CONTROL STRATEGIES OF APPLE PROLIFERATION, A SERIOUS DISEASE OCCURING BOTH IN SLOVENIA AND IN ITALY

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ABSTRACT

Apple proliferation (AP) is a serious disease that mainly affects apple-trees. It is caused by a phytoplasma diffused in Europe, particularly in the South. Recently, serious epidemics have been reported to occur in northern Italy, particularly on cvs Golden Delicious, Florina, Canadian Renette and Granny Smith, grafted on different rootstocks. The disease was found to be in progress also in Slovenia. Also the new genotypes resistant to scab and derived from *Malus floribunda* are susceptible to AP. Because of the poor quality of fruits, the infected orchards easily became economically not convenient. In Friuli-V. G., the percentage of symptomatic trees in an infected orchard can be easily over than 50%. In general, depending on the environment, cultivar and agronomic treatments the infected trees can recover from the symptoms and produce regularly. In some cases, the fruits produced by recovered trees are near to normal and of good quality. The disease has been recorded also in nurseries. In this case AP was transmitted to the young seedlings either by grafting or by natural vectors. In both cases a great and complicate problem arises. In nature the AP - agent is transmitted at least by two species of psylla (*Cacopsylla costalis* and *C. melanoneura*). AP is systemic in the host plant and it is transmitted also by grafting. The cycle of AP and of the natural vectors is roughly known. At present, we dispose of sensitive and reliable diagnostic techniques as: the use of DAPI staining, serology and molecular biology techniques. The disease is not possible to be practically cured.
Preventive procedures are on the contrary possible, mainly based on the knowledge of the epidemiology of AP. The most important and general prevention measures are as

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follows: utilize tested material when planting new orchards; use weak rootstocks; avoid the most sensitive cvs; obtain resistant/tolerant genotypes; establish nurseries in AP-non infected areas and avoid to use propagation material derived from infected areas. When operating in an already epidemic situation: vector control by using insecticides. Roughing especially during the initial phases of the epidemiology; take advantage of recovery; use of apomictic rootstocks resistant to AP; avoid heavy pruning or pollarding; keep the plants in vegetative balance; do not replace young sensitive plants in recently rouged orchards that are placed in infected areas still during the epidemic phase of the disease.

Key words: Apple proliferation, AP, control measures

IZVLEČEK

STRATEGIJE NADZORA NAD METLIČAVOSTJO JABLAN, RESNO BOLEZNIJO, KI SE POJAVLJA TAKO V ITALIJI KOT TUDI V SLOVENIJI

Metličavost jablan (AP) je resna bolezen, ki večinoma okužuje jablane. Povzroča jo fitoplazma, ki je razširjena po Evropi, predvsem pa po Južni Evropi. V zadnjem času poročajo o epifitocijah te bolezni v Severni Italiji, predvsem na kultivarjih zlati delišes, florina, kanadska reneta in Granny Smith, cepljenih na različne podlage. Tudi v Sloveniji smo v zadnjem času opazili večjo razširjenost te bolezni. Tudi novi genotipi jablan, odpornih na jablanov škrlup, ki so jih vzgojili *iz Malus floribunda*, kažejo občutljivost na metličavost. Slaba kakovost sadja postavi pridelovalne nasade v ekonomsko neugoden položaj. Na območju Furlanije v Severni Italiji lahko odstotek dreves z izraženimi bolezenskimi znamenji v posameznih nasadih preseže 50%. Na splošno velja, da lahko posamezna okužena drevesa v odvisnosti od okolja, kultivarja in kmetijske prakse izgubijo bolezenska znamenja (angl. 'recovered', slov. 'ozdraveli') in dajejo pričakovani pridelek. V nekaterih primerih lahko taka 'ozdravela' drevesa normalno obrodijo sadeže dobre kakovosti. O bolezni poročajo tudi iz drevesnic, v katerih lahko pride do okužbe sejančev s cepljenjem ali pa z naravnimi prenašalci. Ne glede na način prenosa bolezni, nas takšna situacija postavi pred velik in zapleten problem. V naravi fitoplazmo metličavosti prenašata dve vrsti bolšic (*Cacopsylla costalis* in *C. melanoneura*), zaradi njene sistemske razporejenost v gostiteljskih rastlinah pa je možen tudi prenos s cepljenjem. Naravni ciklus metličavosti in njenih prenašalcev je v grobem znan. Na voljo so občutljive in zanesljive diagnostične metode kot na primer nespecifična tehnika z barvanjem DAPI ter serološke in molekularnobiološke metode. V praksi je okužena drevesa nemogoče popolnoma ozdraviti.

