

Prevalence, incidence and severity of apple powdery mildew infecting apple trees in the Fes-Meknes Region, Morocco

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Abstract

Apple powdery mildew, *Podosphaera leucotricha* (Ell. And Ev.), highly infects apple trees in the Fes-Meknes region in Morocco. A disease survey was carried out during fruit set stage of apples in late spring 2018. Three most popular cultivars in the region were assessed for the incidence and severity of the disease. It was obvious that the cultivars were highly susceptible to powdery mildew (Starking Delicious: 17.1%; Golden Delicious: 13.5% and Gala: 11.1%). The correlation between powdery mildew incidence and its severity was highly positive ($r=0.90$). We recorded the highest disease incidence in Tigrigra (21.5%) and the least in Sidi El Makhfi (4.1%). In view of ensuring good plant protection practices, we recommend that apple farmers carry out disease scouting and consider the action threshold before applying fungicide sprays.

Keywords: Disease survey, Apple powdery mildew, Fes-Meknes region

INTRODUCTION

Apple powdery mildew, which infects apple trees worldwide (Biggs *et al.*, 2009), is caused by *Podosphaera leucotricha* (Ell. and Ev.) (Grove *et al.*, 2003; Holb, 2009). The disease is very common in the apple-producing provinces in the Fes-Meknes region in Morocco. As a matter of fact, apple production in the provinces is faced with a number of challenges among which diseases pose serious problems with regard to control methods. Apple powdery mildew causes noticeable effects on the developing temperate fruits and extensive crop losses in all apple production areas (Blazek, 2004).

Apple powdery mildew can easily develop under different weather conditions of apple-producing areas (Aldwinckle and Jones, 1990; Biggs *et al.*, 2009). The disease can result in fruit russetting, loss of tree growth as well as yield. Moreover, the fungus may survive for many years in a plant material. This makes it so difficult to control (Yoder, 2000). Because of the long-lasting problem of the apple powdery mildew, more control efforts require the knowledge of how susceptible the cultivars are (Biggs *et al.*, 2009). Infected trees of susceptible cultivars may be seriously affected if a control measure is not taken into consideration (Sholberg and Haag, 1994).

The prevalence of apple powdery mildew in the Fes-Meknes region results in a number of fungicide applications. More importantly, no cultivar susceptibility has been documented in the region. In this regard, the survey was carried out primarily to determine the difference in the susceptibility of three cultivars in the apple orchards across three major apple-producing provinces in Fes-Meknes region.

MATERIALS AND METHODS

Study area

We conducted a survey in three main apple-producing provinces in the Fes-Meknes region, where apples have been established since 1920s (MADRPM, 2014). The surveyed provinces were El Hajeb, Ifrane and Sefrou. The three most popular cultivars of apple in the region, Golden Delicious, Starking delicious and Gala were keenly inspected in a given location. Out of about twenty cultivars of apples grown in Morocco, Golden Delicious occupies approximately 50% of the surface area, followed by Starking delicious (14%) and about 5% of Gala cultivar (MADRPM, 2014). Subsequently, the disease incidence and severity of powdery mildew (Figure 1) were recorded on the three selected cultivars in an orchard. Furthermore, the geographical coordinates of each orchard were recorded in view of mapping out and comparing the prevalence of these two diseases. A total of 99 apple orchards were surveyed in the three provinces (Table 1).

Quantification of disease incidence and severity of apple powdery mildew

The commercial orchards were surveyed during the fruit set stage in the growing season of 2018. The assessment was carried out after dormant sprays and systemic fungicides have been applied in the orchards. We assessed the severity of powdery mildew by comparing sampled leaves to the standard scales. To do this, trees were keenly observed at random from each orchard. Disease incidence and severity were assessed on apple trees and leaves with visible symptoms. Disease incidence, as the proportion of infected trees with at least one lesion on a

leaf, was calculated as: $P = n/N \times 100$ (P is disease incidence expressed in percentage, n is number of attacked trees, N is total number of investigated trees).

The disease severity, scored as percentage plant leaf area affected with powdery mildew, was evaluated visually on individual leaflets as the percentage of infected area, using a 0 to 4 scale (Kim *et al.*, 2004) (Table 2).

