

Effect of mechanically removing of leaf litter on apple scab (*Venturia inaequalis*) infestation in organic apple production

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Abstract

In a project conducted between October 2010 and 2015 different methods to reduce the ascospore inoculum of Venturia inaequalis are tested and compared in regard to their effect on apple scab infestation. The project is funded by "Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft" and aims to reduce the use of copper. The field experiments are conducted throughout Germany at DLR Rheinpfalz (Rhine valley), KOB Bavendorf (Lake Constance) and ÖON (area Altes Land). The effect on apple scab of disposing the leaf litter using a leaf vacuum is compared with products to speed up the decomposition of leaf litter in this trial. At all three locations the leaf litter was eliminated large scaled out of the trial orchards in the early spring, before start of primary season. In this "cleaned" orchards a number of plant protection versions are tested. An assumption of the project was, that the reducing of the inoculum could make copper redundant to fight apple scab. Or at least, to make very low amounts of copper work successfully against scab. All treatments are tested twice: once in a "cleaned" orchard, without leaf litter and once in an untreated orchard, where no activity to reduce the inoculum took place.

Results: It was possible to reduce the amount of leaf litter by 50 to 80 %. The effect on apple scab is ambiguous until now. The clearest correlation between disposing the leaves and decreased scab infestation can be found at the region of Lake Constance. Here the reduction concerning to scab on long shoots is about 15 to 67 %, concerning to scab on fruits it's about 50 to 70 % in the last three years. The results produced by the project partners DLR Rheinpfalz and ÖON were mostly positive as well. Even though the positive effect could not have been seen as constant as at Lake Constance.

Keywords: Apple scab, *Venturia inaequalis*, organic, sanitation, copper reduction

Introduction

Apple scab is a major disease in organic fruit farming, (MacHardy, 1996). The fungus overwinters in form of pseudothecia on infected leaves. In spring these pseudothecia produce ascospores which are discharged into the air when triggered by rain. In Northern Germany up to 20 ascospore infections occur during primary season, depending on the yearly weather conditions. Primary season usually takes place between March and the middle of June in Northern Germany.

Currently no agent or plant protection strategy that shows a comparable efficiency to the use of copper fighting apple scab is known. Especially against the important first scab infections of the year copper shows a good effect (Palm, 1995, 1999). Copper belongs to the heavy metals, the use as plant protecting agent leads to an accumulation in the soil, so the use of copper is criticized as a non-sustainable practice in organic fruit farming.

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When the amount of apple leaves is reduced in an orchard, for example destroyed by shredding, scab risk can be reduced up to 90 % (Sutton et al, 2000). Within the project different methods to reduce the leaf litter before the beginning of primary season are tested and compared. This article focuses on the mechanically removing of leaf litter out of orchards by using a leaf vacuum. Overall the project includes further methods of sanitation which are presented separately. The success of the used leaf vacuum was evaluated directly, for that the amount of leaf litter was determined before and after using the leaf vacuum. The sanitary measure of disposing the leaf litter was combined with different plant protection strategies. Included are strategies without using copper as well as strategies with reduced use of copper. With the help of the different strategies the indirect success of the sanitary measure is evaluated by scab ratings.

The trials are carried out in three German fruit growing areas, located at the Elbe Delta (ÖON), in the Rhein Valley (DLR Rheinpfalz) and at Lake Constance (KOB Bavendorf). The project started in autumn 2010 and will be finished in the end of 2015.

Material and Methods

In early spring, before beginning of primary scab season the leaf litter is disposed at all experimental orchards using a leaf vacuum. At all three trial stations large scaled blocks are cleaned, to avoid influence from the direct environments. The tool is the leaf vacuum "Emma", which is used in the Lake Constance area since a few years or equates to it technically. The leaf litter is removed as late as possible from the trial orchards, to reduce negative influence on the soil life as far as possible. The leaf vacuum is tractor geared, the vacuumed leaf litter is collected in an accumulation bin and disposed out of the trial orchards. The leaf vacuum was used only during suitable weather conditions, meaning dry soil and no rain or snow while using the leaf vacuum. The direct effect concerning to the amount of leaf litter was detected by collecting leaves at 12 one square meter sized plots in the "cleaned" orchards and in the untreated control respectively. Subsequently the leaves are dried and weighed.