Postopki za preprečevanje okužbe v glavnem temeljijo na poznavanju epifitotiologije AP. Najpomembnejši postopki zajemajo: uporabo testiranega sadilnega materiala v novih pridelovalnih nasadih, uporabo šibkih podlag, odklanjanje občutljivih sort, pridobivanje odpornih/tolerantnih genotipov, postavljanje drevesnic v območja, kjer bolezni ni ter odklanjanje sadilnega materiala, ki prihaja iz okuženih območij. Kadar pa že imamo opravka z epifitocijo, so načini zatiranja bolezni: uporaba insekticidov, izkop predvsem v zgodnji fazi epifitocije, izkoriščanje pojava 'recovery', uporaba apomiktičnih podlag odpornih na AP, opuščanje močne rezi, vzdrževanje dreves v uravnovešeni rasti, izogibanje sajenju občutljivejših mladih dreves na epifitotična območja, predvsem tam, kjer so pred kratkim izkopali okužena drevesa.

Ključne besede: Apple proliferation, AP, metličavost jablan, nadzor

1. INTRODUCTION

Apple proliferation (AP) was first detected and described in Italy by Rui *et al.* (1950). AP is caused by a phytoplasma of the AP group, together with European stone fruit yellows (ESFY) and Pear decline (PD) (Seemüller *et al.*, 1998). These phytoplasmas are transmitted in nature by psyllas. AP is transmitted by *Cacopsylla costalis* (Frisinghelli *et al.*, 2000) and *C. melanoneura* (Alma *et al.*, 2000); ESFY, by *C. pruni* (Carraro *et al.*, 1998); PD, by *C. pyri* (Lemoine, 1991; Carraro *et al..*, in press) and *C. pyricola* (Jensen *et al.*, 1964; Davies *et al.*, 1998). The transmission of phytoplasmas is of the persistent type (Purcell, 1982). AP is a systemic in the plant (Mc Coy *et al.*, 1989) even if it is unevenly distributed in low titres in woody hosts, mostly present in petiols, stipules and leaves (Amici *et al.*, 1972). The spread of the disease was found to be in progress during last years in Europe, particularly in several regions of Northern Italy and also in Slovenia. The most important susceptible varieties of apple are Golden Delicious and Granny Smith, but also scab resistant cultivars derived from *Malus floribunda*, such as Florina. The disease is not curable: preventive procedures are mainly based on epidemiological knowledge. Discovery of the vectors and the use of the modern sensitive diagnosis (PCR (Petrovič *et al.*, 2001), ELISA and IF (Loi *et al.*, 1998)) enabled better intervention decisions. The main aim of the present work was to analyse, select and propose appropriate control measures, in specific situations, and based on past experiences.

2. MATERIAL AND METHODS

Control strategies. Since antibiotic utilization is prohibited in agriculture at present we cannot cure phytoplasma diseases. It is to emphasize that the AP disease is tremendously complex due to: biodiversity of pathogen (phytoplasmas are similar to bacteria; they are prone to mute); active presence and dynamics of natural vectors; dissemination and concentration of host plants of vector and pathogen-host interactions. The disease progress, its epidemiology as well as the reaction of the infected plants are highly variable. On the other hand guidelines to control AP can be identified and assembled on the basis of the following situations:
a) the disease is not yet present in the area;
b) the disease is at the beginning of its local diffusion;
c) the percentage of infected trees is already high.
The main criteria (and decisions) to take in consideration for interventions in practice are: roguing the infected trees, the annual rate and stability of recovery, the advisability or not to replace young healthy plants after roguing, the real economical damage caused by AP, this depending also by the apple cultivar and environmental conditions, the way to control insect vectors, and the nursery production.

3. RESULTS AND DISCUSSION

General criteria to prevent AP diffusion and to control the disease. The most important general control measures are: to utilize tested material when planting new orchards; to avoid the most AP susceptible and sensible cultivars; to search resistant or tolerant genotypes also among the autochthonous, rustic and adapted varieties; to use weak rootstocks or resistant to AP; to establish nurseries in not contaminated areas and to refuse propagation material originated from infected areas; to keep the plants in the orchard in vegetative balance; to control of the vectors using proper insecticides at the right time.