Three different cultivars of apple were taken into consideration at random in the apple orchards in the three provinces. Since several cultivars are found in the some orchards, the plots were chosen for each cultivar.

Table 2: Grading scale used for the evaluation of apple powdery mildew infection caused by *Podosphaera leucotricha* (Kim *et al.*, 2004)

Score	Severity
0	No symptoms
1	1 to 5%
2	5.1 to 20%
3	20.1 to 40%
4	40.1 to 100%

Statistical analysis

The data gathered were analyzed with the aid of Excel 2013. Student test with two-sample assuming unequal variances with alpha value at 0.05 were performed.

RESULTS AND DISCUSSION

Prevalence of apple powdery mildew infecting apples in the Fes-Meknes region

Overall, apple powdery mildew incidence and severity of Sidi El Makhfi commune were statistically different from the other communes. Moreover, there was a strong correlation between powdery mildew incidence and its severity ($r = 0.90$). With regard to the three cultivars, "Starking Delicious" seemed to be relatively the most susceptible to apple powdery mildew with the incidence of 17.0% followed by "Golden Delicious" (13.5%) and "Gala" (11.1%) (Table 3). However, there were no significant differences among the cultivars. The high incidence and severity of apple powdery mildew in the region could be attributed to the choice of varieties, lack of proper management practices and lack of

Table 1: A summary description of the communes covered in 2018 apple tree disease survey

Province	Commune	Cc	N	Soil type	Altitude (m)	T(°C)	P(mm)
Ifrane	Ain Leuh	E ₁	8	Clay-loam	1103-1308	-4.2- 45	700-800
	Dayat Aoua	E ₂	8	Clay-limestone	1413-1478	-10- 35	500-750
	Sidi El Makhfi	E ₃	10	Clay loam	1069-1111	-4.2- 45	650-750
	Tigrigra	E ₄	13	Clay-limestone	1105-1287	-10- 45	700-800
Sefrou	Ait Sbaa	E ₅	23	Sandy-clay	1072-1423	9.5- 25	460-642
	Laanoucer	E ₆	24	Sandy-clay	1349-1419	9.5- 25	460-642
El Hajeb	Ait Naamane	E ₇	13	Clay	1111-1276	16-34	400-600

Cc: Code of Commune N: number of orchards surveyed, T: Mean annual temperature, P: Mean annual rainfall



Figure 1: Apple leaves infected by apple powdery mildew

knowledge on the appropriate fungicides to be used for the management of the diseases (Byarugaba *et al.*, 2013; Marine *et al.*, 2010).

The present result shows the highest incidence of apple powdery mildew in Tigrigra commune (21.5%), followed by Ain Leuh (17.7%), Dayet Aoua (15.4%), Laanoucer (14.9%), Ait Sbaa (13.5%), Ait Naamane (10.8%), and Sidi El Makhfi (4.3%) (Figure 3). The severity, calculated as percentage of leaf area affected, proved to be correlated to the severity in each of the communes. The severity was highest in Tigrigra commune (17.7%), followed by Ait Sbaa (14.1%), Dayet Aoua (13.7%), Ain Leuh (12.3%), Laanoucer (12.3%), Ait Naamane (8.8%) and Sidi El Makhfi (4.1%).

Apple powdery mildew was widespread in the three major apple growing provinces. As a matter of fact, apple orchards are not evenly distributed in the region due to factors such as topography, soil fertility, weather, etc. Consequently, orchards are clumped in areas that are more prone. According to the prevalence of the disease,

there were less symptoms of diseases in El Hajeb province (21% of the orchards surveyed in the province). In contrast, apple powdery mildew was higher in Sefrou province (47.8% of orchards surveyed manifesting the symptoms of apple powdery mildew) than in Ifrane (30% of the orchards surveyed in the province showed the presence of the disease).

