Pest status of the sooty blotch and flyspeck complex in Asturian (NW Spain) apple orchards

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Abstract

Sooty blotch and flyspeck (SBFS) fungi occur on apple surface in regions with moist climate, such as Asturias, in the Northwest coast of Spain. Due to the lack of knowledge on SBFS in our region, research has been conducted to determine (1) the timing of appearance of symptoms, (2) the incidence of these fungi on different cultivars, orchards and years and (3) the effectiveness of several fungicides for controlling this disease. Development of SBFS signs was followed in the 2011 season from early July to harvest in several cultivars and orchards. SBFS signs were observed from July 20 onwards. Signs classically related to SB and those of FS appeared on the same date. Some variation in symptom development was observed among cultivars and orchards. Cultivar susceptibility was recorded just before harvest in 2010 and 2011. The severity of SBFS depended greatly on the cultivar but also on the orchard. Damage level in individual cultivars and orchards was rather similar in the two years of observation. Lime sulphur and potassium bicarbonate (Armicarb) sprayed alone or combined with wettable sulphur provided good control of SBFS when they were applied fortnightly from early June to late September (9 sprayings). The clay Myco-San was not as efficient at controlling fruit blemish although diminished the symptoms compared to untreated trees. The use of potassium bicarbonate had, however, side effects increasing lenticel spotting to intolerable limits and reducing fruit weight and yield. This study allowed us to determine the importance of the disease and the cultivar susceptibility in our conditions. Further research is needed to develop a forecasting model and to use fungicides more efficiently.

Keywords: SBFS complex, cultivar susceptibility, organic control, symptom development

Introduction

Sooty blotch and flyspeck (SBFS) fungi occur worldwide in regions with moist climate, including Asturias, in the Northwest coast of Spain. The development of these fungi on apple surface causes the appearance of black spots that produces an aesthetical damage and reduces consequently the yield value. Sooty blotch symptoms are diffuse dark areas of different size while flyspeck ones are small dots closely clumped. These two different types of symptoms led to a two-disease paradigm (that sooty blotch was caused by a single species and that flyspeck was caused by a different single species) that remained until recent years. However, nowadays, it has been shown that SBFS is caused by a complex of fungi comprising more than 60 different species (Gleason *et al*., 2011). SBFS complex is likely not composed of the same species assemblage at each region (Gleason *et al*., 2011) and so SBFS may have a different local response to factors such as temperature or fungicides. Therefore there is a need to conduct local studies on the species assemblage and their environmental biology at each apple-producing region (Gleason *et al*., 2011).

Apple in Asturias is mainly devoted to cider production and thereby aesthetical damage is not as important as in the case of dessert apple. However, there is an increase in the

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surface of orchards guided to produce organic apple for fresh consumption. SBFS may be a constraint for apple production in those orchards, but there is a lack of knowledge on the SBFS status in our region. To fill this gap, research was conducted to determine (1) the timing of appearance of symptoms, (2) the incidence of these fungi on different cultivars, orchards and years and (3) the effectiveness of some fungicides for controlling this disease.

Material and Methods

In all the essays disease occurrence was scored following Mayr & Späth (2008): 0=no symptoms; 1=small spots; 2= symptoms on <10% fruit surface; 3= on 10-25%; 4= on 25-50% and 5= on >50%. Disease incidence was the percentage of fruits with symptoms while severity was calculated as: $(\Sigma(n*c)/(N*5))*100$, where n is the number of fruits of each class, c is the evaluation class (0-5), N is the total number of fruits and 5 is the highest class of the evaluation scale. In all the cases we differentiated between the classical SB symptoms and those of FS. Occurrence of lenticel spotting was recorded in the same scale.

Timing of appearance of SBFS signs

The occurrence of disease symptoms on apples was recorded weekly in four untreated orchards from the first week of July to the end of September 2011. Two or three cultivars were evaluated at each orchard. Ten trees per cultivar were selected and marked at the end of June. Then ten apples per tree were randomly selected at each sampling date and disease occurrence was recorded for each apple.

Cultivar susceptibility

Occurrence of SB and FS signs was recorded in 2010 and 2011 just before the respective harvest of the cultivars. Eight dessert cultivars and 22 cider cultivars were observed. When possible, each cultivar was observed in five organically-conducted orchards and then ten apples of five trees of each cultivar were observed at each orchard.

