Assessment of disease susceptibility and fruit quality

Claude Eric Parveaud, Christelle Gomez, Gilles Libourel, François Warlop, Vincent Mercier

Assessment of disease susceptibility and fruit quality of 28 peach cultivars

C-E. Parveaud[1], C. Gomez[1], G. Libourel[2], F. Warlop[2], V. Mercier[3]

Abstract

The susceptibility to diseases is not considered as a key-criterion in peach breeding programs. Even if the turn-over of peach cultivars is important, suitability for organic and low-input systems remains unknown for most of the cultivars. A first program has been carried out from 2001 to 2008 to assess peach leaf curl, powdery mildew and aphid susceptibilities of 18 cultivars in an experimental station. Fruit quality was also assessed. A high variability in leaf curl (Taphrina deformans) *and powdery mildew* (Sphaerotheca pannosa *var* persicae) *susceptibilities and fruit quality was observed among the cultivars. Reine des Vergers and Belle de Montélimar were identified as relevant cultivars for specific markets, because of low susceptibilities to diseases and high fruit quality. In 2009, they have been included in a second assessment program among 10 other cultivars, which is still going on. The variability of peach leaf curl susceptibility between cultivars was strongly influenced by the disease pressure. In 2011, we identified different levels of tree recovery among the cultivars after severe damages caused by peach leaf curl and* Monilinia *spp.*

Keywords: cultivar susceptibility, peach, leaf curl, *Monilinia spp.*, powdery mildew

Introduction

The choice of the peach cultivar is one of the keystones to set up less input-dependent orchards. During the last decades, breeders have mainly selected peach cultivars on yield and fruit appearance (Byrne, 2002). As a consequence, most of the commercial cultivars are highly susceptible to peach diseases which are difficult to control in organic and low-inputs orchards. Nowadays, the choice of peach cultivars is large but reliable data concerning their suitability to organic and low-inputs systems are rare.

The lack of reliable information on peach cultivars' susceptibility to diseases and pests is partially explained by several methodological bottlenecks. Indeed, the choice of the experimental design strongly affects the assessment results. Random and block tree distribution can affect the spatial dissemination of diseases in different ways. The pest and disease management is also a key-point, because the optimal date for spraying is not necessarily the same for the range of tested cultivars. Moreover, the difference in susceptibility to diseases between cultivars can be very narrow. As many factors are difficult to be controlled by the experimental design and management, misleading results could be observed.

To help the growers in their choice of peach cultivars, the susceptibility to main diseases of a wide range of peach cultivars was assessed in two field trials.

[1] GRAB, Research Group for Organic Farming, France, 26320 Saint-Marcel-les-Valence, claudeeric.parveaud@grab.fr
[2] GRAB, Research Group for Organic Farming, France, 84911 Avignon Cedex 9, gilles.libourel@grab.fr
[3] INRA, National Institute for Agricultural research, UERI Gotheron, 26320 Saint-Marcel-les-Valence, France, mercier@avignon.inra.fr

Material and Methods

Trial 1.

In 2001, 18 cultivars were planted at the INRA Gotheron experimental station in the Rhône Valley production area, in the South-East of France. Some promising old cultivars and parents coming from INRA breeding nursery with low susceptibility to diseases were selected for the experiment (Warlop *et al.*, 2006). All cultivars were own-rooted and planted at 1.5 m distance in a single row in a stony loam soil. Water was supplied with a microjet irrigation system. Each cultivar was represented by one tree. The commercial cultivar Summergrand was used as reference for high leaf curl susceptibility.

Mineral oil was applied in years when aphid (mainly *Brachycaudus persicae*) pressure was high (table 1). A sulphur-based treatment was applied in 2003 -to control powdery mildew (*Sphaerotheca pannosa* var *persicae*) and avoid a heterogeneous growth of the young trees. No other fungicides and insecticides were applied during the period 2001-2008. Leaf curl (*Taphrina deformans*) and powdery mildew (*S. pannosa* var *persicae*) symptoms were observed each year in April-May and in May-June, respectively. The severity of damages was ranked in 3 classes: high, medium, low. Organoleptic fruit quality was assessed by one score ranging from 1 (low quality) to 10 (very good quality) during tasting sessions.

