

Screening apple cultivars better adapted to organic fruit production – a transborder and participatory approach

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Abstract

Many of the varieties currently grown in Organic Production (OP) are still the result of selections carried out in conventional production. Other priority criteria apply in organic production, such as better resistance/tolerance to pests and diseases, greater robustness, lower susceptibility to biennial yield, good storage capacity, etc. As part of the INTERREG 'Biodimestica' project between the Centre Régional de Ressources Génétiques (CRRG) in France and the Centre Wallon de Recherches Agronomiques (CRA-W) in Belgium, two low input organic evaluation orchards have been set up at the two partners' sites. The aim was to select apple varieties that are more suitable to low input organic farming systems. Trees are grafted onto M9 rootstock and grown under low-input organic conditions, in order to evaluate the best performing varieties in terms of regularity of production, disease and pest tolerance. Fruit quality parameters are also studied. Initial and final choice of varieties are discussed on a participatory base. The final most promising varieties are proposed to organic growers that are members of 'NovaFruits' – a transborder organic participative breeding association with 31 professional growers. Results of a comparative assessment of 21 varieties are presented in this paper.

Keywords: Cultivars; participatory breeding; disease tolerance; *Elsinoë piri*; European canker.

Introduction

In Belgium, the Jonagold cultivar (cv.) is still the most important commercially grown variety. This choice is justified by its high yield and the good cold-storage properties. However, it is quite highly susceptible to scab and powdery mildew, making it less suitable for organic farming. In the future, the use of certain copper-based treatments will be more regulated or even banned. Therefore, there is an urgent need to evaluate and select other varieties that are more robust and better suited to low-input cropping systems (Warlop *et al.*, 2010). With this in mind, the CRA-W started a large research project in 1975. This project addressed issues of safeguarding, evaluating and valorization of local fruit tree genetic resources. Thereby, varieties that are more robust, less susceptible to most common diseases and pests, and therefore better suited to very low-input organic farming systems (e.g. orchard meadows, agroforestry, ...) or to be used as parents as sources of polygenic disease resistances, can be identified (Lateur & Populer, 1994; Lateur *et al.* 1999). As part of a cross-border European project between the *Centre de Ressources Génétiques Fruitières* (CRRG) in France and the *Centre Wallon de Recherches Agronomiques* (CRA-W) in Belgium, two low input evaluation orchards were set up in 2007 at each of the two partners' sites (Lateur *et al.*, 2009). The most promising cvs. are offered to 'NovaFruits' – a participatory breeding association of 31 cross-border organic fruit growers in order to select 'elite' varieties. Fruit quality parameters and storage potential are also studied. One of the CRA-W selection, 'Ducasse'^{PBR} cv., currently meets most of the expected requirements. Organic growers are

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planting this cultivar on a larger scale. Promotional campaigns are advertising the cv. via various marketing channels.

Materials and Methods

Since its creation in 2007, evaluation orchard has been farmed organically. Organic control methods are applied in the orchard, but only in cases of highest infestation risk following Rimpro forecasting software. Due to climatic conditions and an extensive spraying program in the evaluation orchards, nearly all known scab races are present (Lateur *et al.*, 2002). The orchard is designed with both susceptible control trees and cvs. that are less susceptible to diseases. In this way, we can observe the behavior of the cvs. with low phytosanitary protection. All evaluated traits are following the Lateur *et al.* (2022) descriptors list. The orchard was planted at 1.5 x 4 m planting distance, on M9 rootstocks. This study focuses on results gained between 2018 and 2023, with trees in full production. 21 apple varieties were selected for our study. The panel of cvs. consisting of (I) controls: 'Jonagold' ('Marnica' mutant), 'Topaz' and 'Pilot'; (II) CRA-W breeding selections: 'AF 34', 'AG 14', 'AG 81', 'AG 90' ('Coxybelle'^{PBR}), 'AK 28', 'AQ 84' ('Ducasse'^{PBR}), 'AY 88' ('Transparente de Lesdain'^{RGF-Gblx}), 'BG 65' and 'BK 75'; (III) modern cvs.: 'Autento', 'Jazz', 'Opal' and 'Wellant'; (IV) and older varieties: 'Gris Braibant'^{RGF-Gblx}, 'Président Van Dievoet'^{RGF-Gblx-CRRG}, 'Reinette Dubois'^{RGF-Gblx} and 'La Bazadaise'.