SBFS control with organic products

An experiment was conducted in 2011 on the cultivar *Goldrush* to evaluate the effectiveness of four treatments: potassium bicarbonate (Armicarb, 0.5%), potassium bicarbonate (Armicarb, 0.5%) combined with wettable sulphur (Bayer, 0.4%), lime sulphur (Sulfoluq, 3%) and the clay Myco-San (0.8%) mixed with an adjuvant (Nu-film 17, 0.1%). Treatments were applied exactly every two weeks from early June to late September (9 sprayings) using a backpack sprayer. Treatments were applied on dry leaf and never with rainy weather. Results were compared with untreated trees. A randomized complete block design with three replicates was used. Each replicate consisted of a five-tree subplot, in which sampling was done on the three central trees.

Results and discussion

Timing of appearance of SBFS signs

Both signs of SB and FS were observed for the first time on July 20, specifically on cultivar *Regona* in orchard 3 (Figure 1). In both cases fungi developed at a different rhythm depending on the cultivar. A correlation was found between the date at which the first symptoms were observed and the final severity recorded for both SB and FS signs: the sooner the cultivars showed first signs, the higher was the severity they suffered (Figure 2). According to the disease development on the different cultivars, an orchard effect may be also appreciated in the case of FS: pressure seemed higher in orchard 3 followed by orchard 4 and then orchards 1 and 2 (Figure 1B). In other studies, between-year variability in the development of SBFS infection has been observed and related to rainfall variables (Mayr *et al.*, 2010; Spolti *et al.*, 2011). Therefore, new observations taking into account weather variables should be performed in our case in order to develop a forecasting model.

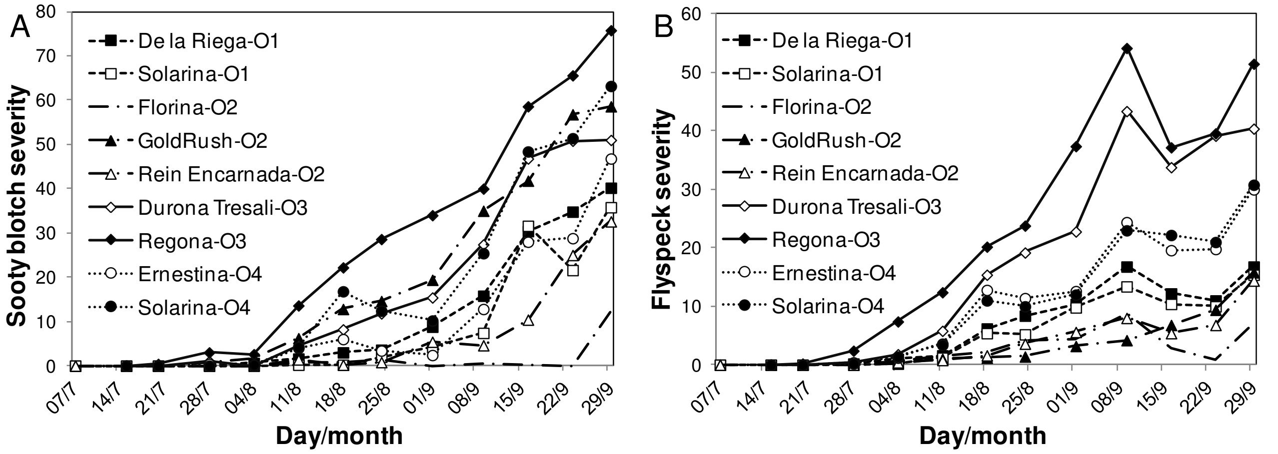

Figure 1: Temporal progress of SB (A) and FS (B) severity in 2011 in different cultivars from four orchards (O1 to O4).

