

## THE CONTROL OF APPLE SCAB: A SET OF SUBSTRATEGIES TO MEET THE DEMANDS OF INTEGRATED PLANT PROTECTION

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### ABSTRACT

Control of apple scab in central Europe consumes most of the about 80% fungicides used for fruit growing with very often unsatisfactory success despite many applications or excessive spraying. Reasons are excessive pruning, wrong application dates and mainly one spray schedule for all orchards of a farm.

To reduce conidial inoculum, pruning methods have to be changed while for reducing high ascospore inoculum, sanitary treatments have to be applied to highly infested orchards. Therefore autumn scab assessments are basic for attack related scab control.

During primary season the simulation programme RIMpro together with data from the weather forecast enables prediction of maturation of ascospores, ascospore release and release related severity of infection for five days in advance. Completed by information on leafgrowth since the last spray directed application of protectants has become possible.

For maximizing efficiency of fungicides severe primary infections are controlled by double sprays with a protectant right before the onset of rain and an additional curative compound after the infection. This strategy also slows down development of resistance and gives better results than practise. Predicted light infections are controlled only with reduced dose rates of protectants or not at all in non-sensitive varieties or low inoculum orchards.

Further assessments are necessary to decide about the necessity of continued spraying during secondary season. If threshold levels are not exceeded, sprays can be omitted until begin of storage treatments.

To eliminate sprays caused by fear and doubt scab warning should be centralized, informing farmers via fast media in short intervals about the actual and future development and all necessary actions.

### IZVLEČEK

#### ZATIRANJE JABLANOVEGA ŠKRLUPA: VRSTA SUBSTRATEGIJ, DA BI ZADOVOLJILI ZAHTEVAM INTEGRIRANEGA VARSTVA RASTLIN

Za zatiranje jablanovega škrlupa se v osrednji Evropi porabi približno 80% fungicidov pri pridelavi jabolk s pogosto nezadovoljivim uspehom kljub številnim aplikacijam ali celo preštevilnim pršenjem. Razlogi za to so premočno obrezovanje, neustrezni roki pršenja in večinoma en sam pršilni program za vse sadovnjake na kmetijskem obratu.

Da bi zmanjšali konidijski inokulum, moramo spremeniti načine obrezovanja, medtem ko je za zmanjšanje inokuluma askospor potrebno izvesti v močno okuženih sadovnjakih sanitarna tretiranja. Zato je jesensko ocenjevanje škrlupa podlaga za zatiranje, ki je v korelaciji z okužbo.

V zgodnji pomladi omogočajo simulacijski program RIMpro skupaj s podatki vremenske napovedovalne službe napoved zorenja askospor, njihovo sproščanje in od askospor odvisno intenzivnost okužb za pet dni naprej. To, dopolnjeno s podatki o rasti listja od zadnjega pršenja, omogoča usmerjeno tretiranje s protektivnimi fungicidi.

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Da bi dosegli maksimalno učinkovitost, zatiramo nekaj primarnih okužb z dvakratnim pršenjem s protektivnim fungicidom, tik predno se začne deževje in z dodatnim kurativnim fungicidom po okužbi. Ta strategija tudi upočasni razvoj odpornosti glive proti fungicidom in daje boljše rezultate kot običajna praksa. Napovedane blage okužbe zatiramo le z zmanjšanimi odmerki protektivnih fungicidov ali sploh ne pri neobčutljivih sortah ali v sadovnjakih z malo inokuluma.

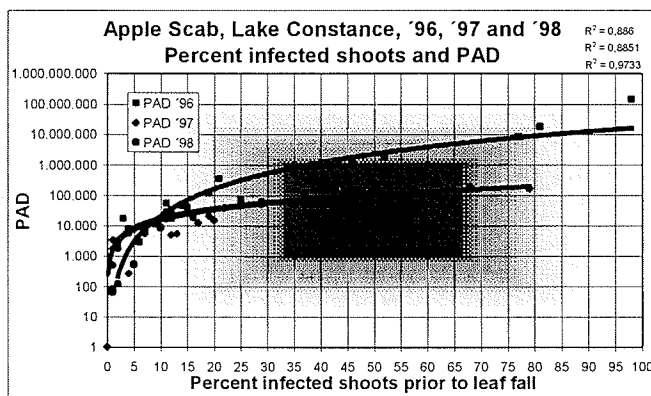
Nadaljnja ocenjevanja so potrebna, da se odločimo ali so potrebna kontinuirana pršenja v drugi rastni dobi. Če pragovi niso prekoračeni, lahko tretiranje opustimo do začetka pršenj za preprečevanje skladiščnih bolezni.

