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First indications on the development of *Myzus persicae* (Sulzer) (Rhynchota Aphididae) on different herbaceous species (*)

Abstract - The suitability of fifteen species as hosts for the green peach aphid was evaluated measuring the intrinsic rates of increase (r_m) and other biological parameters. The weed species tested (*Pisum sativum* L., *Trifolium repens* L., *T. pratense* L., *Lupinus polyphyllus* Lindley, *Saponaria ocymoides* L., *Zinnia elegans* L., *Taraxacum officinale* Weber, *Matricaria chamomilla* L., *Centaurea cyanus* L., *Achillea millefolium* L., *Bellis perennis* L., *Amaranthus retroflexus* L., *Lepidium sativum* L., *Linum rubrum* L., *Papaver rhoeas* L.) are very diffused in the orchards, hobby gardens and in natural or uncultivated areas; thus they are potential secondary hosts and a source of infections by the aphids. Experiments were conducted to study, under controlled conditions, the development of *M. persicae* and the suitability of the plants shown by the aphid. The symptoms caused by its attack on the weed species are also reported. The results have shown that *M. persicae* has a dissimilar development on the different species and it prefers to grow on some of them as *Z. elegans, T. officinale, C. cyanus* and A. *millefolium.* On the contrary *L. rubrum, L. polyphyllus* and *Trifolium* spp. were not suitable hosts of *M. persicae.* Moreover, this study shows that not all plants, even if they could be considered secondary hosts, are negatively affect by the presence of the green peach aphid. The results highlight that many, rather common, spontaneous species could be suitable hosts of *M. persicae.*

Riassunto - *Prime indicazioni riguardo allo sviluppo di* Myzus persicae *(Sulzer) (Rhynchota Aphididae) su differenti specie erbacee.*

La preferenza per 15 specie erbacee da parte dell'afide verde del pesco è stata valutata calcolando l'innata capacità di accrescimento (intrinsic rates of increase, r_m) ed altri parametri biologici. Le specie erbacee impiegate (*Pisum sativum* L., *Trifolium repens* L., *T. pratense* L., *Lupinus polyphyllus* Lindley, *Saponaria ocymoides* L., *Zinnia elegans* L., *Taraxacum officinale* Weber, *Matricaria chamomilla* L., *Centaurea cyanus* L., *Achillea millefolium* L., *Bellis perennis* L., *Amaranthus retroflexus* L., *Lepidium sativum* L., *Linum rubrum* L., *Papaver rhoeas* L.) sono comunemente diffuse nei frutteti, giardini, orti e nelle aree coltivate e

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naturali; per tale motivo sono considerate potenziali ospiti secondari e fonte di infestazione dell'afide. Sono riportati inoltre i sintomi determinati dall'attacco afidico. I risultati hanno mostrato l'influenza del substrato vegetale sulla popolazione afidica. Lo sviluppo di *M. persicae* è meglio supportatato da alcune specie quali: *Z. elegans, T. officinale, C. cyanus* e *A. millefolium;* al contrario *L. rubrum, L. polyphyllus* e *Trifolium* spp. non possono essere considerati ospiti di *M. persicae.* I risultati ottenuti indicano anche come piante che supportano un'elevata popolazione afidica non sempre sono negativamente influenzate dall'attacco dell'insetto. Si evidenzia come specie spontanee molto comuni possono essere validi ospiti secondari per lo sviluppo di *M. persicae.*

Key words: secondary hosts, host suitability, symptoms, intrinsic rates of increase