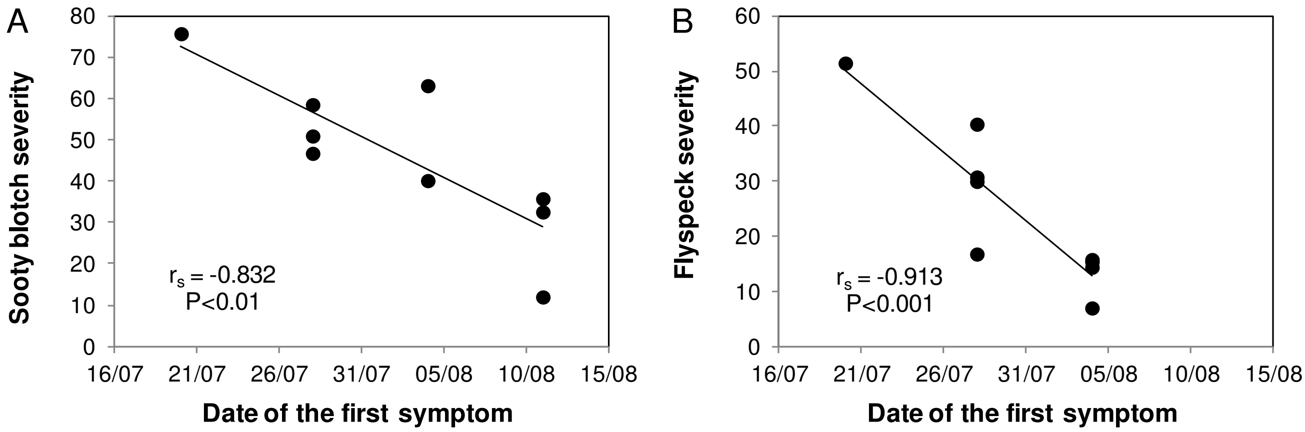

Figure 2: Correlation between the date when first symptom was observed for each cultivar and the final severity recorded for those cultivars.

Cultivar susceptibility

Susceptibility to SBFS varied widely among cultivars (Table 1). For all the cultivars but *Florina* SB severity was higher than FS severity. The four cultivars with higher SB severity (*Goldrush*, *Regona*, *Verdialona* and *Durona de Tresali*) produce yellow or light green apples that ripen late in the season, supporting previous findings (Biggs *et al.*, 2010, Mayr *et al.*, 2010). Notable differences among orchards were also recorded. For example, SB severity in *Goldrush* in different orchards ranged between 51.2 and 84.4 and FS severity between 4.4 and 28.0. In general, lower fruit blemish was observed in orchards placed in sunny slopes and/or orchards with lower leaf and branch density in the tree canopies.

Table 1: Cultivar susceptibility to the sooty blotch & flyspeck complex. Data from different orchards in 2010 and 2011 were pooled for calculations (mean ± SE are shown).

Cultivar	SB severity	FS severity	Cultivar	SB severity	FS severity
Dessert cultivars			**Cider cultivars**		
Florina	14.6 ± 1.9	18.5 ± 3.2	*Durona de Tresali*	51.4 ± 1.7	31.9 ± 1.7
Galarina	14.4 ± 3.9	3.2 ± 1.3	*Ernestina*	39.5 ± 4.0	21.7 ± 2.8
GoldRush	65.0 ± 2.0	15.4 ± 1.6	*Fuentes*	48.1 ± 2.1	18.8 ± 1.4
Liberty	18.3 ± 3.2	16.4 ± 3.7	*Limón Montés*	32.5 ± 3.7	13.6 ± 2.0
Priscilla	28.1 ± 4.0	16.1 ± 2.9	*Meana*	21.8 ± 2.9	20.2 ± 2.9
Reineta Roja Canadá	5.0 ± 3.0	0.0 ± 0.0	*Panquerina*	31.7 ± 4.2	15.3 ± 1.8
Reineta Blanca Canadá	31.4 ± 2.6	7.2 ± 1.6	*Perezosa*	19.5 ± 3.4	8.2 ± 1.6
Reineta Encarnada	22.7 ± 3.2	15.4 ± 1.6	*Perico*	30.1 ± 3.2	9.7 ± 1.2
			Prieta	19.6 ± 4.4	12.4 ± 3.2
Cider cultivars			*Raxao*	34.6 ± 2.9	24.6 ± 1.9
Blanquina	25.0 ± 4.3	12.5 ± 1.8	*Regona*	62.3 ± 2.9	40.0 ± 1.8
Carrió	21.2 ± 3.8	19.5 ± 3.1	*San Roqueña*	19.5 ± 3.9	6.6 ± 1.8
Clara	34.1 ± 1.9	9.8 ± 1.5	*Solarina*	24.7 ± 2.8	17.1 ± 1.9
Collaos	42.9 ± 2.2	29.3 ± 2.2	*Teórica*	5.5 ± 1.8	4.5 ± 0.9
Coloradona	21.2 ± 2.8	4.3 ± 1.2	*Verdialona*	60.6 ± 4.1	20.8 ± 2.6
De la Riega	38.6 ± 3.4	23.8 ± 2.7	*Xuanina*	35.6 ± 3.4	20.1 ± 2.5

