Is leaf litter removal more efficient than leaf litter shredding to control apple scab? An answer in a commercial organic orchard

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Abstract

In organic apple orchards, sanitation practices are a keystone of a sustainable scab management. Because the suppression of the inoculum by leaf litter removal could be a promising practice, we carried out an experiment to assess the interest of leaf removal versus leaf shredding on disease development and fruit damages. For one of the two cultivars studied, we showed that leaf litter removal can significantly decrease scab damages on fruit and leaf in comparison to leaf shredding.

Introduction

Apple scab, caused by *Venturia inaequalis*, is one of the most serious diseases in apple, especially in organic orchards. In France, the management of apple scab in organic orchards mainly relies on copper and sulphur based products. However, copper and sulphur have respectively environmental side-effects on soil microbial activity, beneficial arthropods and earthworms (*e.g.*Van Zwieten et *al*., 2004).

V. inaequalis primary inoculum mainly comes from ascospores released from pseudothecia on overwintered infected leaves in the leaf litter. The suppression or reduction of this inoculum can be done by application of compounds active on leaves degradation or *V. inaequalis* inhibition such as urea (Sutton et al., 2000). However, urea compound is not registered in the European organic farming standards (Appendix II, R EEC/2092/91). Another way to reduce ascosporic inoculum is to induce leaf decomposition by shredding (Vincent et al., 2004) or to remove leaf litter (Gomez et al., 2007). Devices to mow weeds are more commonly used by farmers and can be used to shred leaf litter in the alley. The removal of leaf litter in the alley could be more efficient than leaf shredding to reduce scab inoculum, indeed Gomez et al. (2007) showed a 95% reduction of aerial ascospore concentration with removal of leaf litter. However, specific devices for leaf removal in orchard are not commercialised. Devices adapted to other use can be use but they imply modifications and a specific investment.

In order to assess the interest of leaf litter removal to control scab, we conducted a 4-year experiment to assess the effect of leaf removal *versus* leaf shredding on disease development and fruit damages.

Material and methods

The orchard (1.2 ha) planted in 2001 was located in Loriol (Drôme, France). This commercial organic orchard included two apple cultivars: Pinkgold® Leratess (7336) and Galaxy (6716), both considered as very susceptible to scab. In the orchard composed of 30 rows, 4 rows of Pinkgold® alternated with 4 rows of Galaxy. Planting distances were 4.0m between the row and 1.25m within row. Rows were north-south oriented. The alleys between rows were regularly mowed. An automatic retractable cultivator that tilled and ridged the soil was used to control weeds within rows. In November 2009, the orchard was divided in 4 blocks. Each block was composed of 4 rows of Pinkgold® cultivars and 4 rows of Galaxy cultivars, except for the block n°4 composed 4 rows of Galaxy cultivars and 2 rows of Pinkgold® cultivar.

Two treatments were tested:
(i) 'reference': in the alley, leaf shredding of leaf litter using a Chabas® FU 2.50 m device equipped with hammers used to shred wood; within the row, leaf ploughing using an automatic retractable disc cultivator.
(ii) 'leaf removal': in the alley, removal of leaf litter using an Amazone Tondobalai® (Tondobennable LGD 180) device; within the row, leaf ploughing using an automatic retractable disc cultivator as for 'reference' treatment.

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Leaf removal and leaf shredding treatments were applied at the same date after leaf fall the 20 November 2009 and 16 February 2010 (season 2010), the 19 January 2011 (season 2011), the 15 December 2011 (season 2012) and the 22 February 2013 (season 2013). Within the row, leaf ploughing was realised at the same date for both treatments with the cultivator. Except for leaf litter management, the orchard was managed according to usual practices in organic orchards in Rhône Valley. Scab was managed by copper and sulphur-based products applied before announced rain.
Scab assessment was done on Pinkgold® and Galaxy cultivars.

For each cultivar, 16 trees were selected within the two inner rows of each plot, excluding trees of the plot edge. Two growing shoots and 10 fruits were selected at random from each tree. On leaf, incidence (percentage of scabbed leaves) and severity (mean number of scab lesions per leaf) were assessed on a sample of 128 shoots / treatment / cultivar. On fruit, incidence (percentage of scabbed fruits) and severity (mean number of scab lesions per fruit) were assessed on a sample of 640 fruits / treatment / cultivar. Scab damages on leaf were observed in May when the scab lesions associated with the first contamination event were observed and in June at the end of the primary infection period. Scab damages on fruit were observed before harvest. An analysis of variance (ANOVA) was performed on the leaf and fruit scab incidence and severity to evaluate differences between leaf shredding and leaf removal. Anova were computing using Statgraphics plus 5.1 software (Manugistics, Rockville, MD, USA). The normal distribution of ANOVA residuals was checked using Shapiro-Wilks test, the independence of ANOVA residuals and the intra-treatment variance equality were visually checked using the residuals/predicted values graph.

Results

Scab development conditions

In 2010 and 2011, climatic conditions were unfavourable for the development of scab in the orchard. Because such conditions didn't allow assessing the effect of the two different sanitation practices, these results are not presented in this document. Only 2012 and 2013 results are presented in this study.

At a local scale, from 18 March 2012 to 4 July 2012, 16 risks of infection occurred:, 7 risks 'Light', 5 risk 'Moderate' and 4 'Severe', according to the levels of Mills and Olivier infection periods (Olivier, 1986). From 23 March 2013 to 9 July 2013, 18 risks of infection occurred: 4 risks 'Angers', 4 risks 'Light', 6 risk 'Moderate' and 4 'Severe'.