Trial 2. In 2008 and 2009, 12 cultivars (including the two most promising cultivars selected in trial 1) were planted at the same experimental station in an adjacent plot. All cultivars were grafted on GF305 rootstock and 10 trees per cultivar were.planted at 4 x 4 m distance randomly-located in the plot. The two most promising cultivars from trial 1, Belle de Montélimar and Reine des Vergers, had to be grafted again in August 2009 and 2010 because of bud grafting failure. Water was supplied with a microjet irrigation system. Bénédicte cultivar was the reference for low leaf curl susceptibility. Mineral oil completed with localized chemical treatments was applied when aphid pressure was high (table 1). Copper and sulphur-based treatments were restricted to critical situations (1) to limit leaf curl damages on young grafted trees and (2) to limit interactions between diseases and permit the assessment of all studied diseases.

Leaf curl and powdery mildew symptoms were observed twice a month on leaves as long as they occurred (table 2). Flower necroses caused by *Monilinia spp.* symptoms (mainly *Monilinia laxa*) were observed after bloom. Each year, the results are given for the date when severity scores were at maximum. Statistical analyses were computed using Statgraphics plus 5.1 software (Statgraphics plus 5.1, Manugistics, Rockville, MD, USA). The level of significance was set at 5% for all the statistical tests performed. Anova and Bonferroni post-hoc tests were used to assess the differences between cultivars.

Table 1: Pesticide applications against aphids and diseases in trial 1 and 2. Dose of copper and sulphur per treatment is indicated in brackets. Sanitary methods (*e.g.* decayed fruit removing) were also realised.

	Trial 1	**Trial 2**
Plot management	Organic farming	Conventional / very low inputs
Disease treatments	sulphur (6kg/ha): 24/04/2003	copper (0.7kg/ha): 25/02/2010; 10/05/2010 sulphur (6.0kg/ha): 13/08/2010 ; 03/05/2011 ; 24/06/2011
Aphid treatments	mineral oil : 26/02/2003 ; 04/03/2004 ; 15/03/2006 ; 01/03/2007 ; 21/02/2008	mineral oil: 17/03/2010 ; 21/02/2011 localized treatments: 24/04/2009 ; 27/04/2010 ; 10/05/2010 ; 18/04/2011 ; 27/05/2011

Table 2: Severity classes for the assessment of leaf curl and powdery mildew symptoms observed on leaves (expressed in percentage of leaf damage in the whole crown) and *Monilinia spp*. symptoms observed on flowers (expressed in percentage of flower necrosis in the whole crown) in trial 2.

Infection class	**Leaf curl and powdery mildew damaged leaves (%)**	***Monilinia spp.* damaged flowers (%)**
0	0%	0%
1	1 – 5%	1 –10%
2	6 – 30%	11 – 25%
3	31 – 60%	26 – 50%
4	60 –100%	51 – 100%

Results

Trial 1

Three different groups of cultivars could be identified from the 6-year data on leaf curl, powdery mildew and fruit quality in trial 1 (table 3). Cultivars in group A had a low to medium susceptibility to leaf curl and a high fruit quality. Reine des Vergers and Belle de Montélimar were found to be the most promising cultivars for these criterions. In group B, cultivars were highly susceptible to leaf curl, and their fruit quality was interesting. In group C, the high disease susceptibility and/or the low fruit quality made them unsuitable for commercial production.

Table 3: Leaf curl and powdery mildew susceptibility (Hi: high, Me: medium, Lo: low) and organoleptic fruit quality of 18 cultivars. Values are the mean susceptibility and fruit quality scores from 2003 to 2008 (1: low quality, 10: very good quality). *N* = 1 tree / cultivar.

Cultivar	Group	Harvest	Leaf curl	Powdery mildew	Fruit quality
Belle de Montélimar	A	29/8	Lo	Me	8
Reine des Vergers		01/9	Lo	Lo	8
Mme Guilloux		28/8	Lo	Hi	6
GF 305		25/8	Lo	Hi	6
GF305-1 × S3928		25/8	Lo	Me	6
(S3928 × GF305-1-2)^{6}		27/7	Me	Me	5
5745^{2}		25/8	Lo	Me	4
Surpasse Amsden		10/7	Me	Hi	5
Combet		02/9	Me	Me	8
Summergrand	B	07/8	Hi	Hi	5
Genadix 4		10/7	Hi	Me	7
Tournier		21/7	Hi	Hi	7
Véraud		27/7	Hi	Me	8
Précoce de Hale		27/7	Hi	Me	7
2240 : 23 : 2 × S4577	C	28/8	Me	Hi	2
Génard		03/8	Hi	Hi	4
Marnas		22/8	Lo	Me	1
(S3747 × GF305-1-1)^{2}		27/7	Me	Hi	2