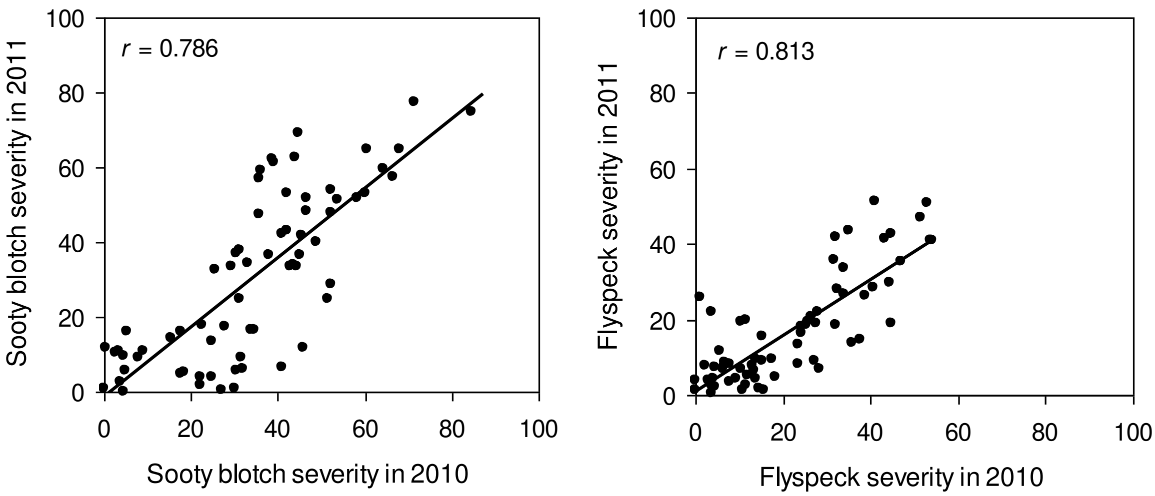

Figure 3: Correlation between sooty blotch (A) and flyspeck (B) severity in 2010 and 2011 (data for each cultivar-orchard pair are plotted).

The overall disease severity stayed in the same range for the two years of observation (SB severity in 2010 and 2011 was respectively 36.3 and 33.1, whereas FS severity was 21.8 and 17.1. In addition, there was a high correlation between years in the disease severity observed from each cultivar at each orchard (Figure 3). All these results support previous observations indicating that orchards have more importance than years at explaining disease occurrence (Trapman, 2006).

Control with organic products

Goldrush apples were harvested on 14th of November. Accordingly to the results in the untreated trees, the SB pressure was very high (Table 2) whereas the occurrence of FS symptoms was, by contrast, very low (Severity index = 3.3; results not presented). All the treatments reduced the SB severity although in a different degree. Armicarb (alone and mixed with wettable sulphur) and lime sulphur provided an excellent control of SB signs, with 100% of marketable apples (level damage lower than 2, i.e. less than 10% of the fruit surface blemished) (Table 2). Spraying with Myco-San resulted in an intermediate level of blemish and marketable apples (Table 2): most of the apples showed symptoms but in general only occupying a small fruit surface, usually the less exposed. Lime sulphur and Myco-San left visual residues on the apples. Excellent protection against SBFS by Armicarb (alone or with wettable sulphur) has been previously shown (Tamm *et al.*, 2006; Mayr *et al.*, 2010).

Table 2. Treatment effect on the occurrence of sooty blotch signs: percentage of apples in each infection class, severity index and percentage of marketable apples.