At each location the experimental orchards are departed in areas with and without sanitary measures. The used apple cultivars are different. At DLR Rheinpfalz "Gala" is used, at KOB Bavendorf "Jonagold" is used and at ÖON the cultivar "Delbarestivale" is used. Subsequent to the use of the leaf vacuum a number of different plant protection strategies are carried out in the experimental orchards during primary season. For a better comparability only the "standard treatment, " which was conducted at all trial locations, is described. "Standard treatment " means protective use of copper, application before expected infections and lime sulphur used for stop sprays. This strategy is usually applied by organic working fruit growers.

To review possible consequences on the soil life the appearance of "*Lumbricus terrestris*" is monitored within the project. Four randomized plots are analyzed in both parts of the trial orchards (with and without leaf vacuum). At each plot 60 g mustard flour are dissolved in 10 l of water and effused to the ground on a specified plain. The number of earthworms per square meter can be detected and compared between the plaines with and without use of leaf vacuum.

Results

In the first three years of testing the amount of leaf litter was reduced between 55.9 and 94.3 percent by using the leaf vacuum "Emma". Problems are caused by unevennesses of the soil, particularly tractor ruts. Table 1 represents the quantities of leaf litter found in the trial orchards. The total amounts of leaf litter differ between the trial areas. Due to the

colder and snowier winters in the Lake Constance area, the most leaf litter always is found there. The percentage reduction of litter differs from year to year at the three trial locations, the data between the trial locations differ in a similar frame.

Table 1: Reduction of leaf litter by using a leaf vacuum in the years 2011 – 2013 at trial areas (the data refer to g/m², if not otherwise specified)

	2011			2012			2013		
	Control	Vacuum	Reduction	Control	Vacuum	Reduction	Control	Vacuum	Reduction
ÖON	15.3	6.3	58.8%	10.7	3.5	67.30%	7.0	0.4	94.3%
DLR	20.4	9.0	55.9%	8.3	2.4	71.10%	10.0	2.9	71.0%
KOB	54.7	5.6	89.8%	39.2	12.8	67.30%	18.1	4.3	76.2%

Until now, three years of testing at three different locations can be evaluated. In some cases the presentation of the generated data concerning to the reduction of apple scab is not constructive. In cases when scab infestation was very low, slightest differences produce disproportionate efficiency factors. Hence, these cases are not shown below. In figure 1 scab infestation on long shoot leaves in both treatments as well as the reduction rate are represented. Clear positive efficiencies between 58 and 78 %, are achieved at DLR in 2011 and 2013, and at KOB in 2011 and 2012. The results at ÖON show no scab reducing effect on the leaves at all.