INTRODUCTION

Although many weed species have been brought as secondary hosts of the green peach aphid, *Myzus persicae* (Sulzer), which can spend the summer period on more than 40 families of plants (Blackman & Eastop, 1985), little or no information can be found on the rate of growth and reproduction of this aphid on herbaceous hosts. In fact the majority of researches were carried out mainly on agricultural species as *Solanum tuberosum* L., *Pisum sativum* L., *Lens culinaris* Medikus, *Cicer arietinum* L., *Capsicum annuum* L. (Tremblay & Souliotis, 1974; Blackman & Eastop, 1985; Harrewijn & Minks, 1989; Edwards, 2001) and only a few on spontaneous species as *Lupinus angustifolius* L. (Owain, 2001), *Trifolium repens* (Costello & Alteri, 1995), *Lepidium perfoliatum* L. and *Amaranthus retroflexus* L. (Tamaki & Olsen, 1979). Vegetables that are also reported to support green peach aphid include artichok, asparagus, bean, beet, broccoli, Brussels sprout, cabbage, carrot, cauliflower, cantaloup, celery, corn, cucumber, fennel, kale, kohlrabi, turnip, eggplant, lettuce, mustard, okra, parsley, parsnip, pea, pepper, potato, radish, spinach, squash, tomato, turnip, watercress and watermelon. Previous studies have indicated that the herbaceous species have an important role in the spread of *M. persicae* in England (Heathcote *et al.*, 1965), in Californian valleys (Duffus, 1971), in Washington (Tamaki & Olsen, 1979) and in Spain (Fernandez-Quintanilla *et al.*, 2002). Conversely, there are practically no references on the development of *M. persicae* and symptoms on many weeds, even if Tamaki (1975) estimated that from 3 to 16 million aphids per acre were produced on weeds growing on the floor of peach orchards in Washington, and up to one-third of the aphids feeding on weed species were carrying beet western yellows virus (BWYV) (Tamaki & Fox, 1982).

The main objective of this research was to study the development of *M. persicae* on a variety of crop and weed species (present in the orchards) and the symptoms derived by the punctures of suction of the aphids to the plants under controlled conditions. Our selection has gone toward spontaneous and not herbaceous species that are present in fields, gardens or in greenhouses.

MATERIALS AND METHODS

INSECT CULTURES. At the beginning the rearing of *M. persicae* was done on *Pisum sativum* L. Five apterous females, from the same population, were placed on each plant. Seeds were placed ($^3/_4$ of high) in every clear plastic pots of 5.9 cm diameter and 8.8 cm high. These pots were filled with 50% vermiculite and 50% perlite (previously sterilized under microwaves). Then the pots were placed in the greenhouse (for 16:8 h light-night, +22 °C and 75±5 % RH). However, from the first results of the experiment, it was clear that *M. persicae* prefers *Zinnia elegans* L. and *Bellis perennis* L. and they might be better hosts for rearing it. Thus the rearing was maintained on *Z. elegans*. In fact other populations of the aphid were settled in 8 pots (14 cm diameter and 28 cm high): 4 pots with 5 plants of *Z. elegans* and 4 pots with 5 plants of *B. perennis*, all covered with clear plastic cage.

PLANT CULTURES. The selection of the 15 weed species has been based on their affiliation to the most important botanical families, to their diffusion on the Italian territory, to the possibility to retrieve seeds certified, to their vast use in weed management, to the diffusion in the nearness or in the surrounding area of peach orchards representative of our agricultural conditions. The weed species selected belong to: Leguminosae (*Pisum sativum* L., *Trifolium repens* L., *T. pratense* L., *Lupinus polyphyllus* Lindley), Caryophyllaceae (*Saponaria ocymoides* L.), Compositae (*Zinnia elegans* L., *Taraxacum officinale* Weber, *Matricaria chamomilla* L., *Centaurea cyanus* L., *Achillea millefolium* L., *Bellis perennis* L.), Amaranthaceae (*Amaranthus retroflexus* L.), Cruciferae (*Lepidium sativum* L.), Linaceae (*Linum rubrum* L.) and Papaveraceae (*Papaver rhoeas* L.). In addition, the species were selected on the basis of their biology and their presence and budding during the migration period of *M. persicae* from peach to secondary hosts. Plants of the 15 weed species used in the study were grown from seeds in standard potting with sterile soil mix under greenhouse conditions (24 °C, 75±5% UR and 8:16 h photo phase). The plants were sub-irrigated every day.

