uno abbandonato e l'altro sottoposto alle normali operazioni colturali. È stata definita la struttura della comunità erbacea. Le osservazioni sull'acarofauna sono state compiute raccogliendo campioni di foglie delle specie più diffuse. La comunità vegetale è risultata molto più complessa nel vigneto abbandonato. La sua composizione è influenzata da una maggiore presenza di Dicotiledoni nell'appezzamento incolto, sia come numero di specie che come abbondanza. La copertura vegetale è maggiore in condizioni di naturalità che non nell'appezzamento coltivato. I Fitoseidi sono molto abbondanti nel vigneto abbandonato, assenti nell'altro, anche sulle erbe colonizzate nel primo. In condizioni di non

coltivazione sono state raccolte 5 specie. Sulle Graminacee non sono mai stati reperiti Fitoseidi. Le indagini evidenziano la grande importanza ecologica dell'inerbimento per il mantenimento delle popolazioni di Fitoseidi, per le quali è ipotizzabile un flusso da e per la coltura. È però risultata altrettanto evidente la notevole influenza negativa delle comuni pratiche colturali sulla composizione floristica da una parte, sui Fitoseidi dall'altra.

Key words: green cover, cultural practices, Phytoseiids, ecological refuge, floristic composition, biodiversity.

INTRODUCTION

The importance of the vegetation surrounding the vineyard as far as the ecological stability of the culture is concerned, has been known for many years (Boller *et al.*, 1988, 1997; Lozzia and Rigamonti, 1990). On the contrary, the data relative to the role of the vegetation within the vineyard is insufficient, altough the influence of a diversified flora on the number species of arthropods species is known (Remund *et al.*, 1989; Boller *et al.*, 1997). The objective of this work is to evaluate the importance of cultural practices on the floristic composition and on Phytoseiids in order to determine the role of weed management for the protection of populations of these mites.

MATERIALS AND METHODS

The experiment was carried out in two vineyards of Lombardy in summer 1995 and 1996. The first, called Casaglio, is located in Gussago (Brescia) in the vineyard area of Franciacorta. It is characterised by a state of abandon which started two years before the beginning of the research and it is the example of a changing agro-ecosystem towards a state of increased naturalness. The second, called Gozzi, is located in Monzambano (Mantova) in the area of the Mantua Morenic Hills of the Garda Lake. Weed control and all other traditional cultural practices are carried out. The two vineyards have been put under a series of observations aimed at highlighting the differences concerning the floristic composition of their weed management and the presence of Phytoseiids.

The method of survey adopted was primarily systematic botanical survey. Firstly a representative area from both lots was defined, which contained the natural vegetation species mainly present and which characterised the two floristic situations. For this purpose square observation areas of 1 m^2 size in succession and at random were examined, noting after every examination the number of plant species collected in that specific area (Scossiroli *et al.*, 1974). It was thus possible to establish the area where the average number of plant species identified represented a constant characteristic

pattern. In this area, considered representative for the weed composition, the classification of the plant species was carried out and also their dominance was assessed. The analysis of these observations made the evaluation of the ground area occupied by vegetation necessary noting, during the random assessment described above, on a piece of millimetre grid paper, the real distribution of the species that have been observed. The difference between the two plant communities was then defined by means of a binomial descriptive statistical model.

For the application of this method of data analysis the whole area examined at random in 25 squares has been subdivided, so that from K repetitions there were nK = 25K samples. If the distribution of the individuals among the samples is random, one has for each sample a probability p to find individuals of a certain species group and a probability q = (1-p) that species or that group is absent. Indicating with an x the number of times when the species appears in each repetition, the distribution of the individuals can be represented by the binomial law singled out by the parameters n and p and which is expressed as: $\beta(n,p)$. Its function, through which the frequencies expected for each value of x can be derived, has the formula: $\beta(x,n,p) = p^{xq(n-x)}$

Due to the aim of this analysis, a comparison between the frequencies effectively observed and those expected was not carried out following a binomial model with the parameters n and p already fixed, but an analysis of the probabilities p and q was. In the present case, the vegetation made up of weeds was subdivided according to whether they belonged to Monocotyledons or to Dicotyledons and then the probability of finding a Graminaceae in each sample of vineyards studied was calculated. This was then compared to the values of probability obtained in the two cultural situations, considering them sufficient, as they were put together with other data relative to the analysis of dominance mentioned above, to characterise the two environments of experimentation from a vegetation point of view.