Results

Susceptibility to biotic stresses

Most of the evaluated cvs. show very low apple scab symptoms on both leaves and fruits. On the other hand, 'Jonagold', 'AF34' and mostly 'Jazz' show a higher scab susceptibility (Figures 1 A, 1 B). The susceptibility to *Elsinoë piri* varies greatly among different cultivars. Many so called 'old cultivars' like: 'Gris Braibant'^{RGF-Gblx}, 'Président Van Dievoet'^{RGF-Gblx-CRRG}, 'La Bazadaise' but also 'Autento', the latest one, express very low susceptibility (Figure 1 C). On the other hand, new ones such as 'Opal', 'AF34' and 'Topaz' show the highest susceptibility (Figure 1 C). Regarding powdery mildew susceptibility, 'AG 81', 'BG 65', 'Président Van Dievoet'^{RGF-Gblx-CRRG} and 'AG90' are the less susceptible while some cultivars such as 'Wellant', 'Jonagold' and 'Pilot' show the highest susceptibilities (Figure 1 D). Due to the very light treatment schemes applied in our trial orchards, large differences in rosy apple aphid (Figure 1 E) and European canker (Figure 1 F) susceptibilities were observed. Moreover, disease pressure of European canker will likely increase in OP, due to changing climate conditions towards a wetter and milder climate. Cvs such as 'Jazz' already express the relative highest disease level.