Da bi se izognili pršenj, ki jih povzročajo bojazen in dvomi, naj bi signalizacijo škrlupa centralizirali, sadjarje pa bi informirali v kratkih presledkih prek hitrih javnih občil o trenutnem in prihodnjem razvoju škrlupa in o vseh potrebnih ukrepih.

Actual apple growing in central Europe can be mainly characterized by four parameters:

1. Under central european climatic conditions about 80% of all chemical input is directed to control fungal diseases of which apple scab consumes most of the fungicides.
2. Scab warning is done on a regional level not taking care of orchard specific situations in terms of growth status and inoculum.
3. Regular protectant sprays and frequent use of curative compounds are still widespread in practise and have not been reduced by the introduction of personal scab warning devices.
4. Despite many treatments that are done mostly on all orchards of a farm some orchards with a traditionally high scab attack and those without any very few lesions may be found on almost any farm.

All four points indicate that even intensive chemical programmes with many treatments and high fungicide dose rates do not automatically result in effective scab control and that in some orchards sprays are wasted since they always show just very few or no symptoms.

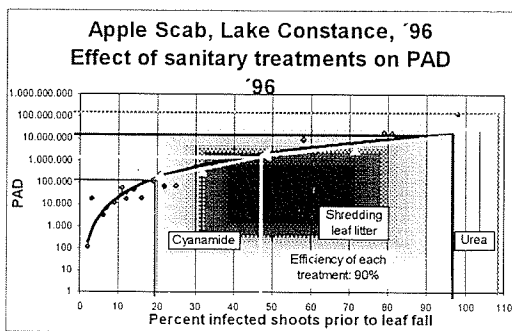


Graph 1: Potential ascospore dose in the past 3 years in commercial orchards

Besides wrong application dates and inadequate fungicide choice a major reason for continuous scab problems is that scab pressure especially in the orchards with a history of scab in many cases is too high to give satisfactory control with only fungicide sprays during primary and

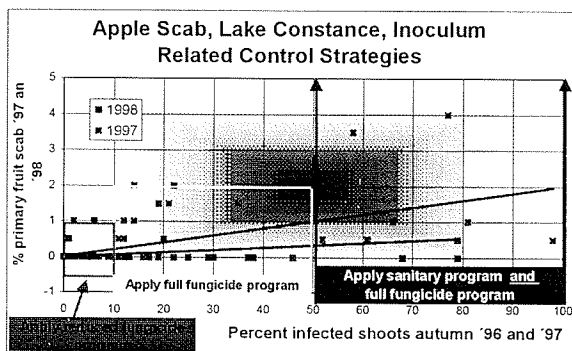
secondary season. High scab pressure may be caused either by excessive pruning regimes that cause vegetative growth not to cease at all or just very late after harvest as well as regrowth after early summer pruning or heavy attack from poor scab control programmes during primary and secondary season.

On excessively growing trees the reduction of vegetative growth is the basic step to bring down sensitivity of the trees to late scab infections and consequently extremely high infection pressure from conidia. To reduce scab pressure from ascospores that may reach more than 100.000.000 ascospores per m<sup>2</sup> of orchard surface (= PAD: potential ascospore dose) in a second step sanitary programmes are required above certain threshold levels which reduce the number of ascospores produced in the leaf litter to a level where the risk of poor control from fungicides becomes relatively low.



Graph 2: Effects of sanitary treatments on PAD

From that reason assessing the pre leaf fall scab attack is considered one of the most important monitoring activities in fruit growing since up to more than 95% of all lesions may develop from August to November and are nearly always missed or even ignored by the growers. This results in a high risk for a surprisingly high scab attack in the following season since this high inoculum will then be controlled just with the risky fungicide applications.