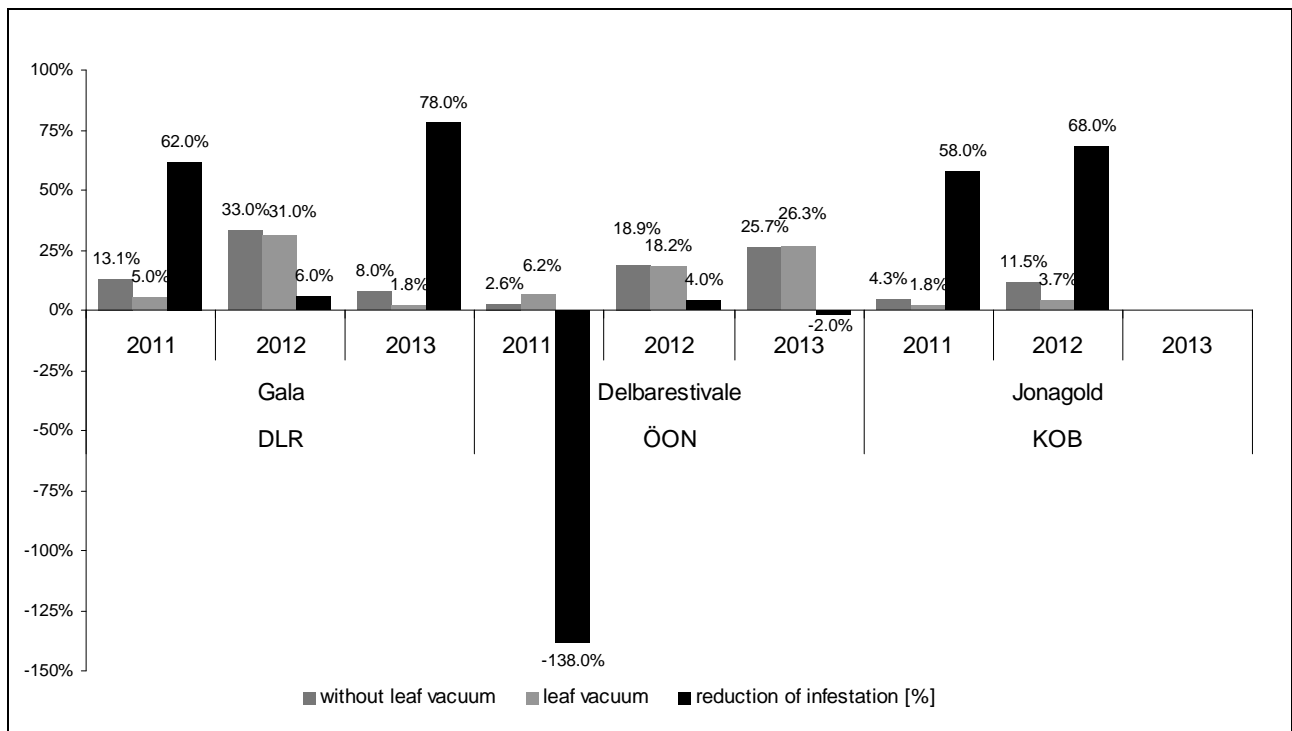


Figure 1: Scab infestation on long shoots at the different locations, each with and without sanitation, 2011-2013

Concerning to scab on fruits, only in 2012 evaluable results were found at trial station DLR. At ÖON a slightly positive effect is visible in 2012. In 2013 the effect seems to be more clearly, on a lower level of disease. In opposite to this, a clearly negative degree of efficiency was found in 2011 at ÖON. The results at KOB show clear positive efficiencies

in every year of testing, with infestation levels between 2.6 and 3.0 % in the treatments using the leaf vacuum and 6.0 to 9.2 % in the treatments without (figure 2).

