

## Summarised project results after five years of testing mechanically removing of leaf litter to prevent apple scab disease

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### Abstract

*Since October 2010 different methods to reduce the inoculum of *Venturia inaequalis* are tested and compared in regard to their effect on apple scab infestation. Several field experiments are conducted throughout Germany at DLR Rheinpfalz (Rhine valley), KOB Bavendorf (Lake Constance) and ÖON (area Altes Land). The project is funded by "Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft".*

*In addition to reduce leaf litter by using a vacuum cleaner in spring, vinasse and yeast extract were used to speed up the decomposition of leaves. The vacuum cleaner was respectively used at the trial stations in early spring to remove leaf litter out of the orchards. Orchards were divided large-scaled into plots with and without additional use of vacuum cleaner. The application of the leaf vacuum was always connected to standard plant protection measures. The plant protection measures were applied similarly during growing season in both plots of the orchards. The same applies for the methods to reduce the inoculum by using products to speed up the decomposition of leaf litter. The aim of the project is to enable a reduced use of copper, by making low amounts of copper working successfully against scab in conjunction with sanitary treatments.*

*According to the soil conditions (tire tracks) and the used technique it was possible to reduce the amount of leaf litter by 39.0 to 94.3 %, when additional hand cleaning was used, the leaf litter could be removed completely. Concerning to the reduction of scab infestation on fruits, 11 of 14 trials in several years showed a positive effect. The clearest correlation between disposing the leaves and decreased scab infestation could be found in Lake Constance area.*

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

### Introduction

Apple scab, caused by the fungus *Venturia inaequalis* is a serious disease in apple production, especially for organic cultivation (MacHardy, 1996). The fungus parasitizes leaves and fruits. The life cycle starts in spring, when ascospores are ejected from infected leaves into the air, triggered by rain events. Usually copper is used in organic apple production, especially to prevent the first scab infections of the year. In this context copper shows a good effect (Palm, 1995, 1999). As copper gets accumulated in the soil, its use is criticized as a non-sustainable practice in organic fruit production. It is known, that the risk of scab infections can be lowered by reducing the amount of leaves in apple orchards (Sutton *et al.*, 2000). In this project, different methods to reduce the amount of leaves until the beginning of primary scab season have been compared.

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This article is focused on the use and the effect of mechanically removing of leaves by means of leaf vacuums. The trials are carried out in three German fruit growing areas, located at the area "Altes Land" (ÖON), in the Rhine Valley (DLR Rheinpfalz) and at Lake Constance (KOB Bavendorf).

### **Material and Methods**

Field trials were conducted in several organically managed orchards in three German fruit growing areas, located at the area "Altes Land" (ÖON), in the Rhine Valley (DLR Rheinpfalz) and at Lake Constance (KOB Bavendorf). The orchards with sizes ranging from one to eight hectare and uniformly distributed scab infestation were large-scale divided into plots with and without additional use of vacuum cleaner.

To avoid, respectively reduce scab infections in spring, the leaf litter was removed from the trial orchards using leaf vacuums before first infections took place, usually from the end of February to the middle of March. In 2014, the trial location in Northern Germany was relocated from the area "Altes Land" to an orchard in a secluded area in Schleswig-Holstein. Furthermore, in 2014 and 2015 in Northern Germany (ÖON) additional hand cleaning was used to remove leaf litter completely.

The removing of leaf litter took place in close proximity to primary scab season. On the one hand, the organic matter ought to remain in the orchards as long as possible, not to impair the nutrient return. Especially for earthworm populations leaf litter is a necessary food base. On the other hand, it was important to ensure that the orchards were as clean as possible when first spores could appear. At every trial station tractor geared leaf vacuums have been used. The leaf litter was blown in accumulation bins and disposed out of the orchards. The use of the leaf vacuum requires dry soil and no precipitation during work. Even frost can be a problem, when the leaves stick to the ground.

In principle, the leaf vacuums had always been tested in combination with organic plant protection strategies. In every plot standard plant protection treatments were applied similarly during growing season. Potential effects of the additional use of vacuum cleaner were investigated by measuring the amount of remaining leaf material in spring and the infestation of apple scab on leaves and fruits in both treatments. The amount of remaining leaf material was measured yearly at the end of March with the beginning of the primary scab season. In each plot remaining leaf material was collected at twelve randomly selected spots using a frame of 1 m<sup>2</sup> reaching from the middle of the tree row to the middle of the drive alley. Collected leaf material was air dried for 24 hours before weighing. To record initial infestation of apple scab before the beginning of the trial (a) and also resulting infestation of apple scab on leaves (b), 50 randomly selected long shoots per plot were examined leaf by leaf in October (a) and July (b). Infestation on fruit was determined in August by visual control of 500 fruit per plot.

### **Results**

Using the leaf vacuums it was possible to reduce the amount of leaf litter between 39.0 % and 94.3 %. Including additional hand cleaning it was possible to remove the litter completely (ÖON 2014, 2015). Between the trial areas remarkable differences concerning to the amounts of leaf litter could be found. Problems in cleaning the orchards are mainly caused by unevenness of the soil and particularly deep tractor ruts. Table 1 represents the quantities of leaf litter found in the trial orchards. The remaining amount of leaves which could have been found in early spring, differed between the years because of climatic differences, as even the percentage reduction of litter was different from year to year.