Trial 2

In 2009, a high variability in leaf curl development was observed and four groups could be statistically identified (figure 1a). This variability was less important in 2010 and 2011 (figure 1b, 1c). Differences in susceptibility between cultivars across years could be related to leaf curl pressure which was moderate in 2009, high in 2010 and very high in 2011. Bénédicte remained the less susceptible cultivar during the observation period. The low susceptibility of Belle de Montélimar and Reine des Vergers observed in 2011 confirmed the previous results of trial 1 (table 3).

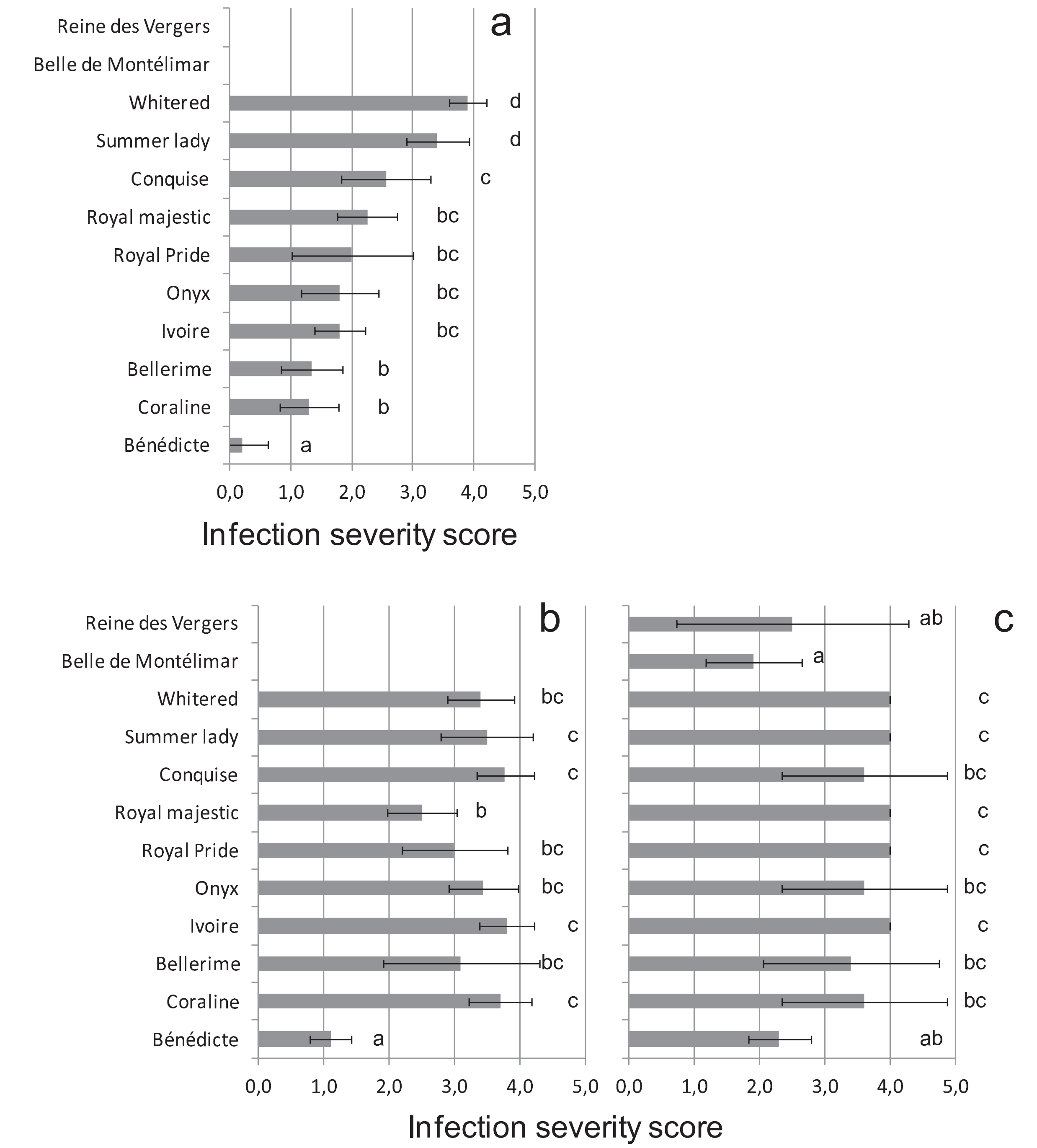

Figure 1: Mean leaf curl severity scores on 22 April 2009 (a), 6 May 2010 (b) and 21 April 2011 (c) in trial 2. Reine des Vergers and Belle de Montélimar cultivars were not observed in 2009 and 2010. Standard deviations are indicated by bars. Results of the Bonferroni test are indicated by letters.