HOST SPECIES SUITABILITY TESTS. A series of laboratory experiments was carried out to compare the growth of *M. persicae* on the different species. The symptoms caused by its punctures and saliva to the hosts were also recorded. For each host species twenty plants were used for the experiment. In total 300 plants were used. Nymphs, randomly selected, were gently removed from the colony and placed on the bud of each plant. Transfer of the aphids was done one week after the germination of the plants. Afterwards each plant was covered with a clear extra fine net. The designed experiments allowed annotating, under controlled conditions, the increment of aphid populations. The rate was recorded every 2 days for 3 weeks. To quantify the major life cycle parameters of the aphid growing on the selected species, the pre-reproductive time (number of days from birth to the first reproduction), the fecundity and longevity were recorded daily. The intrinsic rate of natural increase (r_m) was calculated for aphid growth on each weed species according to the Wyatt & White (1977) equation:

$$r_m = 0.783\ (\log_e Nd)/d$$

where *Nd* is the number of progeny an aphid produces up to the time its own first progeny reproduce (i.e. pre-reproductive period) and *d* is the pre-reproductive development time. The appearance of winged individuals was also recorded. Indirect estimates of r_m using the Wyatt & White (1977) method or the mean relative growth rate, are less time consuming, and useful for obtaining relative comparisons between different treatments (Guldemond *et al.*, 1996).

The host species suitability tests were carried out for 3 weeks for each species, however for some species where *M. persicae* had a good development (*T. officinale*) or some species with particular interested (*B. perennis* and *A. retroflexus*) the research was done for a longer period. In these cases two plots of 20 plants for each species were used to replicate again the test on the biology of the aphid. In all these cases each plant was initially infested with 2 apterous specimens. The biology was investigated for five weeks.

RESULTS

DEVELOPMENT OF THE POPULATION. In Table 1 the development of *M. persicae* on 15 herbaceous species, during 3 weeks, is reported. A moderate population growth of *M. persicae* was observed on *L. sativum*, *P. rhoeas*, *S. ocymoides*, *M. chamomilla*. In fact, the r_m of the aphid on these 4 species ranged from 0.11 to 0.17. Population growth was very good on *Z. elegans*, *T. officinale*, *A. millefolium*, *B. perennis*, *C. cyanus*, *P. sativum*, *A. retroflexus* (Table 1). The best population growth, with the maximum r_m (0.28), among all species, was obtained on *Z. elegans*. In fact after 3 weeks the number of aphids on *Z. elegans* was almost 4 times the initial number and in some cases even 5 times. In addition the appearance of 1 alata after 2 weeks and 2 winged after 3 weeks confirms that this species is a suitable host for the green peach aphid. In fact as aphid densities increase or plant condition deteriorates, winged forms are again produced to aid dispersal.

The development of *M. persicae* on *Z. elegans* was followed also for 5 weeks and in same case the number of individuals reached more than 110 specimens per plants. Moreover, the aphid established a good population in all replicates. For these reasons the rearing of the aphid was continued on this species rather than on *P. sativum* (r_m = 0.215). Furthermore, the larger size of the leaves and their flat surface compared to the leaves and the buds of *P. sativum* make *Z. elegans* more suitable for rearing purposes.

M. persicae grew very well also on *A. millefolium*, *T. officinale* and *B. perennis* with intrinsic rates of increase (r_m) of 0.2. Our results agree with Kaakeh and Hogmire (1991) who report that *T. officinale* as a secondary host is very pleasant during the summer in West Virginia orchards.

In the case of *B. perennis* the largest population was recorded after 3 weeks (Fig. 2). In fact in the 4th week the average number of individuals was 10 times its initial number. The rapid increase of the population is evident in Fig. 2.

Table 1 - Mean ± SE of individuals of Myzus persicae *(Sulzer) recovered per plant on 15 herbaceous species.*