The distribution of the diseases in the three provinces showed the differences among the orchards surveyed. In the province of El Hajeb, there were more orchards with no visible symptoms of either of the diseases. Mean minimum temperature and mean maximum temperature in this province were 16°C and 34°C, respectively, whereas the average annual rainfall for the last ten years was 520 mm. In the province of Sefrou, the average annual rainfall was about 460 mm, average annual temperature was 16°C with an average maximum of 25°C and a minimum of 9.5°C. The hot and dry prevailing winds blow during the summer in the North-Northeast directions (Hamdani, 2015). In Ifrane province the av-

Table 3: Prevalence of apple powdery mildew in the Fes-Meknes region

Commune	Golden Delicious		Gala		Starking Delicious	
	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)
Ain Leuh	0.0	0.0	13.3	5.0	40.0	32.5
Ait Naamane	28.0	23.0	0.0	0.0	0.0	0.0
Ait Sbaa	9.3	11.0	10.5	12.1	20.0	19.0
Dayet Aoua	18.3	16.2	5.6	5.0	23.3	20.0
Laanoucer	17.2	13.1	18.3	15.0	9.3	8.0
Sidi El Makhfi	0.0	0.0	13.3	12.5	0.0	0.0
Tigrigra	21.4	17.9	16.7	12.8	26.7	23.3
Grand mean	13.5a	11.6a	11.1a	8.92a	17.0a	14.7a

Percentages followed by the same letter do not differ significantly by Student *t* test at $P=0.05$ S: percentage leaf area affected

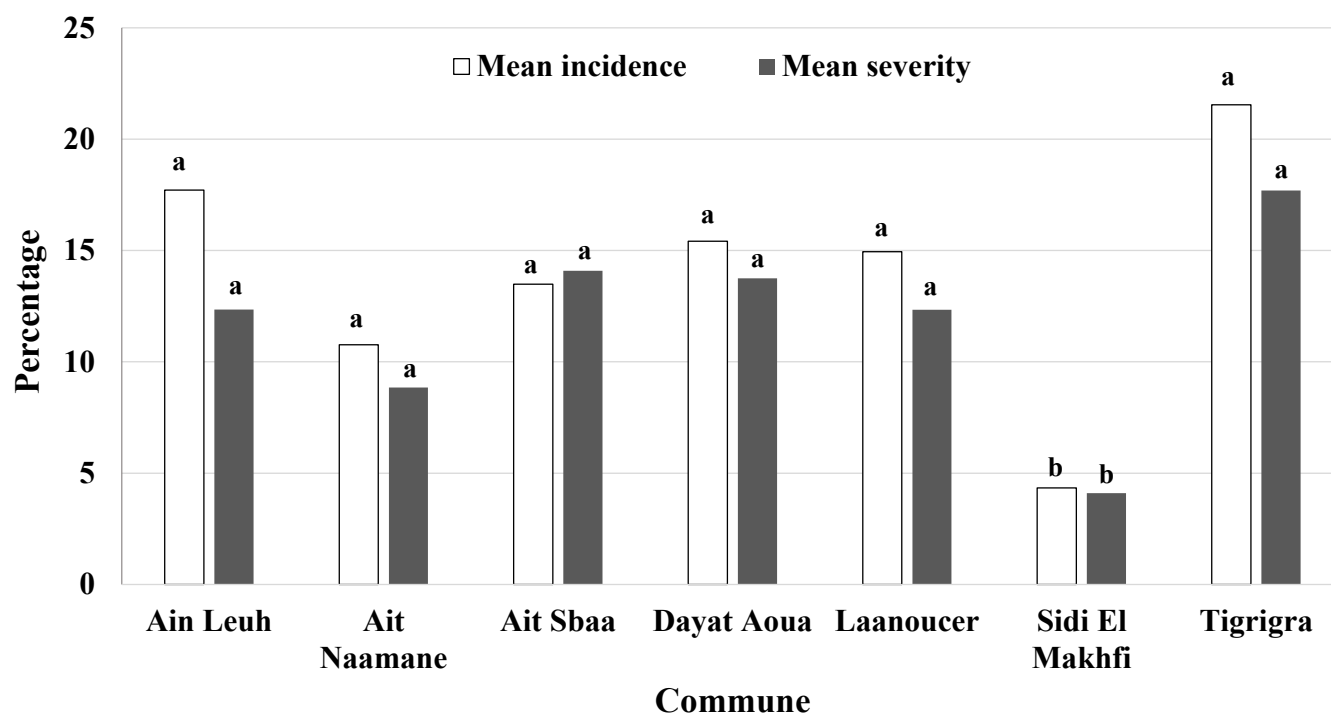


Figure 2: Mean incidence and severity of apple powdery mildew in apple producing communes in the region Fes-Meknes. Bars with the same letters indicate no significant differences between means according the least significant difference test ($p \leq 0.05$)

average annual rainfall is greater than 600 mm with the minimum and maximum temperature for the last ten years were - 24°C and + 37°C, respectively (Ministère de l'Intérieur, 2016). In the course of this study, it was noted that Ifrane province, which experienced lowest temperatures and highest average annual rainfall among the three provinces, apple powdery mildew was less important. In Sefrou province where temperatures are higher and rainfall is lower, powdery mildew is a major problem. Similar findings have been reported by Byarugaba *et al.*, (2013).