Scab damages on leaf

In 2012, no significant effect of the treatment on scab incidence was observed at the 15 May on Pinkgold® (*p*=0.07) and Galaxy (*p*=0.16) cultivars (data not shown). The 26 June 2012, *i.e.* 42 days later, a significant decrease of leaf scab incidence and severity was observed on Pinkgold® cultivar on the 'leaf removal' treatment (table 1). No significant difference of scab incidence and severity was observed on Galaxy cultivar (*p*=0.07 and *p*=0.17, respectively), but the same trend can be noticed.

In 2013, the incidence and severity of scab observed the 23 May was very low and no significant effect of the treatment was observed (data not shown). The 27 June 2013, a significant decrease of leaf scab incidence and severity was observed on Pinkgold® cultivar on the 'leaf removal' treatment (table 2). Scab incidence and severity was respectively decreased by 22% and 35% on the 'leaf removal' treatment. No significant difference of scab incidence and severity was observed on Galaxy cultivar (*p*=0.09 and *p*=0.08, respectively), but the same trend can be noticed as in 2012.

Table 1: Leaf scab incidence and severity observed the 26 June 2012 on Pinkgold® and Galaxy cultivars.

	Leaf incidence		Leaf severity	
	Pinkgold®	Galaxy	Pinkgold®	Galaxy
Reference	37.29 a	27.65 a	3.25 a	1.73 a
Leaf removal	24.61 b	20.41 a	2.12 b	1.20 a

Table 2: Leaf scab incidence and severity observed the 27 June 2013 on Pinkgold® and Galaxy cultivars.

	Leaf incidence		Leaf severity	
	Pinkgold®	Galaxy	Pinkgold®	Galaxy
Reference	48.04 a	22.40 a	4.31 a	1.01 a
Leaf removal	37.57 b	14.62 a	3.00 b	0.59 a

Scab damages on fruit

In 2012, a significant decrease of fruit scab incidence and severity was observed on Pinkgold® cultivar (table 3). Scab incidence and severity was respectively decreased by 26% and 46% on the 'leaf removal' treatment. No significant difference of fruit scab incidence and severity was observed on Galaxy cultivar (*p*=0.71 and *p*=0.96, respectively). In 2013, no significant effect was observed on both cultivars (table 4).

Table 3: Fruit scab incidence and severity observed the 18 July 2012 on Pinkgold® and Galaxy cultivars.

	Fruit incidence		Fruit severity	
	Pinkgold®	Galaxy	Pinkgold®	Galaxy
Reference	35.47 a	32.19 a	1.68 a	0.98 a
Leaf removal	26.25 b	35.31 a	0.91 a	0.97 a

Table 4: Fruit scab incidence and severity observed the 16 July 2013 on Pinkgold® and Galaxy cultivars.

	Fruit incidence		Fruit severity	
	Pinkgold®	Galaxy	Pinkgold®	Galaxy
Reference	22.19 a	29.69 a	0.62 a	1.02 a
Leaf removal	18.28 a	23.44 a	0.53 a	0.70 a

Discussion

The contribution of overwintered conidia located on shoots or buds have to be mentioned because they could interfere with the reduction of ascosporic inoculum. However, Holb et al. (2004) have demonstrated these conidia only slightly contributed to early spring epidemics in orchards with high levels of scab infection in autumn. Moreover, Gomez et al. (2007) have shown that ascospores reduction strongly decreased spring scab development in a continental climatic context. Thus, the contribution of overwintered conidia can be considered as negligible compared to ascospores contribution to the scab epidemic under our climatic condition.

The leaf removal method used in this trial leads to a significant decrease of scab incidence observed on leaf (2012 and 2013) and fruit (2012) on Pinkgold® cultivar. Although the results observed on Galaxy cultivar are not significant, conclusion for this cultivar needs to be nuanced because results observed on leaf follow the same trend as Pinkgold® cultivar and *p-value* are close to the threshold value of 0.05. In this study, the leaf removal method is compared to a leaf shredding method usually employed by organic growers. This study points out the results observed by Gomez et al. (2007) showing an interest to remove leaf in comparison to the shredding of leaf litter.

References

Carisse O., 2004. Apple leaf shredding as a non-chemical tool to manage apple scab and spotted tentiform leafminer. *Agric. Ecosyst. Environ.* 104: 95-604.
Gomez C., Brun L., Chauffour D., De Le Vallée D., 2007. Effect of leaf litter management on scab development in an organic apple orchard. *Agric. Ecosyst. Environ.* 118: 249–255.
Holb, I.J., Heijne, B., Jeger, M.J., 2004a. Overwintering of conidia of Venturia inaequalis and the contribution to early epidemics of apple scab. *Plant Dis.* 88, 751–757.
Olivier, J. M., 1986. La tavelure du pommier, conduite d'une protection raisonnée. *Adalia* 1, 3-19.
Statgraphics, 2001. Statgraphics Plus, Version 5. 1 for Windows. User Manual. Manugistics, Rockville.
Sutton D.K., MacHardy W.E., Lord W.G., 2000. Effects of shredding or treating apple leaf litter with urea on ascospore dose of *Venturia inaequalis* and disease buildup. *Plant Diseases* 84: 1319-1326.
Van Zwieten L., Rust J., Kingston, T., Merrington G., Morris, S., 2004. Influence of copper fungicide residues on occurrence of earthworms in avocado soil. *Science of the Total Environment* 329: 29-41.
Vincent, C., Rancourt, B., Carisse, O., 2004. Apple leaf shredding as a non-chemical tool to manage apple scab and spotted tentiform leafminer. *Agric. Ecosyst. Environ.* 104: 595-604.