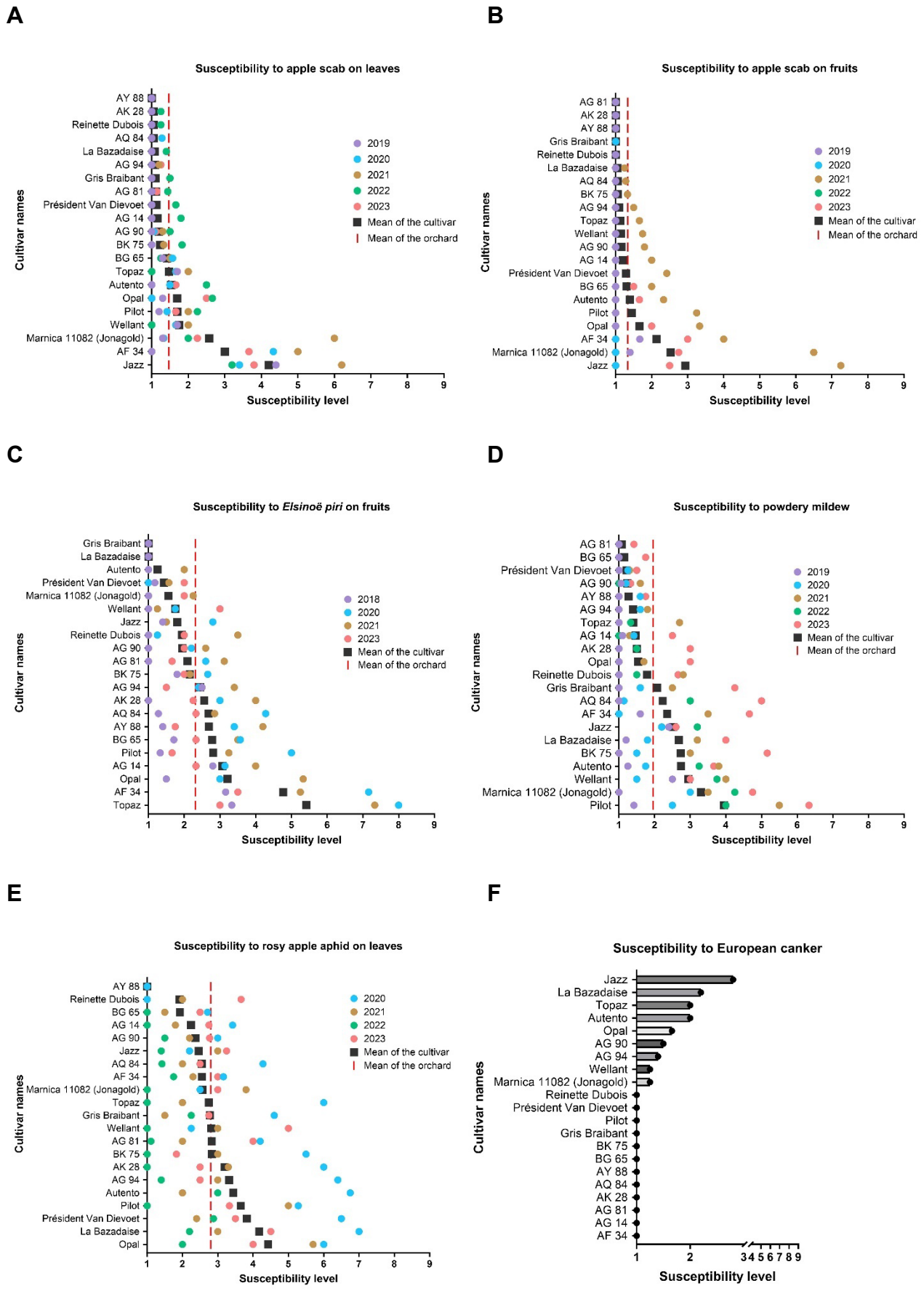


Figure 1: Susceptibility to **A:** apple scab on leaves; **B:** Apple scab on fruits; **C:** *Elsinoë piri*; **D:** Powdery mildew; **E:** Rosy apple aphid on leaves and **F:** European canker between 2018 and 2023.

For each cultivar, the mean of the year is represented by a colored dot. The mean of the orchard throughout the evaluation period is represented by the red dashed line. For each cultivar, the mean throughout the evaluation period is represented by a black square. $n \geq 3$.

Foliage quality

Foliage quality is a new trait that we developed in order to assess one global component of 'robustness' (Figure 2). Assessment is based on overall health appearance and represents a global combination of disease tolerance, robustness and good nutrient uptake efficiency which are expressed by more healthy green leaves. Modern cvs. like 'Wellant', 'Pilot', 'Opal' and 'Jazz' which have a low global foliage quality have been selected under more intensive input conditions. In contrast, many of our CRA-W selections which involve at least an old cv. as one of the two parents were selected in extremely low input conditions. These selections show a higher level of so called 'robustness' traits.

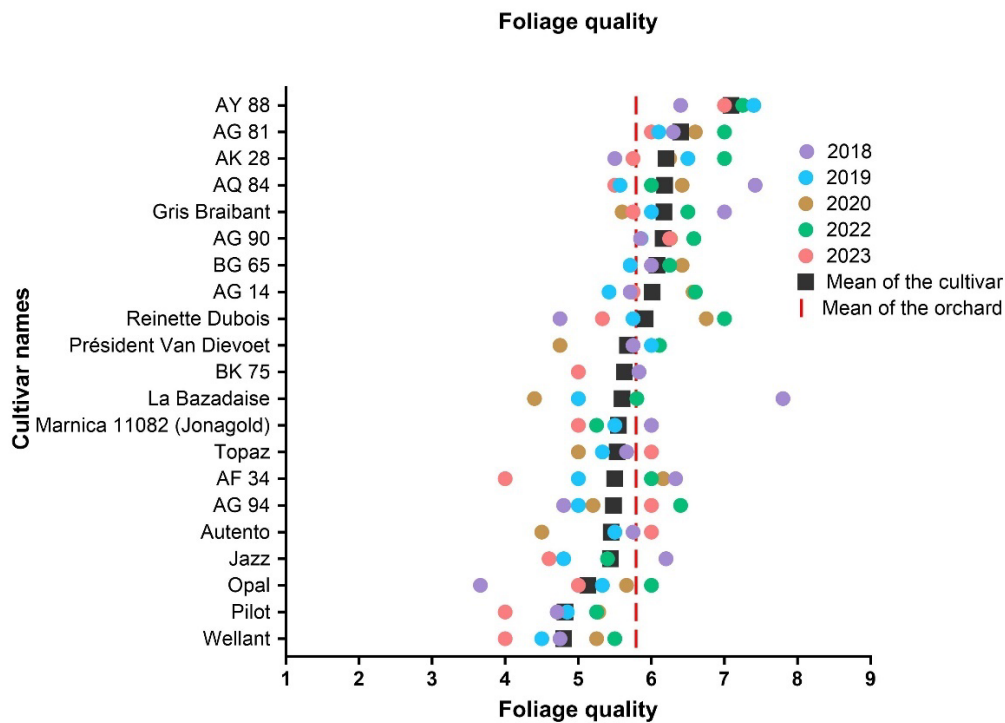


Figure 2: Assessment of the general foliage quality between 2018 and 2023. For each cultivar, the mean of the year is represented by a colored dot. The mean of the orchard throughout the evaluation period is represented by the red dashed line. For each cultivar, the mean throughout the evaluation period is represented by a black square. $n \geq 3$.

Agronomic traits

Most important traits are summarized in Figures 3 A and 3 B. In our conditions, cvs 'Topaz', 'AY 88' ('Transparente de Lesdain'^{RGF-Gblx}) and 'Reinette Dubois'^{RGF-Gblx} expressed the lowest biennial bearing habit and the highest yield.