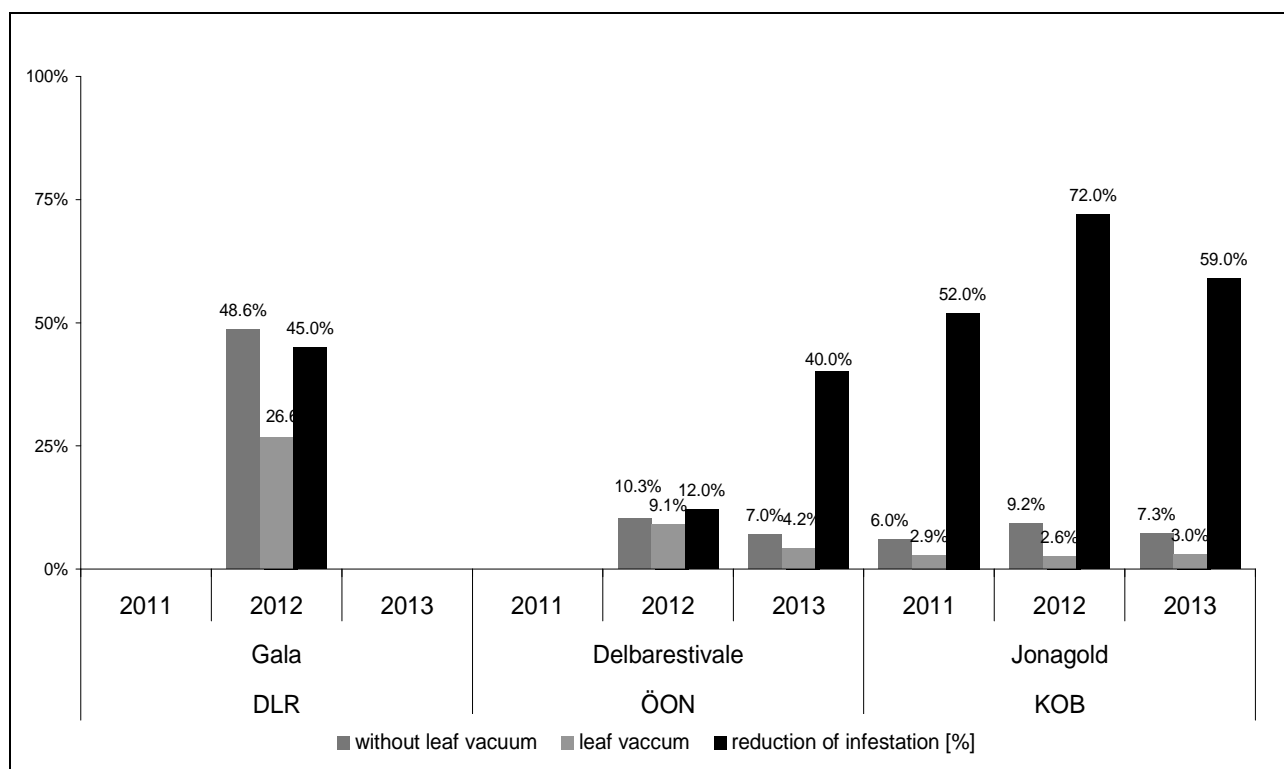


Figure 2: Scab infestation on fruits at the different locations, each with and without sanitation, 2011-2013

The differences between the orchards which have been treated with the leaf vacuum and the control treatments concerning to the appearance of *Lumbricus terrestris* can be seen at table 2. As visible, the number of determined worms ranges clearly between the years. The determined differences are not significant, except for the results found at DLR in 2011, when considerably more worms were found inside the untreated control. Extreme differences were often even found within the orchards between plots which are located close to another.

Table 2: Number of *Lumbricus terrestris* [m²]

	2011		2012		2013	
	Control	Vacuum	Control	Vacuum	Control	Vacuum
ÖON	169.0 a	235.0 a	60.0 a	29.0 a	33.0 a	45.0 a
DLR	19.0 a	5.3 b	6.3 a	4.2 a	16.9 a	30.6 a
KOB	7.3 a	9.4 a	56.2 a	52.0 a	94.6 a	112.3 a

Discussion

In all experimental orchards a considerable reduction of leaf litter could be achieved by using the leaf vacuum. The degrees of efficiency referring to this are similarly between the different trial stations, although the absolute amounts differ between the trial locations.

The effects of leaf removing on apple scab infestation are different between the involved trial stations. Over the years, a clear correlation between leaf disposal and the incidence

of scab infestations on leaves and fruits can be found only at the Lake Constance area. Here the amounts of removed leaves, as well as the amounts of leaves in the orchard before using the vacuum were highest in the first three years of testing. At the stations DLR Rheinpfalz and ÖON clear correlations between leaf disposal and apple scab infestation could not be found in every year.

An effect on the abundance of *Lumbricus terrestris* can not be detected until now. As the amount of recorded worms even differs between plots which are located close to another, it is reasonable to assume that other determining factors have a stronger influence on the abundance of *Lumbricus terrestris* than deprivation of leaves in early spring.

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