Graph 3: Effect of PAD on next years primary scab attack and proposed control programmes

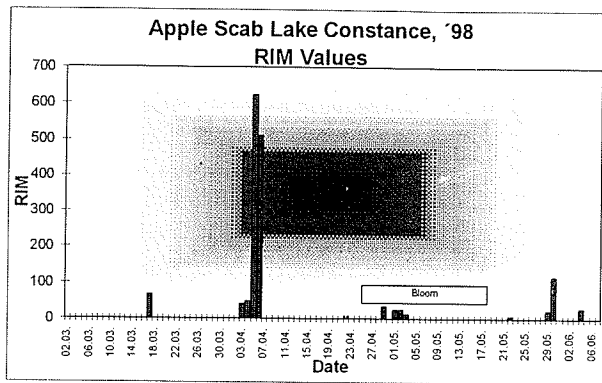
And poor control increases the principally high financial input for scab control once more. In first trials to develop threshold levels for orchard specific scab control it could be shown that at least at scab attacks above 50% infected shoots prior to leaf fall a sanitary programme is necessary to bring down scab pressure to levels that orchards with good control usually have. For these orchards and those ones with a scab attack from about 10 to 50% percent final attack a regular fungicide programme is recommended while for orchards with less than 10 % infected shoots a minimum fungicide programme covering only the few severe infections during primary season can be applied to achieve good control with fruit scab not exceeding 1%.

A third step is better timing of fungicide sprays and the selection of fungicide applications according to severity of infection. This is achieved with the simulation programme „RIMpro“ which is calculating maturation of ascospores in the leaf litter, ascospore release and the infection process on leaves and fruit computing the severity of infection according to the number of released ascospores that were able to penetrate leaves and fruit as well as incubation periods and degradation of fungicide residue.

These features at the first time allow the directed application of reduced dose rates of protectant fungicides right before the onset of rainy periods according to leaf growth since the last spray and the maturation of ascospores without using a weather forecast for simulation. The prediction improves once more when data from the weather forecast are incorporated, since then ascospore releases and severity of infections can be predicted several days in advance.

<u>Use of the scab simulation program RIMpro and the weather forecast for the simulation of the primary season:</u>
<b><u>The possibilities of RIMpro:</u></b>
<ul style="list-style-type: none"> <li>• Calculation of percent immature ascospores</li> <li>• Calculation of the percentage of ascospores to be potentially released at the next rainy periode</li> <li>• Calculation of of percent ascospores released</li> <li>• Calculation of the infection progress</li> <li>• Calculation of the severity of infection (number of released ascospores, that could infect = RIM-Value)</li> <li>• Calculation of development of leasons</li> </ul>
<b><u>Additional possibilities with weather forecast:</u></b>
<ul style="list-style-type: none"> <li>• Prediction of ascospore release (when and how many spores will be released)</li> <li>• Prediction of the infection progress</li> <li>• Prediction of the infection (when and how severe the infection will be)</li> </ul>

Table 1: The possibilities of RIMpro for apple acab simulation



Graph 4: RIM-Values at Lake Constance 1998

To maximize the efficiency of fungicides and to minimize the selection pressure for resistance to curative compounds, these curative scab fungicides are used **only** for scab control and are sprayed **only** after severe primary infections but always additionally to the protectant before the onset of rain. All minor infections are controlled just with a reduced rate of a protectant which is sprayed right before the onset of rain. In all trials this strategy reduced the number of applications (-15%) and quantity of fungicides used (-75%) in comparison to practise significantly and has proven to give better control (+34%) than practical spray schemes. In orchards with a very low inoculum including non-sensitive and resistant varieties only these severe infections need to be controlled to give satisfactory results.

Inoculum related fungicide program primary season:		
Percent infected shoots previous autumn	Orchards with <u>max. 10%</u> infected shoots	Orchards with <u>more than 10%</u> infected shoots
Weak number of mature ascospores	Protectant only in sensitive varieties right before the onset of rain	Protectant in all varieties right before the onset of rain
High number of mature ascospores	Protectant in all varieties right before the onset of rain	Protectant in all varieties right before the onset of rain
Weak infection (RIM ≤ 200)	-----	-----
Heavy infection (RIM > 200)	-----	Additionally a curative fungicide in all varieties right after the infection!!! (= double treatment)

Curative compounds only additionally after heavy infections if a protectant was applied before the onset of rain (to prevent rapid build up of resistance and masking of infections)