Plant families	Herbaceous species	I week	II week	III^a week	r_m	N°wingeds/week
Leguminosae	*Trifolium repens* L.	1.7±0.67	1.8±0.90	1.9±0.83	0	
	Trifolium pratense L.	0.6±0.67	1.2±0.72	0.8±0.68	0	
	Pisum sativum L.	3.1±1.51	3.9±1.77	6.1±3.1	0.215	2 - III
	Lupinus polyphyllus Lindley	1.9±0.75	1.9±0.85	1.8±0.77	0	
Compositae	*Taraxacum officinale* Weber	3.1±1.51	5.2±3.4	6.6±2.95	0.210	1-III
	Zinnia elegans L.	4.1±2.85	5.9±2.32	9.6±3.99	0.280	1-II, 2-III
	Centaurea cyanus L.	2.9±1.36	4.2±1.57	6.1±2.11	0.181	1-IIIk
	Matricaria chamomilla L.	2.05±1.53	2.4±1.69	3.2±1.91	0.110	
	Bellis perennis L.	2.6±0.86	5.8±2.14	6.8±3.31	0.209	1-III
	Achillea millefolium L.	3.1±1.43	3.8±1.94	6.1±3.18	0.215	
Caryophyllaceae	*Saponaria ocymoides* L.	2.5±1.19	2.8±1.22	3.6±1.35	0.123	
Papaveraceae	*Papaver rhoeas* L.	2.4±0.78	2.8±1.50	2.3±1.43	0.170	
Amaranthaceae	*Amaranthus retroflexus* L.	2.3±2.10	5.2±3.30	6.8±4.09	0.200	
Linaceae	*Linum rubrum* L.	0.6±0.67	0.9±0.70	1.2±0.75	0	
Cruciferae	*Lepidium sativum* L.	2.6±0.86	3.3±1.79	2.5±1.59	0.152	

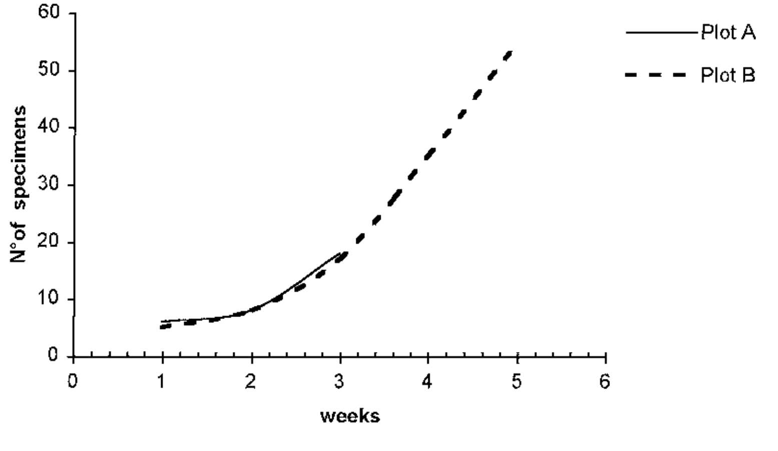

Fig. 1 - Population growth of *Myzus persicae* Sulz. on *Taraxacum officinale* Weber. The replicates were pooled in two plots of ten plants each. Plot A :used to measure the development for 3 weeks, Plot B used to follow the growth of the aphid for 5 weeks. Each plant was initially infested with 2 specimens.

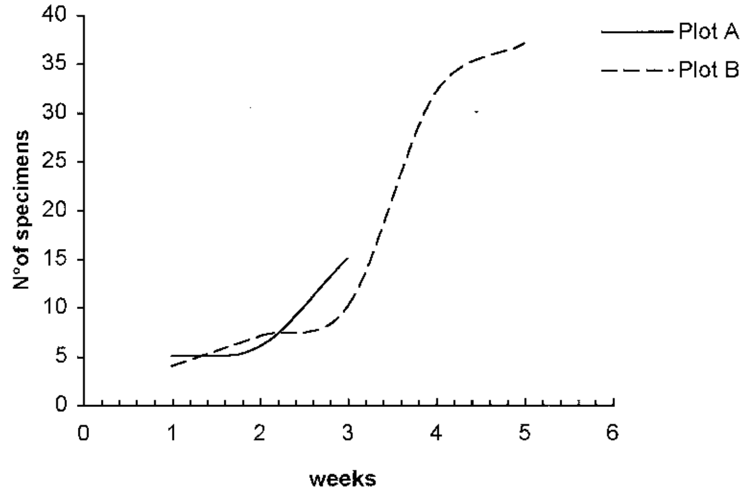

Fig. 2 - Population growth of *Myzus persicae* Sulz. on *Bellis perennis* L.. The replicates were pooled in two plots of 10 plants each. Plot A: used to measure the development for 3 weeks, Plot B used to follow the growth of the aphid for 5 weeks. Each plant was initially infested with 2 specimens.