Table 1: Reduction of leaf litter in the years 2011-2015 at all trial areas (the data refer to g/m<sup>2</sup>, if not otherwise specified) (\*<sup>1</sup> additional hand cleaning was used).

	DLR			ÖON			KOB		
	Control	Vacuum	Reduction	Control	Vacuum	Reduction	Control	Vacuum	Reduction
2011	20.4	9.0	55.9%	15.3	6.3	58.8%	39.1	12.9	67.0%
2012	8.3	2.4	71.1%	10.7	3.5	67.3%	39.2	12.8	67.3%
2013	10.0	2.9	71.0%	7.0	0.4	94.3%	18.1	4.3	76.2%
2014	13.3	4.1	69.0%	38.8	0.0	100%* <sup>1</sup>	23.3	14.2	39.0%
2015	6.7	2.9	57.0%	6.0	0.0	100%* <sup>1</sup>			

The trials took place at three trial stations with different regional climate conditions. This factor even has an effect on scab infestations in primary season. Beyond that, we do not actually know, if the scab races are the same or comparable at all. For those circumstances, the effect on scab infestation has to be estimated separately at each area. Until now, five years of testing are analyzable. As the leaf vacuum could not have been used in Lake Constance region in 2015 due to technical problems, "14 years" of testing are evaluable until now. In some years, when scab infestation was very low, little differences caused disproportional efficiency factors. These years are marked with circles in the following figures (1, 2) and are not rated as positive results.

Figure 1 shows the scab infestation on long shoots. At trial station DLR (Rhine Valley), in 2011, 2013 and 2015 positive effects could be found. No effect could be seen in 2014, although the scab infestation was high. Concerning to scab on long shoots, no positive effects could have been found at trial station ÖON in the years between 2011 and 2013, in 2011 a clearly negative degree of efficiency was recognizable.

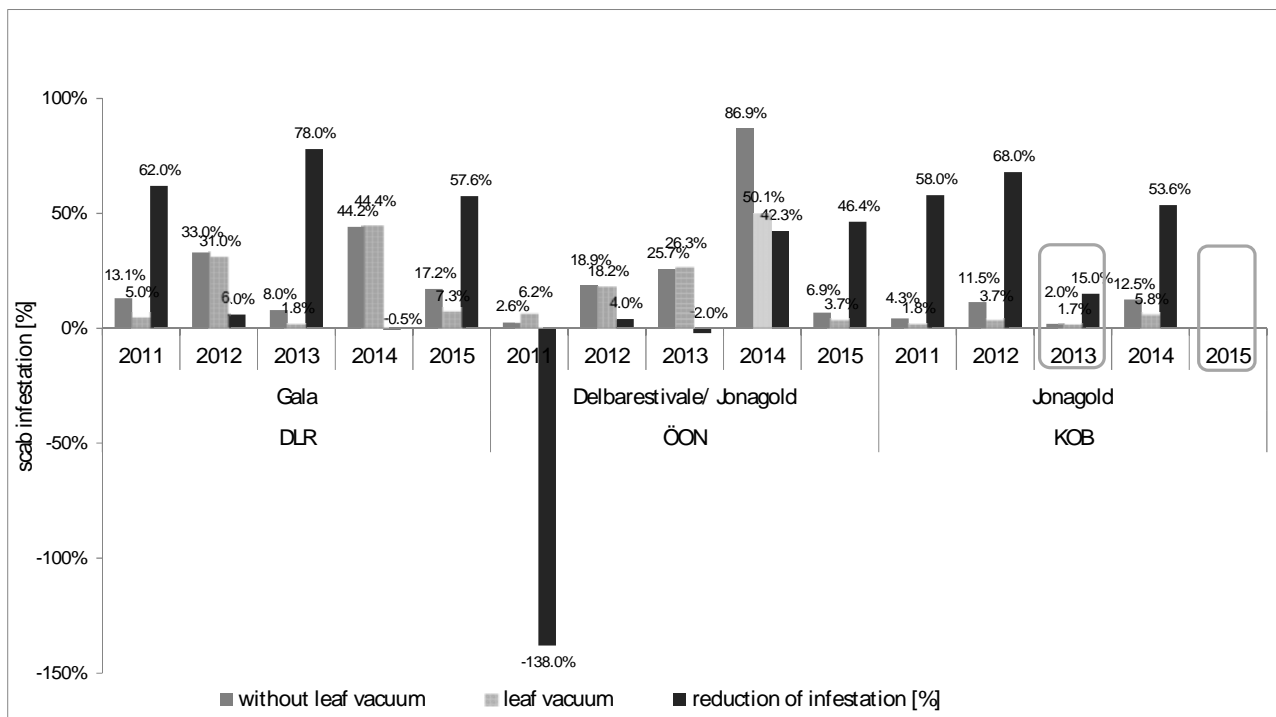


Figure 1: Scab infestation on long shoots at the different trial locations, each with and without leaf vacuum use, 2011-2015.

