Selection from old local varieties as expanding gene resource for apple breeding

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Abstract

Since 1920, apple breeders have used easy-to-handle monogenic resistances for apple varieties in modern commercial fruit growing. This led to the frequent use of six parent varieties, which resulted in a genetic constriction.

Breakdown of the monogenic resistance and society's demand for less use of pesticides, require new sources in resistance breeding.

Old robust varieties could be such a new source because they usually contain a partial resistance that cannot be broken so quickly.

Data on the resistance of old local varieties are scarce and were usually not gained in extensively treated orchards under no fungicide-spray conditions.

Therefore a variety monitoring of the old local varieties was carried out at the variety conservation centre Baden-Württemberg KOB and LVWO Weinsberg.

Keywords: old local varieties, apple breeding, genetic diversity, vitality

Introduction

Apple breeding over the past 100 years has severely restricted the genetic basis of the apple varieties currently available on the market. The breeding goals were then as now fruit quality (appearance, taste), yield capacity, shelf life and easy handling of the trees (lower cutting effort). Only later was the resistance to diseases added.

All modern varieties are more or less derived from only three ancestor varieties *Golden Delicious*, *Cox Orange* and *Jonathan* (Bannier 2010, Noiton et. al.1996).

Also with the so-called "scab-resistant" apple varieties this breeding path was taken, with the only difference that the monogenic resistance from the wild apple variety Malus floribunda 821 (so-called Vf resistance, Rvi6) was used to get resistance versus apple scab (Bus et al. 2009).

This genetic restriction has led to an increase in susceptibility to fungal diseases (especially apple scab and powdery mildew) and other pests.

A possibility to widen the gene pool again, is the breeding with old varieties which do not originate from any of these ancestor varieties.

Some of the old apple varieties have a polygenic resistance that is more stable to diseases than that of today's resistance cultivars because it has been proven in the landscape for centuries.

Investigation of the fruit assortment at KOB and LVWO for suitable old varieties for breeding purposes to broaden the genetic basis is required.

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Material and Methods

The apple variety preservation is done at the variety conservation centre BW KOB close to the Lake of Constance and the LVWO Weinsberg in the Neckar valley.

The 242 traditional varieties at KOB were grafted on M2 rootstock represented by three trees and were treated according to biological criteria. The orchard was planted at the KOB in 1996. 75 varieties on seedlings with one or two trees per variety, planted in 2012.

At LVWO 80 historical apple cultivars were grafted on M9, planted in 1997 and were grown without fungicides or other pest control treatments since 2016. Every variety was represented by two trees.

In addition, in an orchard at Weilheim (Bavaria) there are still strongly growing rootstocks available, which could be grafted. No pesticide application is carried out in Weilheim.

Since four years, susceptibility to fungal diseases like *Venturia inaequalis* (apple scab), *Podosphaera leucotricha* (powdery mildew), *Nectria galligena* / *Cylindrocarpon mali* (cancer) and **Marssonina coronaria** was valued from 1 to 9.

Also a fruit evaluation was made, where shelf life, storability in cold storage at 1-2 °C and the taste was investigated.

Because of the late frost 2017 flowering behaviour and frost resistance of the flower are also an included criteria.

Organoleptic evaluation was also made with tasting sheets and more detailed tastings additionally with the “Aromarad” of Christine Brugger (Brugger 2011).

Varieties which are triploid, varieties which do not constitute a genetic extension and varieties which are considered to be very demanding or susceptible varieties are not included for breeding.

The susceptibility of a variety is always related to location, because different scab races affect the variety. In 2017 and 2018 there was only low scab pressure at the KOB. Therefore, it was difficult to make meaningful data.

At the LVWO the year 2019 had a high scab pressure.

Results

Different cultivars show great differences in susceptibility to scab, mildew and cancer.

A comparison of the varieties shows that there are overlaps with regard to vitality at the two locations KOB and LVWO.

55 of the varieties can be found at both locations.

None of the common varieties is robust against both diseases: scab and mildew. However, there are varieties that are robust against one of the diseases at both locations.

Six of these varieties were completely free of scab on leaves or fruit. Seven of the varieties have low leaf scab infestation in either or both locations. And three of the common varieties show only scab on fruit.