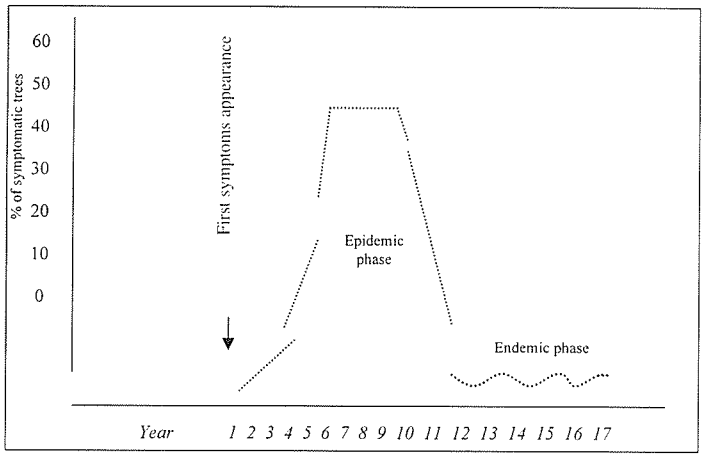
Strategies to be adopted in a not yet infected areas. In this case the aim is to prevent AP introduction from infected areas. The best choice is to organize local nurseries and to utilize domestic material. If imported, the plants should be derived from not infected areas. Testing should be carried on roots and canopy. Precautionary insecticide should be sprayed against the reimmigrant psylla adults, better to be applied twice early in spring. Less important are the insecticide applications against the exules (young adults borne in local healthy apple trees).
Control strategies when the disease is at the beginning of its diffusion. In this case the prominent aim is to attempt the eradication of the disease: which could have a heavy economic effect on local fructiculture. As a consequence it is strongly advisable the immediate and absolute roguing the infected trees (and also the contiguous ones), even if they could later recover and produce. In this contest it is very important to avoid the secondary diffusion of AP from the already infected plants. It was in fact demonstrated that the disease tends to spread within the orchard in line or in patches, this indicating the role played by apple trees as internal sources of inoculum (data not shown).
A second purpose again, it is indispensable to block or at least to reduce as much as possible new infections due to the reimmigrant psyllas: the control of vectors by using insecticides is consequently important both for reducing the secondary as well as the newly introduced infections. To prevent secondary AP diffusion it is important not only to consider the adults but also all other mobile forms of the vectors. Based on past observations, the annual rate of newly infected trees in a given orchard depends more on secondary spreads than on newly introduced infections.
Control strategies when the disease is already spread in the area. Roguing is recommended if the percentage of infected trees is below 5%. Later on roguing is conditioned by the expected recovery of the infected trees and by the real influence of AP on the total production (Osler *et al.*, 2000). If recovery is really effective in production (es. for Florina cv.) or the genotype is tolerant to AP (Renette of Canada, adult trees), roguing is not advisable. In general roguing is to suggest especially when infected trees are very young or close to the economic treshold owing to the age. Recovery could be enhanced by keeping the plants in balance, avoiding heavy pruning or pollarding or excessive nitrogen fertilisation. Recovered trees (as seen for Florina cv.) do not act as important sources of inoculum, since the phytoplasmas generally disappear from the canopy (Loi *et al.*, paper in progress). Moreover, for the cv. Florina, it was calculated in Italy that the mean chance of the recovered trees to show AP symptoms again is 4.1 times lower if compared with trees that were not previously infected, which indicates induced resistance (Castelain *et al.*, 1997). Where recovery is not expected, as in Germany for cv. Golden Delicious (Seemüller, personal communication), roguing is suggested till the orchard continues to be economically justified (in general, till 20% of rogued trees). Replacement of the rogued trees with young plants is not advisable during the epidemic phase (Fig. 1) of the disease (no resistant apple cultivars are available). Treatments against vectors are recommended both to avoid new infections and reinfections. The annual period of presence of the AP vectors on apple trees (primary host) is reasonably short. In our common environmental conditions, *C. melanoneura* is known to fly back to apple in February. Two insecticide treatments are enough to cover the dangerous active period of natural inoculations. When less roguing is practiced the vector control must be intensified. Particular apomictic rootstocks (*Malus sieboldii* x *M. sargenti* x *M. pumila*) are promising to be resistant to AP but further investigations are needed.
The alternative to the flexible differentiated criteria is the immediate absolute roguing of all of the ifected trees (also where it is already highly diffused) in order to speed up

the eradication of the disease: perhaps an easier decision under the scientific point of view but with possible heavy economical consequences (concerning the concrete possibility to extinguish in the meantime local fructiculture).

4. CONCLUSIONS

Apple proliferation is a very complex disease. Consequently, its control is not based on a single intervention against single agent, host or vector. Particularly in an already infected area a flexible integrated approach, adaptable to the different situations, is reccomended. Roguing and vector control (especially if broadly adopted) remain the two basic ways to actively reduce the natural infection pressure of the disease. Moreover, the origin and natural extinction of the epidemics (Fig. 1) are controlled by complex biological factors such as new biotypes of the pathogen, different vectors or strains of the vector, changed general conditions and plant/vector interactions. Rigid, permanent and universal rules are not possible despite that AP is a dangerous quarantine disease. Large and prolonged monitorings are recommended, directed to plants and to vector population and infectivity. Captured wild psyllas should be tested also for their ability to infect apple. AP is an European disease: we should pay more attention to the autochthonous coevoluted and well adapted apple genotypes, utilizable also as sources of resistance/tolerance against AP. A second point interesting to study is the recovery phenomenon which could act also as an induced factor influencing the epidemics.

Figure 1: Type-trend of Apple proliferation epidemics in a newly infected area. The aim of the control measurers is to keep the top of the curve low, the ceiling-line short, and to induce a more rapid final slope.



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