Only when the trials were conducted in isolated location in Schleswig-Holstein positive results can be seen. At KOB in every year the use of the leaf vacuum showed a clear positive effect on scab infestation on long shoots.

On figure 2 scab infestations on fruits are shown. At DLR three of the five years indicated positive effects, in 2014 and 2015 the degrees of efficiency seemed to be distinguishable. In Northern Germany evaluable results on fruits were found from 2012 to 2015. The results conducted in Lake Constance area by KOB showed positive degrees of efficiency in every year the leaf vacuum was used (2011 to 2014). The degrees of efficacy ranged between 52.0 % and 72.0 %.

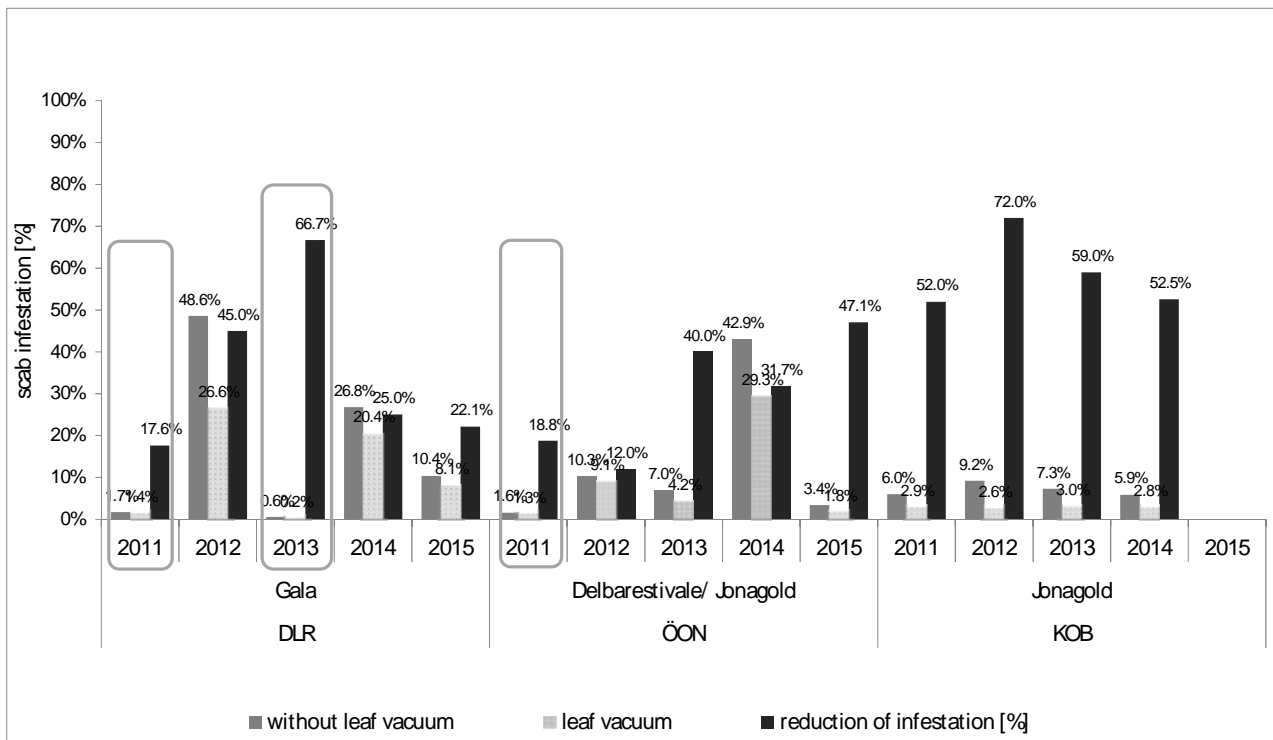


Figure 2: Scab infestation on fruits at the different trial locations, each with and without leaf vacuum use, 2011-2015.

## Discussion

The used technique was able to reduce the leaf litter in every trial orchard. The degrees of efficiency differed widely, so reduction rates between 39.0 % and 93.4 % have been measured. The wide range of efficacy appeared within the same regions, e.g. Lake Constance area (KOB), where due to deep tractor ruts only 39.0 percent reduction was gained in 2014.

Regarding to the impact on scab infestation, even considerable differences occurred. These results did not always correlate with the achieved reduction of leaf litter. In 2014 at KOB, when only a reduction of leaf litter of 39 % was measured, scab infestation on leaves was reduced by 53.6 % and by 52.5 % on fruits.

Even between the carried out scab ratings on leaves and fruits, differences between the severities of infestation occurred. In 2012 and 2013 at trial station ÖON the positive correlation between using the vacuum and the reduction of scab infestation was only found on fruits but not on the leaves.

In conclusion it can be summarized, that concerning to scab infestation on long shoot leaves in 8 out of 14 trials positive effects could be found, concerning to scab on fruits 11 out of 14 trials showed a positive correlation. A clearly negative correlation was found only in 1 trial, concerning to scab on fruits 11 times out of 14 show a positive correlation. A clearly negative correlation only was found 1 time out of 28 scorings, in another case the negative degree of efficiency was low.

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