These observations were linked with the analysis of the mite fauna present on the grapevine and on the herbaceous flora which makes up the grass cover. For this purpose samples of 100 grapevine leaves and 25 leaves of every other plant species were taken. They were kept in a refrigerated container during transportation to the laboratory where they were checked under a stereoscopic microscope. The observation of the leaves permitted a quantitative survey of the mite fauna present followed by the identification of the collected specimens.

RESULTS AND DISCUSSION

The data presented in table 1 show obviously a more trivial composition of the weed community in the cultivated lot. The smallest representative area singled out for the vineyard in Gozzi was of 8 m^2, against the 32 m^2 of the vineyard in Casaglio. The number of plant species found was clearly superior in the abandoned area. In this case a total of 40 species was recorded (table 2) and an average abundance of 6.01 species / m^2 was observed. The situation in Gozzi was clearly different, where a total

Table 1 - Comparison of the floristic composition and the presence of phytoseiids in vineyards studied.

Parameters	Gozzi	Casaglio
number of species	14	40
number and (%) of annual species	8 (58)	14 (35)
number and (%) of biannual species	0 (0)	3 (8)
number and (%) of perennial species	6 (42)	23 (57)
% of Monocotyledon species	87	15
% of Dicotyledon species	13	85
% of ground covered by Monocotyledons	22	18.8
% of ground covered by Dicotyledons	23	81.2
% of bare ground	55	0.0
average number + S.E. of plant species/m^2	3.5 ± 0.519	6.01 ± 0.530
species of Dicotyledons collected	4	11
species with phytoseiid mites	0	9
species of Monocotyledons collected	4	6
species with phytoseiid mites	0	0
phytoseiid species collected on the grapevine	*A. andersoni, T. pyri*	*E. finlandicus, K. aberrans*
species of phytoseiids collected on the grass	-	*A. andersoni, B. subsoleiger, E. finlandicus, K. aberrans, T. pyri*

of 14 plant species was observed with an average of 3.5 species/m^2 (table 1). The grass species found in both vegetation areas studied were subdivided into annual, biannual and perennial species. Furthermore, a distinction was made between Monocotyledons and Dicotyledons. The aim of these subdivisions was to verify if the impact of disturbance caused by the cultural practices determines the dominance of plant species belonging to one of the two categories.

When the disturbance by weed control was absent the number of perennial grass species was higher compared to the situation in the vineyard in Gozzi with a traditional cultivation system. In the first case 23 perennial grass species (57% of the total), were found, compared to 6 in the second case (42%). The data concerning the presence of Mono- and Dicotyledons was more interesting as they show a clear prevalence of broad leaves dycots in conditions of non cultivation. This observation was supported by the analysis of the reports of dominance, that is by the surface occupied by the two plant categories (table 1). Finally, the data relative to the dominance according to the binomial model it was possible to prove that the probability of finding a Monocotyledon in the unit of area is almost double in the vineyard in Gozzi compared to the vineyard in Casaglio (11% and 6%, respectively).

The results confirm other reports on the prevalence of Dicotyledons in absence of cultivation (Remund *et al.*, 1989). Therefore, it can be concluded that in conditions of naturalness a vegetation cover can develop with an increase plant species richness

Table 2 - Species present in the vineyards and their cycle.