Table 1: Visualization of the varieties without or little apple scab at the locations KOB and LVWO in the years 2017-2019

Varieties without scab on leaf and fruit	Varieties with little scab on leaf	Varieties with little scab on fruits
Börtlinger Weinapfel	Brettacher	Blumberger Langstiel
Dülmener Rosenapfel	Jakob Fischer	Grahams Jubiläumsapfel
Gartenmeister Simon	Linsenhofer Sämling	Sonnenwirtsapfel
Gehrers Rambur	Mauks Hybride	
Öhringer Blutstreifling	Prinz Albrecht von Preußen	
Schneiderapfel	Rheinischer Winterrambur	
	Roter Eiserapfel	

Table 2: Visualization of the varieties which are highly susceptible to powdery mildew at the locations KOB and LVWO in the years 2017-2019 (in descending order)

highly susceptible to mildew at the location KOB	highly susceptible to mildew at the location LVWO
Gelber Richard	Schweizer Orangenapfel
Flandrischer Rambur	Cadel
Jonathan	Jonathan Watson
Prinzessinapfel	Lausitzer Nelkenapfel
Weißer Winterkalvill	Red Winter
Großherzog Friedrich von Baden	Jonagold
Wettringer Taubenapfel	Öhringer Blutstreifling
Schöner aus Nordhausen	Horneburger Pfannkuchenapfel
Schönster vom Neckartal	
Sponheimer Flurapfel	
Roter Winterkalvill	

A variety-specific susceptibility to the disease Marssonina coronaria could not be confirmed in this study.

Since the frost year 2017, the flowering behaviour of the fruit varieties has also been investigated. A distinction is made between late, long and robust flowering.

In the years 2018 and 2019, the LVWO was able to evaluate the varieties “Spätblühender Taffetapfel” and “Bittenfelder” as late flowering varieties in both years. Other varieties which are also late flowering in both locations are “Engelsberger”, “Heslacher Gereutapfel” and “Rote Sternrenette”. The comparison of the varieties of both sites did not show any similarities with regard to the subdivision into a long flowering period.

In the tastings, the historical apple varieties are for the most part clearly behind modern varieties. It has to consider that the taste has changed from soft fleshy to crunchy apples. In the past, the varieties were also used less for direct consumption as table fruit and more frequently as commercial fruit for storage as vitamin sources in winter as dried fruit, apple puree, juice or cider (Inderbitzin et al. 2017).

The shelf life of the old varieties is also significantly reduced. Old varieties with good shelf life are, for example, in descending order "Martini", "Roter Eiserapfel", "Champagnerrenette" or "Wettringer Taubenapfel".

Discussion

A large part of the varieties is also described in the literature as robust.

Among the particularly robust varieties, triploid varieties are often found. However, these are bad pollen donors and cannot be used for breeding because they produce few viable seeds (Janick et.al. 1996). With regard to their vitality, it should be considered whether crossing experiments with triploid varieties should be carried out despite the high lethality of the offspring?

In studies and surveys, unknown or rare varieties often prove to be particularly robust (Laurens et al. 2004).

Widespread varieties, in particular dessert apples, are more susceptible or are among the more sensitive to the diseases examined. Also in preliminary tests in Weinsberg, the offspring of wild species performed significantly better than the crosses with various old varieties.

This could be due to the fact that pathogens adapt over time to the "host species" and overcome defence mechanisms. The more frequently an apple variety occurs, the better they can do this.

Changed environmental conditions such as an increase in annual average temperatures, stricter winters and hotter summers, decrease in the chilling phase of fruit trees, accompanied by a refraction of dormancy will probably increase over the next few years.

The literature references on resistance of old fruit varieties are probably unreliable and have yet to be verified for breeding purposes under standardised experimental conditions.

The robust apple in relation to all fungal diseases does not exist. In addition, the disease can vary in severity depending on the location.

This study shows that a comparison between varieties at different locations is very difficult.

By growing them at the same location, varieties can be directly compared and differences in location, cultivation and maintenance can be excluded.

In addition there are the missing repetitions and the relatively short time.

Numerous blind tastings in the years 2016 to 2019 show that the old varieties cannot withstand the taste and texture of the new varieties. The old varieties should therefore be considered for the different forms of use (Agnolet et.al. 2017).

Also old apple varieties sometimes have an extravagant phenotype (for example Schafnasen) or colour which can be used in the trade.

They only have a chance in the dessert fruit sector if their good characteristics such as a unique taste are used in new breeding.

Nevertheless, in connection with the development of new diseases, the old apple varieties could be an important genetic component in their control (Mayr 2017). However, it must be noted that robustness against diseases can only be achieved in individual steps within the breeding process.

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