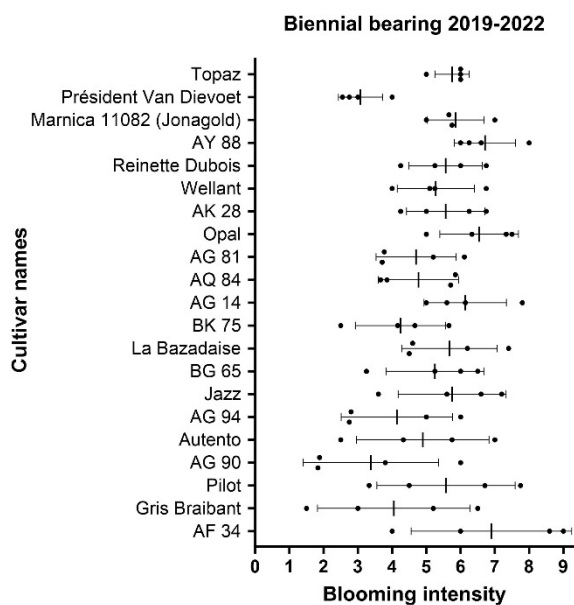
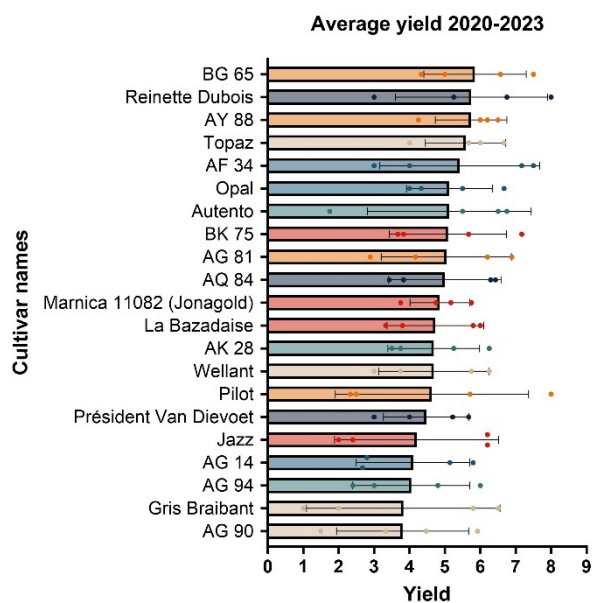
A**B**

Figure 3: **A:** Evaluation of the biennial bearing habits between 2019 and 2022. For each cultivar, the mean blooming intensity for the four years is represented by the central vertical black line and the blooming intensity of each year is represented by black dots. The horizontal black line represents the fluctuation between years for each cultivar. Cultivars are sorted from lowest biennial bearing habits (top) to highest biennial bearing habits (bottom). **B:** Mean yield between 2020 and 2023. The colored columns represent the mean yield over 4 years of evaluation. For each cultivar, the mean yield of each year is represented by a colored dot. SD is represented by the horizontal lines. $n \geq 3$.

Discussion

Scab is still the most important disease which needs high attention. In low input OP cvs., level of scab resistance/tolerance relies either on (i) one major gene (e.g. *rvi6*) – like ‘AF 34’ -, (ii) a combination of major resistance genes and polygenic resistance (e.g. cvs. ‘AY 88’ (‘Transparente de Lesdain’^{RGF-Gblx}), ‘AK 28’, ‘Ducasse’^{PBR}), or (iii) on polygenic tolerance (e.g. ‘Reinette Dubois’^{RGF-Gblx}, ‘La Bazadaise’). Including polygenic partial resistance is favourable, as their high scab tolerance is much more durable. *E. piri* will likely become a major concern in very low input OP in our region (Chandelier *et al.* 2022), which needs to be considered by selecting tolerant cvs. and avoiding most susceptible ones like ‘Topaz’ and ‘Opal’. The same principle could be implemented for European canker where cvs. such as ‘Jazz’ are highly susceptible. Powdery mildew is usually a minor problem in OP. Nevertheless, limiting the use of extremely susceptible cvs. like ‘Pilot’, or ‘Jonagold’, ‘Wellant’ and ‘Autento’ needs to be considered. With the cv. ‘AY 88’ (‘Transparente de Lesdain’^{RGF-Gblx}), our results point out a new rosy apple aphid robust cv. Biennial habit is a consistent challenge, particularly within the context of OP. It is therefore crucial to thoroughly evaluate this trait on selected cvs. Finally, ideotype traits which incorporate ‘robustness’ compounds like ‘general foliage quality’ are a new approach which will play an increasingly important role in selecting cvs. much better adapted to lower input OP (Parisi *et al.* 2014).

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