Disease monitoring and forecasting is a fundamental part of integrated pest management to rationalize fungicide use. Visual monitoring of 20-50 trees per orchard of apple powdery mildew from green tip to fruit maturity stage will help reduce costs and fungicide inputs. Hickey (1983) suggests a special action threshold level at 20% leaf infection for fungicide application against apple powdery mildew. Knowledge on disease threshold, although not easily implemented, will help farmers confirm the efficacy of fungicide sprays.

CONCLUSION

Apple powdery mildew is a major problem of apples in the surveyed region. The present results, obtained from the field survey on the prevalence of apple powdery mildew, show that the three major cultivars were susceptible to this disease in the surveyed region. The most susceptible cultivar to apple powdery mildew was Starking Delicious. However, the study also showed no statistical differences between either the incidence or the severity of apple powdery mildew of the three varieties. The diseases were influenced by the conditions of temperature and rainfall, which varied among the three provinces. In view of ensuring good plant protection practices, we recommend that apple farmers carry out disease scouting and consider an action threshold before applying fungicides.

REFERENCES

Aldwinckle H., Jones A. L. (1990). Compendium of apple and pear diseases: APS press.

Biggs A. R., Yoder K. S., Rosenberger D. A. (2009). Relative susceptibility of selected apple cultivars to powdery mildew caused by *Podosphaera leucotricha*. *Plant health progress*, 10: 3.

Blazek J. (2004). Pre-selection of apple seedlings for partial powdery mildew (*Podosphaera leucotricha* Ell. et Ev./Salm./) resistance. *Plant Soil and Environment*, 50: 65-69.

Byarugaba A. A., Gard T., Kashaija I. N. (2013). Prevalence of apple scab and powdery mildew infecting apples in Uganda and effectiveness of available fungicides for their management. *African Journal of Agricultural Research*, 8: 2063-2067.

Grove G.G., Eastwell K.C., Jones A. L., Sutton T.B. (2003). Diseases of apple. *Apples: botany, production and uses*, 459-488.

Hamdani M. (2015). Monographie des Ressources en Eau de la Région de Fès-Meknès. www.memoirepfe.fst-usmba.ac.ma/get/pdf/2988 [French].

Hickey K. (1983). Control of apple powdery mildew in the mid-Atlantic region. *Plant Disease*, 67: 245.

Holb I.J. (2009). Fungal disease management in environmentally friendly apple production—a review. In *Climate change, intercropping, pest control and beneficial microorganisms* (pp. 219-292). Springer, Dordrecht.

Kim J.C., Choi G.J., Lee S.W., Kim J. S., Chung K.Y., Cho K. Y. (2004). Screening extracts of *Achyranthes japonica* and *Rumex crispus* for activity against various plant pathogenic fungi and control of powdery mildew. *Pest Management Science*, 60: 803-808.

MADRPM (2014). Conjoncture de la filière pomme. http://www.agriculture.gov.ma/sites/default/files/141022-note_veille_pommes-sl.pdf [French].

Marine S., Yoder K., Baudoin A. (2010). Powdery mildew of apple. *The Plant Health Instructor*.

Ministère de l'intérieur (2016). Monographie de la province d'Ifrane. http://www.abhatoo.net.ma/content/download/20999/383300/version/1/file/monographie_province_ifrane.pdf [French].

Sholberg P., Haag P. (1994). Control of apple powdery mildew (*Podosphaera leucotricha*) in British Columbia by demethylation-inhibiting fungicides. *Canadian plant disease survey* (Canada).

Yoder K. S. (2000). Effect of powdery mildew on apple yield and economic benefits of its management in Virginia. *Plant Disease*, 84: 1171-1176.