Monilinia spp. damages on flower ranged from 0.4 to 2.0 in 2010 and 1.5 to 2.0 in 2011 (figure 2), no damage was observed in 2009. *Monilinia* spp. symptoms were not observed on Reine des Vergers and Belle de Montélimar cultivars in 2010 and 2011 because grafts were not developed enough. Statistical differences were displayed in 2010 only. In 2011, climatic conditions were very favourable to *Monilinia spp.* contamination at bloom for all cultivars.

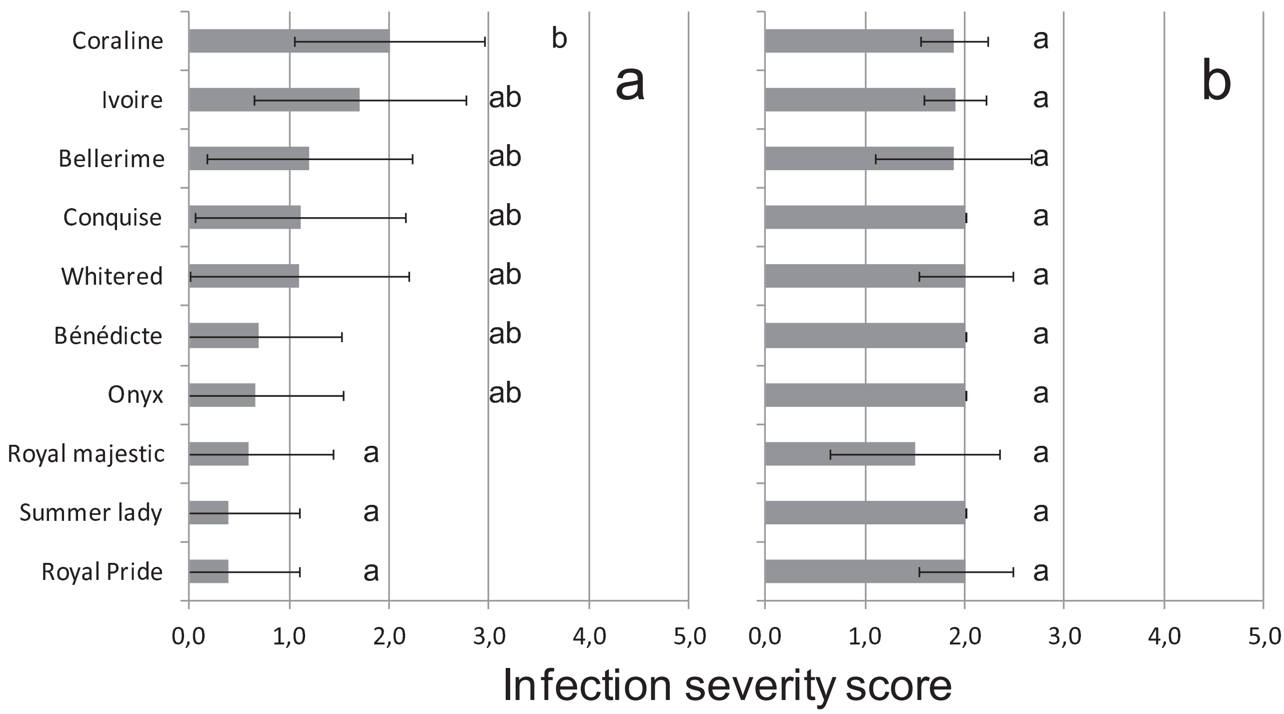

Figure 2: Mean *Monilinia spp.* severity scores on 12 May 2010 (a) and 21 April 2011 (b) in trial 2. Standard deviations are indicated by bars. Results of the Bonferroni test are indicated by letters.

Leaf curl and *Monilinia spp.* damages were very high in 2011. They caused partial or total defoliation of the trees. To express the ability of the cultivars to recover from a severe disease pressure, we have represented the proportion of defoliated shoots just after main contaminations and at the end of the season (figure 3).