Family	Species	Cycle	Casaglio	Gozzi
Amarantaceae	*Amaranthus retroflexus* L.	annual	present	present
Cariophillaceae	*Dianthus sylvestris* Wulf.	perennial	present	
	Stellaria media L.	annual		present
Chaenopodiaceae	*Chaenopodium album* L.	annual	present	present
Compositae	*Achillea millefolium* L.	perennial	present	
	Artemisia vulgaris L.	perennial	present	
	Cichorium intybus L.	perennial	present	
	Cirsium arvense L. (Scop.)	perennial		present
	Sonchus arvensis L.	annual		present
	Sonchus oleraceus L.	annual	present	
	Taraxacum officinale Web.	perennial		present
Dipsaceae	*Knautia arvensis* L.	annual	present	
Labiatae	*Glechoma hederacea* L.	perennial	present	
	Lamium purpureum L.	bi-annual	present	
	Lamium amplexicaule L.	annual	present	
	Salvia pratensis L.	perennial	present	
Leguminosae	*Coronilla varia* L.	perennial	present	
	Medicago sativa L.	perennial	present	
	Trifolium pratense L.	annual	present	present
	Trifolium repens L.	perennial	present	present
	Melilotus officinalis L. Pallas	bi-annual	present	
Malvaceae	*Malva sylvestris* L.	perennial	present	
Umbelliferae	*Daucus carota* L.	bi-annual	present	
	Heracleum sphondylium L.	perennial	present	
Oxalidaceae	*Oxalis corniculata* L.	perennial	present	
Papaveraceae	*Papaver rhoeas* L.	annual	present	
	Fumaria officinalis L.	annual	present	
Plantaginaceae	*Plantago major* L.	perennial	present	
	Plantago lanceolata L.	perennial	present	
Polygonaceae	*Rumex acetosa* L.	perennial	present	
	Polygonum convolvolus L.	annual	present	
Portulacaceae	*Portulaca oleracea* L.	annual		present
Rosaceae	*Potentilla reptans* L.	perennial	present	
Rubiaceae	*Galium verum* L.	perennial	present	
Scrophulariaceae	*Veronica persica* Poir.	annual	present	present
Urticaceae	*Urtica dioica* L.	perennial	present	
Verbenaceae	*Verbena officinalis* L.	perennial	present	
Graminaceae	*Avena fatua* L.	annual	present	
	Bromus sterilis L.	annual	present	
	Digitaria sanguinalis L.	perennial		present
	Festuca rubra L.	perennial	present	
	Hordeum murinum L.	annual	present	
	Lolium multiflorum L.	annual		present
	Lolium perenne L.	perennial	present	present
	Setaria viridis L. Beauv.	annual	present	
	Sorghum halepense L.	perennial		present

and of higher resistance to drought in the summer months.

The analysis of the mite fauna shows a complete absence of the predatory mite fauna on spontaneous Graminaceae, which, do not satisfy the micro-environmental needs required by the Phytoseiids, due to their leaf morphology without the pronounced nerves found in broad-leaf herbs.

Table 3 shows the results of the sampling carried out in the vineyard at Casaglio. Of the 12 species of Dicotyledons examined, only *Glechoma hederacea* L. and *Potentilla reptans* L. did not host populations of Phytoseiids. It seems to be clear anyway that in the absence of cultural disturbance, the spontaneous Dicotyledons represent a particularly favourable environment for these predators, which are often present even in greater measure than those observed on the grapevine.

For the harmful fauna it was noted that the presence of *Tetranychus urticae* Koch was influenced by the weed management even in late summer, when a normal migration on the grapevine was expected. The migratory behaviour of *T. urticae* can be related to the lack of desiccation of the host plant species represented mainly by Dicotyledons in the green cover and therefore quite resistant to summer drought. We conclude that this primary effect is the main reason for the presence of Phytoseiids in high densities contributing directly to the successful biological control of the phytophagus mites.

The composition of the populations of Phytoseiids found on natural vegetation deserves further attention. Among these are polyphagous species characterised by a mixed diet including even plant substrates (e.g. pollen) such as *Typhlodromus pyri* Scheuten, *Bawus subsoleiger* (Wain.) and *Euseius finlandicus* (Oud.) and species dependant on animal prey, such as *Amblyseius andersoni* (Chant). In particular *Kampimodromus aberrans* (Oud.), apart from being present in the weed undergrowth is the dominant species on the grapevine in Casaglio. At this point it is possible to hypothesise an active movement of this Phytoseiid during the vegetation season between the grapevine and the herbaceous vegetation which plays an important role as potential reservoir of useful predatory mites.

The results of the study carried out in the vineyard at Gozzi were completely different, as none of the samples taken contained Phytoseiids, not even on *Amaranthus retroflexus* L., *Chaenopodium album* L., *Taraxacum officinale* Web, which were highly populated in the situation described before. On the grapevine, instead, there were *T. pyri* and *A. andersoni* however only in low densities (0.31 mites per leaf).

In conditions of naturalness the micro-environmental conditions present at ground level is apparently favourable for the establishment of the Phytoseiid acarofauna and for the consequent colonisation of the grapevine.

The positive effect of a natural weed management on the Phytoseiid populations is most likely explained by the shelter provided by the large number of plant species with broad leaves and the abundance of alternative food sources in these natural habitats.

The suitability of natural weed management to host Phytoseiids is supported by the unfavourable situation observed in the vineyard at Gozzi. The data shows a total

Table 3 - Presence of Phytoseiidae and Tetranychidae on the grapevine and herbaceous flora in the vineyard in Casaglio.