Regarding *A. retroflexus,* it is interesting to note that at the beginning our results confirm what was found by Tamaki and Olsen (1979) and Fernandez-Quintanilla *et al.* (2002); in fact for the first two weeks the growth of aphid population was rather scarce. The previous authors stopped the experiment after two weeks reporting *A. retroflexus* as a unsuitable weed host, but at the 3 weeks had a relatively good growth of *M. persicae* population reaching even 17 specimens per plant. Consequently continuing the experiment for another week a rapid increment of *M. persicae* population is evident (Fig. 3).

A scarce population growth was observed on *L. rubrum*, *L. polyphyllus*, *T. repens* and *T. pratense*. In fact the intrinsic rate of natural increase was zero for *M. persicae* developed on these four species at least for the first three weeks. Usually for the test the initial number of the aphids was 2; indeed because on these species the value of r_m was zero, the research was continued also starting with more aphids (4, 6, 8, and 20 individuals). The results confirmed that all these species are not suitable hosts for *M. persicae* even if the initial infestation is rather large. Often, as for the case of *L. rubrum,* the aphids "run away" from the plant and it was difficult even to find back the specimen. Also in the case of *T. repens* and *T. pratense* the transfer of *M. persicae* on these plants was always difficult at least as long as the plants were 60 days old (researches are continuing). In order to find a suitable host, aphids must feed for a short time to determine sustainability; this process is called sap sampling. If the plant is unsuitable, *M. persicae* continues to move from host to host in search of a compatible feeding stimulus. When a suitable host is found the green peach aphid remains,

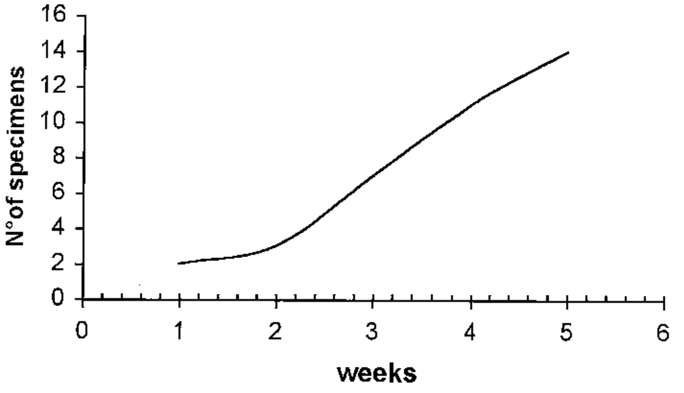

Fig. 3 - Number of indivduals produced in 5 weeks by 2 apterae female of *Myzus persicae* Sulz. on *Amaranthus retroflexus* L..

reproducing almost entirely apterae females offspring. This behaviour can explain why in some cases (*L. rubrum*, *L. polyphyllus*) was difficult to recover the individuals after the transfer.

SYMPTOMS ON THE HERBACEOUS SPECIES. The symptoms recorded for the different botanical species are summarized in Table 2. Nine out of the fifteen species analysed were asyntomatic even if some of them had a great infestation of *M. persicae*. In par-

Table 2 - Symptoms shown by the plants during the tests of development of Myzus persicae *Sulz.*