The calculated ratio evaluates the recovery of the cultivar after high disease damages by measuring newly-emitted vegetative growth. Damages on Summer Lady, Royal Pride and Whitered cultivars were high and these cultivars hardly withstood 2011 disease pressure. Bellerime, Onyx, Ivoire and Coraline expressed a better ability to produce new leaves after a defoliation event.

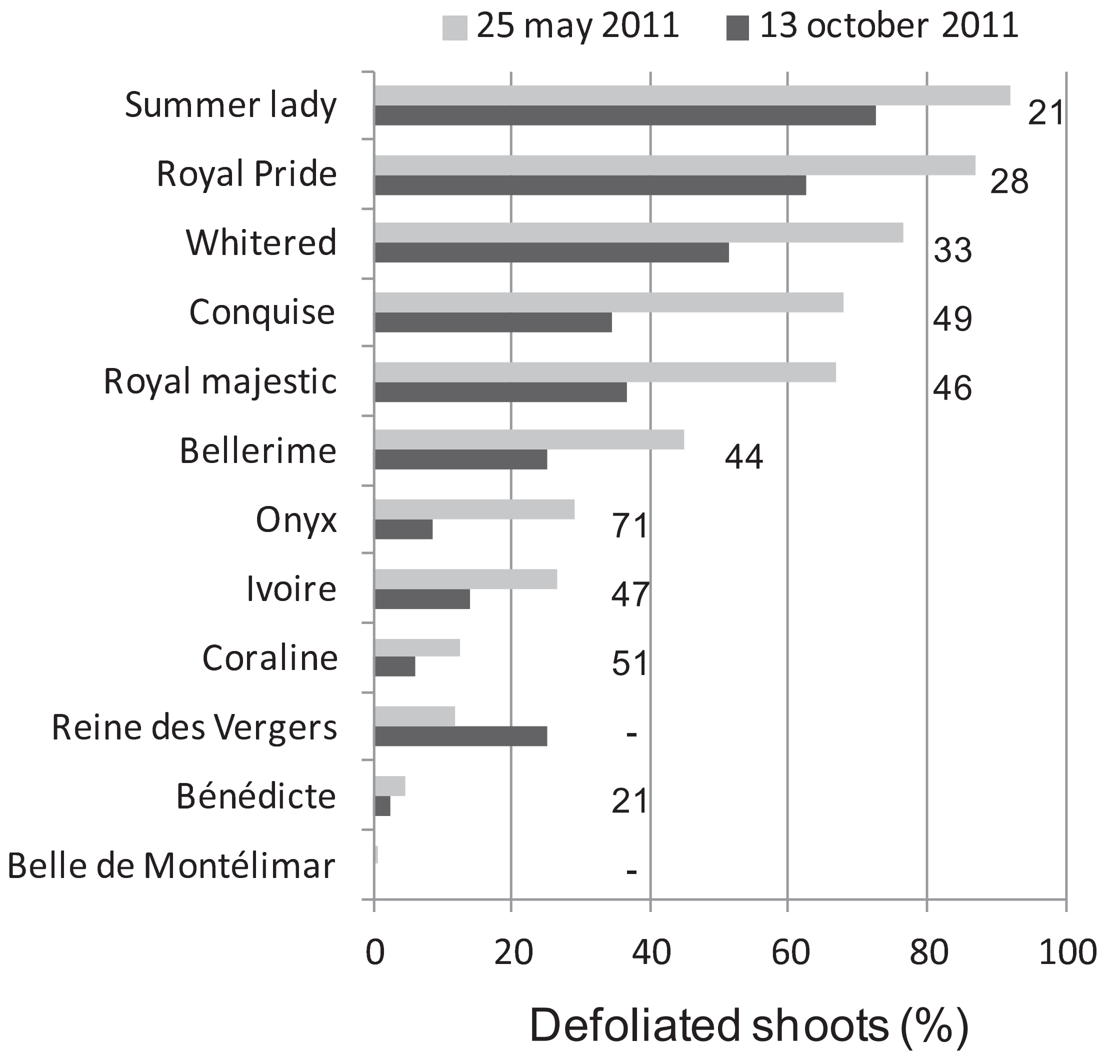

Figure 3: Proportion (%) of defoliated shoots on 25 May 2011 (called *x*) and 13 October 2011 (called *y*). Numbers in the right part of the figure are computed as *(x-y)*100 / x* to evaluate the recovery (measured by vegetative growth) of the cultivars. Main severe damages of leaf curl and *Monilinia spp.* occurred before 25th May 2011.