Treatment	Infection class						Severity index		Marketable apples (%)
	0	1	2	3	4	5	Mean ± SE		(classes 0, 1 & 2)
Control	0.0	1.1	12.2	34.4	24.4	27.8	73.1 ± 5.4	**a**	13.3
Armicarb	66.7	21.1	12.2	0.0	0.0	0.0	9.1 ± 2.3	**c**	100.0
Armicarb + sulphur	65.6	28.9	5.6	0.0	0.0	0.0	8.0 ± 2.1	**c**	100.0
Myco-San	6.7	25.6	25.6	30.0	10.0	2.2	43.6 ± 5.2	**b**	57.8
Lime sulphur	45.6	40.0	14.4	0.0	0.0	0.0	13.8 ± 1.9	**c**	100.0

The latest spraying was done on 23rd of September, that is, almost two months before harvest. During this period there was a considerable increase in SB severity in all the treatments (Figure 4). The high increase in symptoms when spraying ceased supports the results of studies that show that infection can take place throughout the fruit development period (Mayr *et al.*, 2010; Spolti *et al.*, 2011), and suggests the need of covering the whole season with spray applications. Therefore, in cases of late-maturing cultivars and in regions where apples are harvested relatively late, such as Asturias, a high number of sprayings could be necessary to protect apples over their development period.

As a negative side-effect, the use of potassium bicarbonate increased lenticel spotting (sometimes known as “Topaz spots”) to intolerable limits, exceeding even the results in the control trees (Figure 5). Other products, including, curiously, the combination of Armicarb with wettable sulphur, diminished lenticel spots in comparison to the untreated trees. Tamm *et al.* (2006) also recorded an increase in lenticel spotting using Armicarb in Switzerland. Considering as marketable fruits only those without or with small lenticel spots (classes 0 and 1), only 4.4% of the Armicarb-treated apples could have been sold *versus* 65.6% in the control, 80% in the Armicarb + sulphur, 92.2% in the lime sulphur and 95.6% in the Myco-San treatments (data not shown).

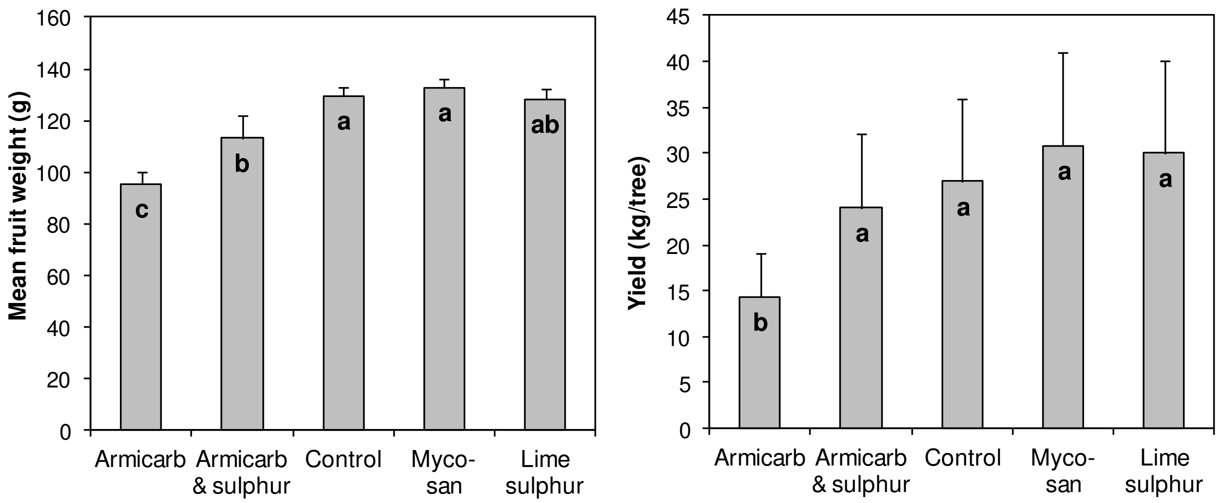

Figure 6: Treatment effect on fruit weight and yield (mean + SE is shown; columns with the same letter are not significantly different).