Herbaceous species	Yellow leaves	Leaf distortions	Necrosis	Reduced growth rate
Trifolium repens L.	X	-	-	-
Trifolium pratense L.	X	-	-	-
Pisum sativum L.	-	-	-	-
Lupinus polyphyllus Lindley	-	-	-	-
Taraxacum officinale Weber	X	X	-	-
Zinnia elegans L.	-	X	-	-
Centaurea cyanus L.	X	-	-	-
Matricaria chamomilla L.	-	-	-	-
Bellis perennis L.	-	-	-	-
Achillea millefolium L.	-	-	-	-
Saponaria ocymoides L.	-	-	X	X
Papaver rhoeas L.	-	-	-	-
Amaranthus retroflexus L.	-	-	-	-
Lepidium sativum L.	X	-	-	-
Linum rubrum L.	-	-	X	-

ticular no evident symptoms were recorded on: *P. sativum*, *L. polyphyllus*, *M. chamomilla*, *B. perennis*, *A. millefolium*, *P. rhoeas* and *A. retroflexus*. Feeding by the green peach aphid results in a wilting, deformation, and retarded growth of the plant. Aphid secrete various toxic saliva into plants causing symptoms such as yellowing, stunting and curling of the foliage in some of the tested plants. In fact, six species were more susceptible to the attack of the aphid and these showed: yellow leaves, necrosis, reduced growth rate. Leaf distortions were not common except on *T. officinale* and *Z. elegans*. The first one showed at 2nd week almost the 20% of leaves yellow and with distortion while the 40% of the plants of *Z. elegans* had at 3rd week leaf distortions. *C. cyanus* was sensitive to the attack of the aphid already after seven days demonstrated by the presence of yellow leaves and wilting. Also *L. sativum* showed, in some replicates, symptoms at the first week and 30% of the plants had yellow leaves after 15 days. The most susceptible species to the aphid punctures were *L. rubrum* and *S. ocymoides*. The first species presented evident necrosis after seven days on the 20% of plants while the 25% of plants of *S. ocymoides* had also a weakly growth.

However the aphid population growth obtained on *T. repens* and on *T. pratense* was almost zero, these two species were sensitive to the punctures and saliva of the aphid. In fact 10% of plants of *T. repens* had yellow patch on the leaves after only one week from the transfer and after 3 weeks the percentage reached the 25%. A similar situation was recorded also for *T. pratense*.

It is interesting to note that the symptoms were not always correlated with the density of aphid population. Feeding damage and injury from toxins in the saliva, that are injected into the plant tissue during feeding, result in thickening, crumpling, and downward curling of leaves. Different plant species have different susceptibility to the aphid saliva. It has been established that plants respond to insect herbivores by activating an array of defence genes to mount resistance to insects. Much of the information regarding plant defence genes regulation has been derived from studies on chewing insects, as well as from the well-established wound signal transduction pathway (Ryan, 2000; De Bruxelles & Roberts, 2001; Kessler & Baldwin, 2002). Much information is available regarding the interaction between chewing insect and plants, but considerably less information is available on molecular mechanisms of plant response to aphids, the largest group of phloem-feeding insects (Salzman *et al.*, 2004). These results could give some indications of plants that could be considered as interesting source of resistance genes.

CONCLUSIONS

The study shows that *M. persicae* can reproduce and survive in several weed species that usually colonize the peach orchards or gardens, tunnels and greenhouses in their neighbourhoods.

Among the fifteen species tested, *M. persicae* grew very well on *B. perennis* and *Z. elegans*. A high growth rate was found also for aphid populations on *P. sativum*, *M. chamomilla*, *A. millefolium*, *A. retroflexus*, *C. cyanus* and *T. officinale*. From the results is also evident that the development of the aphid have not correlation with the botanical family of the hosts. For example *M. persicae* grew well on *P. sativum* but not in the case of the other species of Leguminosae. Similar considerations could be claimed in the case of Compositae: *M. persicae* grew well on all species except for *M. chamomilla*.

It is interesting to note that from the results it seems that the appearance of symptoms is not always related to the density of aphid population. Often plants that support a greater growth of *M. persicae* do not show evident symptoms; this could in part be explain considering a kind of co-evolution between the insect and the plant which is able to tolerate in a better way the injection of the aphid saliva.

Our study showed that *M. persicae* can survive and reproduce on weed species that can commonly find around the peach orchards. The role of herbaceous species in the spread of green peach aphid is extremely important especially considering that *M. persicae* has developed resistance to several insecticides (Cervato & Cravedi, 1995). Holding under control weed and/or applying a selected weed management could help to reduce the number of *M. persicae* and therefore the possibility of dangerous infestations of the aphids or virus transmission.

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