Powdery mildew damages were low in 2010 and severity scores ranged from 0.0 to 1.0 (figure 4a). Conversely, severity scores ranged from 3.5 to 4.0 in 2011. Because defoliation caused by leaf curl and *Monilinia spp.* was very high for some cultivars (figure 4b), powdery mildew assessment was sometimes difficult or impossible (*e.g.* Summer Lady).

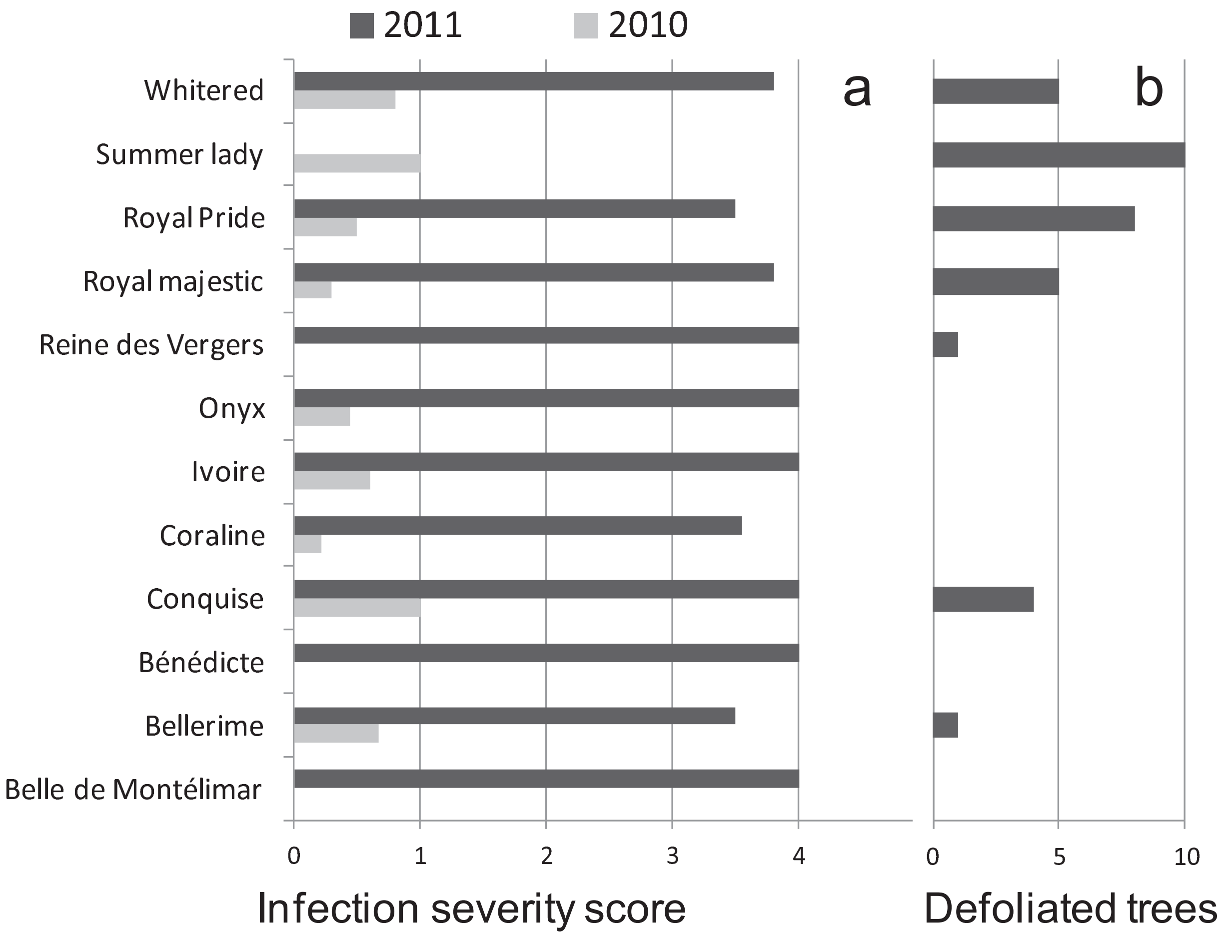

Figure 4: Mean powdery mildew severity scores on 23 June 2010 and 6 June 2011 in trial 2 (a). The number of defoliated trees (more than 95% without leaves) out of 10 trees on 6 June 2011 is represented in (b).