Acknowledgements

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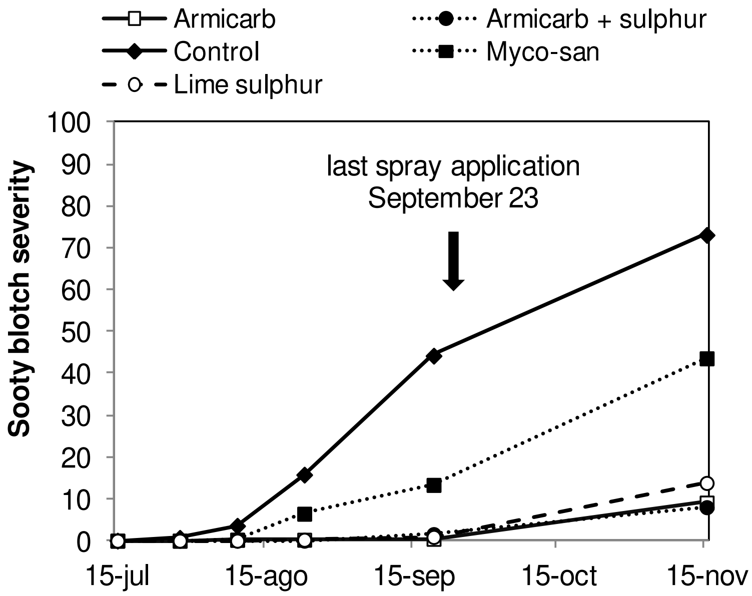

Figure 4: Treatment effect on the temporal progress of sooty blotch severity.

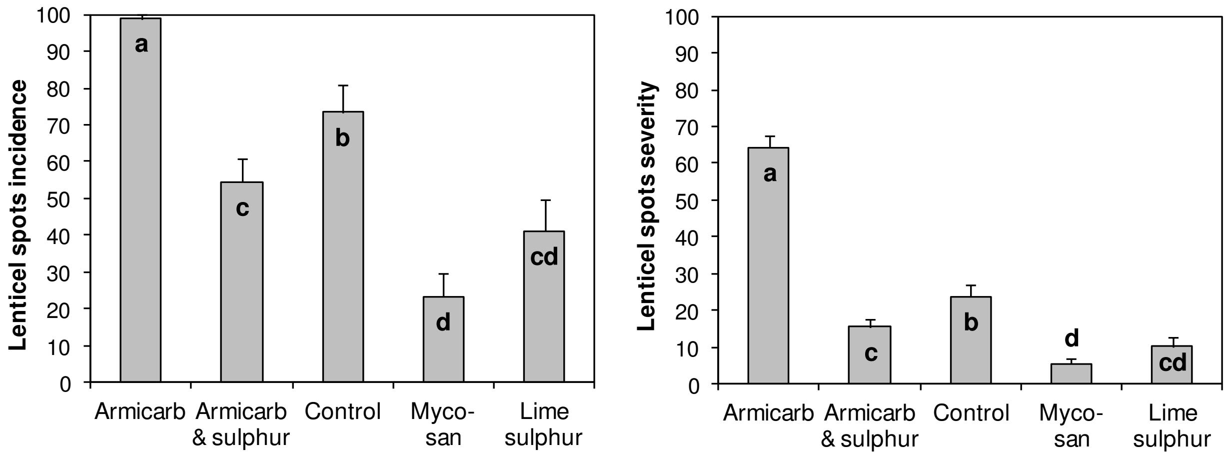

Figure 5: Treatment effect on the incidence and severity of lenticel spotting (mean + SE is shown; columns with the same letter are not significantly different).

Moreover, a reddening in foliage was observed from mid September in some treatments, mainly in Armicarb-treated and in untreated trees. The increase of both lenticell spotting and leaf-reddening may be related to some extent to a toxic effect of Armicarb and may explain the lower fruit weight and total yield observed in Armicarb plots (Figure 6), which may be mediated by a reduction in the photosynthetic capability of trees. Therefore, the use of Armicarb may not be generally recommended before testing the effect of other doses in this and other cultivars. Further research is also required to reduce the number of spray applications.

This first approach to the SBFS status in Asturias allowed us to know the importance of the disease and the cultivar susceptibility in our conditions. Further research is needed to develop a forecasting model and to use fungicides more efficiently.