Sampled species	Casaglio			Gozzi	
	Phytoseiid mites / leaf	Phytoseiids	*T. urticae* / leaf	Phytoseiid mites / leaf	*T. urticae* / leaf
Vitis vinifera	1.64	Ef, Ka	0.00	0.31	0.00
Amaranthus retroflexus	0.80	Aa, Tp	0.00	0.00	0.00
Chaenopodium album				0.00	0.00
Cirsium arvense	1.64	Bs, Ef, Ka, Tp	0.00		
Sonchus arvensis				0.00	0.00
Sonchus oleraceus	0.76	Aa, Ka	6.64		
Taraxacum officinale	1.20	Ef, Ka, Tp	0.36	0.00	0.00
Glechoma hederacea	0.00	-	0.00		
Lamium purpureum	0.72	Ef	0.08		
Salvia pratensis	0.28	Ef	0.88		
Heracleum sphondylium	0.16	Ef	0.00		
Plantago major	2.16	Aa, Bs, Ef, Tp	2.16		
Potentilla reptans	0.00	-	0.00		
Urtica dioica	1.76	Aa, Bs, Ef, Ka	0.04		
Avena fatua	0.00	-	0.00		
Bromus sterilis	0.00	-	0.00		
Digitaria sanguinalis				0.00	0.00
Festuca rubra	0.00	-	0.00		
Hordeum murinum	0.00	-	0.00		
Lolium multiflorum				0.00	0.00
Lolium perenne	0.00	-	0.00	0.00	0.00
Setaria viridis	0.00	-	0.00		
Sorghum halepense				0.00	0.00

Aa = *A. andersoni*, Bs = *B. subsoleiger*, Ef = *E. finlandicus*, Ka = *K. aberrans*, Tp = *T. Pyri*

absence of the acarofauna at ground level. This differences in the results cannot be explained on the sole basis of the existing differences in the floristic composition of the two types of plant communities observed. During the transition from a cultivated monoculture to a balanced agro-ecosystem with a diversified botanical ground cover there is in fact a strong limitation by human interference to the capacity of the green cover to establish higher densities of Phytoseiids. The colonisation of useful arthro-

pods is in particular influenced by the effects of drifting and of accumulation of pesticides applied for the protection of the crop (Carsoulle, 1995). In the vineyard at Gozzi the negative effects on the predators and on the floristic composition caused by pesticides are increased by the traditional mowing regime of the green cover (table 4).

Table 4 - Treatments carried out in the vineyard in Gozzi.

Downy mildew			Powdery mildew		
Active ingredients	Treatments		Active ingredients	Treatments	
	1995	1996		1995	1996
mancozeb	3	3	dinocap	10	7
cymoxanil + copper oxychloride	7	4	wettable sulphur	4	6
copper oxychloride	4	6			

The establishment and maintenance of the reservoir role of the green under-cover has to be achieved by the adaptation of the plant protection and habitat management strategies respecting the predator populations especially using pesticides without harmful side-effects on the antagonists and by the use of modern application techniques reducing or eliminating drift.

From the results of the analysis carried out on weed management it can be concluded that a weed management strategy should emphasise the enhancement and protection of the plant species belonging to the Dicotyledons in order to enhance botanical and faunistic diversity and hence the presence of Phytoseiid mites and other antagonists (e.g. parasitoids) not covered by this investigation. This objective should be feasible at least in those climatic conditions where heavy competition for water and/or erosion are not major problems.

CONCLUSIONS

This investigation carried out on the ground-cover vegetation in two vineyards has shown and confirmed the important ecological role of a natural green cover capable to provide a suitable habitat for stable and consistent populations of Phytoseiids, for we hypothesise the presence of a ground-to-grapevine migration of the predatory mites. The capacity to establish and mantain a useful acarofauna is strongly influenced by the management system of the ground cover (e.g. alternating or traditional mowing regimes, frequency of mowing, weed control practices). Traditional cultivation methods tend to simplify the composition and species richness of the plant community, favouring mostly Monocotyledons, that are unsuitable for the development of Phytoseiid populations. In conclusion, it can be said that the protection of the Phytoseiid populations within the agro-ecosystem of the vineyard requires particular attention, not only with respect to the pest control strategy but also in the adequate management of the habitat of these beneficial arthropods, among which a natural green cover under

and between the grapevine with a predominance of perennial broad-leaf plant species plays a central role.

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