Discussion

This study shows that these two experimental trials are complementary: trial 1 is more suitable for a screening purpose whereas trial 2 permits a more accurate analysis of the differences in susceptibility between cultivars. When considering a set of agronomical features such as the susceptibility to several diseases and fruit quality, the identification of suitable cultivars for a given context becomes a long-term task. In trial 1, 29 cultivars were initially planted; usable data were available for 18 of them (because of tree mortality) and only 2 cultivars were finally selected as suitable for low-input orchards.

The experimental plot design (block *vs.* randomized), the methodology of observation (shoot *vs.* whole tree as a sample unit) and the strategy to control (or not) pests and diseases in the experimental plot raise many methodological questions. On the one hand, choosing a no treatment strategy permits to observe the cultivar behavior. However, the development of several diseases with possible interactions (e.g. leaf curl x powdery mildew) makes the susceptibility assessment tricky. Moreover, severe damages occurring one year can affect the tree growth of susceptible cultivars, which makes a long-term comparison difficult. On the other hand, applying treatments on a range of cultivars is not satisfactory in a random plot because the optimum spraying date depends on the cultivar.

The variability of diseases pressure and the probability for flower contamination needs to be considered as well. Indeed, we have observed that the differences in leaf curl susceptibility between cultivars decreased when leaf curl pressure increased (figure 1). The link between diseases pressure and the gradient of susceptibility between cultivars is unknown. Relations between these two variables could be linear or with threshold effects, which makes the experimental assessment of multi-disease susceptibility a hard task. For *Monilinia spp.*, we have observed that climatic conditions were not always fulfilled for a similar contamination of all the cultivars studied. When contaminations partially affect the cultivars, comparisons become difficult.

In 2011 in trial 2, no fruits were harvested except on Bénédicte cultivar, which demonstrates the low hardiness of the studied cultivars when disease control is strictly limited. As the trees of the cultivars Reine des Vergers and Belle de Montélimar were one or two years younger, the observations have to be continued.

Several studies have assessed the susceptibility to pests and diseases of plum cultivars (*e.g.* Garcia-Galavis et al., 2009) and peach cultivars (*e.g.* Assmann et al., 2010; Ivascu et al., 2006). However, methodological considerations (such as interactions treatment x cultivar) are not tackled. Therefore, there is a need for studies dealing with methodological considerations in order to provide reliable results.

Acknowledgements

The authors wish to thank the technical and the temporary staff of GRAB and INRA Gotheron for orchard maintenance and data gathering. Trials 1 and 2 were supported by the French Ministry of Agriculture thanks to DPEI 2001-2003 program (C0019) and CTPS program 2010-2012 (C02-2009), respectively. The authors wish to thank Thierry Pascal (INRA Avignon), Sophie Stévenin (Chambre d'Agriculture de la Drôme), Sylvain Ionescu (SEFRA), Sylvaine Simon (INRA Gotheron) and Laurent Brun (INRA Gotheron) for their contribution to the choice of peach cultivars or fruitful discussions.

References

Assmann, A.P., Citadin, I., dos Santos, I., Wagner Junior, A. (2010). Peach genotypes reaction to leaf rust. Pesquisa Agropecuaria. Brasileira 45: 32-40.

Byrne, D.H. (2002). Peach breeding trends: a world wide perspective. Proceedings of the 5th International Symposium on Peach. Eds. R.S. Johnson and C.H. Chrisosto. Acta Horticulturae 592, ISHS 2002.

Garcia-Galavis, P.A., Santamaria, C., Jimenez-Bocanegra, J.A., Casanova, L., Daza, A. (2009). Susceptibility of several Japanese plum cultivars to pests and diseases in a newly established organic orchard. Scientia Horticulturae 123: 210-216.

Ivascu, A. & Buciumanu, A. (2006). Situation of peach resistance to diseases in Romania. International Journal of Horticultural Science 12: 65-69.

Warlop, F., Gomez, C., Pascal, T. (2006). Sélection de pêchers tolérants à la cloque pour l'agriculture biologique. Working Group "Integrated plant protection in stone fruit", Proceedings of the meeting at Balandran (France), 14-16 October, 2006. Edited by Fabio Molinari, Jean Lichou & Emmanuele Mazzoni.