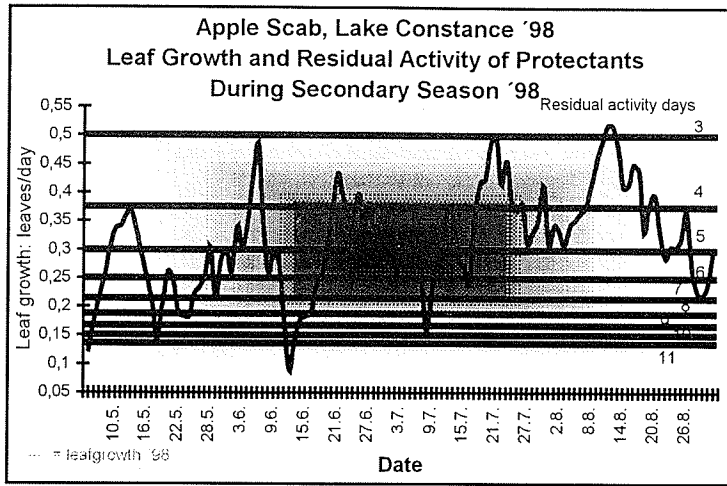
Table 2: Inoculum related fungicide programm during primary season

To decide about the control strategy during the secondary season in a fourth step it is again necessary to assess the attack of the individual orchard after the end of primary season. Below certain levels sprays may be omitted for about four weeks until the next assessment or until the sprays against storage diseases need to be put on. If further scab sprays are necessary only protectants are recommended to keep the risk of developing resistance to curative fungicides as low as possible and to prevent masking of infections that contribute to next year's inoculum. In an orchard with primary attack above the threshold levels the need for these further protective sprays is determined according to leaf growth since the last spray and the possible severity of infection conditions which is calculated with forecasted weather data.

As a fifth step to achieve a reduction in input of chemicals for scab control, to increase efficiency of the fungicides used and keep the risk of developing resistance to curative compounds to a minimum, scab warning should be centralized since climatical conditions do not vary enough to justify scab warning devices on every farm and also ascospore releases and leaf growth are very uniform over large areas and therefore should not be monitored on individual farms apart from the point that time is a very limiting factor on any farm. If all the decision towards fungicide sprays is left at the farmer himself, no reduction of chemical input will be achieved, since in case of doubt and/or poor maintenance of climatical equipment a strong tendency towards treatments from fear and from a feeling of safety can be observed. So all this labour to define application dates and fungicide strategies should be done by independent advisory services allowing the farmer to concentrate on the treatment itself and on the decision which combination of substrategies is necessary in each individual orchard. To avoid any situation where fear may become the reason for spraying, farmers must be familiar with the actual strategies and must be informed about the actual situation in very short time intervals during the season with fast electronic media like fax or email.

Fungicide program, if inoculum is below action threshold:	Fungicide program, if inoculum is above action threshold:
1. Interupt for 4 weeks	Protectant according leaf growth right before onset of rain
2. Interupt for 4 weeks	Protectant according leaf growth right before onset of rain
3. Interupt for 4 weeks	Protectant according leaf growth right before onset of rain
<p align="center"><u>No more use of any curative compound</u> (to prevent rapid build up of resistance and masking of infections)</p>	

Table 3: Attack related fungicide programme during secondary season



Graph 5: Leaf growth related residual activity of protectant fungicides

<p>A centralized scab warning system should contain:</p> <ul style="list-style-type: none"> <li>• Training courses to explain the actual strategies thoroughly to the fruit grower</li> <li>• Rapid electronic information systems (Fax, e-mail, internet)</li> <li>• Frequent supply with actual information (every other day)</li> <li>• Content of the bulletins:                     <ul style="list-style-type: none"> <li>Complete description of the present situation (leaf growth, ascospore maturation, infection status, ...)</li> <li>Prediction of the important parameters for the next days (weather, leaf growth, ascospore maturation and release, date and severity of future infections, ...)</li> <li>Detailed description of the individual actions to be taken in the different orchard classes (Date and time of preventive spray; application windows for curative compounds; best suited fungicides, dose rates, possible side effects, ...)</li> </ul> </li> </ul>
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Table 4: Content of scab warnings