Apfel:gut – More vitality, genetic diversity and less susceptibility as an organic fruit breeding strategy

M. Ristel[1], I. Sattler[2] and H.-J. Bannier[3]

Abstract

The Apfel:gut project under the umbrella of the Saat:gut e.V. does organic varietal development with an participatory approach since 2011. One of the main topics is to make organic fruit growing more resource efficient through less susceptible varieties, which fulfill the needs of the whole production-consumption chain. While conventional breeders try to achieve this goal with monogenic, dominant resistance and biotechnological tools including manipulation of the genome, organic breeding is a different approach. Organic parental selection is based on vitality and robust donors, which are less susceptible.

Keywords: Organic breeding strategy, less susceptibility, vitality, critics on genome manipulation, genetic diversity

Introduction

Most scab resistance apple breeding programs worldwide focus on monogenic dominant resistance genes. With the pyramiding of different resistance genes, the breeding programs try to simulate a quantitative resistance and hope that a breakdown of the latter is less probable (Baumgartner *et al*., 2015). From the yet known 18 resistance genes, 11 are already broken down, and in respect to gene-for-gene relationships, others will follow (Patocchi & Bus, 2016; Haug, 2014).

The best known example of resistance breakdown in apples is the one of *Rvi6*/*Vf* from *Malus floribunda*, the most commonly grown of so called resistant varieties (Haug, 2014). Due to this development, there seems to be a trend in breeding programs (at least in Germany) to put the weight on polygenic resistance donors which are not linked to individual genes (Haug, 2015). While major research programs finance molecular biological approaches (e.g. fruitbreedomics), organic research unfortunately still lacks this support (Baret *et al*., 2015).

Genetically modified (GM) so called “arctic” apples were first released in the USA. These apples do not turn brown after being cut, which is important for fast food packages, mainly for school children (Waltz, 2015). Some breeding programs, that do genetic-based work, declare cis-modification a tool to make organic fruit growing sustainable (Glogger, 2008). In the Netherlands, genetically modified apple trees have been tested in the field since 2011 (Krens *et al*., 2015). Switzerland plans to plant genetically modified trees in a “protected site”, starting spring 2016 (Agroscope, 2015). The organic agricultural movement and at least the majority of the European Union, do not accept genetic modification for decades, regardless whether genes are used of the own species (cis-) or of other species (trans-) (BÖLW, 2015; Eurobarometer 1991-2010). Bergstedt (2010) describes in detail how allowance and support of GM-crops function in Germany.

[1] Öko-Obstbau Norddeutschland, D-21635 Jork, Germany, matthias.ristel@lwk-niedersachsen.de
[2] Projekt Apfel:gut im Saat:gut e.V., D-24876 Hollingstedt, Germany, hagge-nissen@gmx.de
[3] Pomologen-Verein e.V. D-33619 Bielefeld, Germany, alte-apfelsorten@web.de

In annual plants, monogenic dominant resistance genes were widely used in the twentieth century, similar to the paradigm in contemporary fruit resistance breeding. The resistance breakdown of annual crops led to the development of a new sustainable breeding strategy: loss of susceptibility (Pavan *et al.*, 2010). In fruit breeding worldwide, however, there has been no fundamental research done in this direction. Through concentration on the main donors ‘Golden Delicious’, ‘Cox Orange’, ‘Jonathan’, ‘Mc Intosh’ and ‘Red Delicious’, susceptibility increased but vitality got lower. In contrast, extreme vitality is found in some ancient varieties (Noiton & Alspach, 1996; Bannier, 2011).

Material and Methods

The Apfel:gut project develops organic pip fruit varieties with a participative approach (Ristel & Sattler, 2014). Since the last ecofruit conference, three new breeding locations have joined the project: Georg and Lukas Adrion in Backnang, close to Stuttgart, Heidrun Hauke, Frankfurt (Oder) and the fruit research station ESTEBURG at the lower Elbe region “Altes Land” west of Hamburg.

Selection of young seedlings is done with focus on vitality and the loss of susceptibility. If a plan has a high level of vitality, despite biotic and abiotic stress situations, it is positive selected. One typical symptom for vitality is a shining green leaf, even if a disease occurs. From the beginning, seedlings are grown in non-sprayed areas of the orchards provided by project partners. In such a participative approach time and the farmers' care are selective tools. Each site in Germany has quite different climate and soil conditions, which again have an individual effect on the selection results.

Parental selection is done in a recombinant pattern, thereby keeping around 20 different breeding goals in mind. After an evaluation, robust and high yielding old cultivars (cvs) are mainly crossed with not too susceptible new varieties. Additionally, old cvs are crossed with other old cvs and open-pollinated seeds are sown from time to time. Through the use of varieties as donors, which are not closely related to modern varieties, the project expects to increase genetic diversity in potentially releases.

The most northern project partners have raised open-pollinated apple and pear seedlings starting at the end of the 1990’s. These have resulted in seedling hedges, which were evaluated from 2011 to 2015, when they were already fruiting. From positive selected pear lines, test trees (B 30) are planted through Germany on Quince A, and first fruits have already been harvested. From the apple trees, positive selection (grafting on M 9 rootstocks) is done only on the farm.

Results

Breeding is a long-time process, and the results have to be viewed with care. The Apfel:gut project has already worked with vital seedlings for five years, and the first healthy fruits have been harvested. Different progenies show big differences in scab, cancer and mildew susceptibility. The collected information are not completely evaluated, but e. g. a set of ‘Topaz’-seedlings was quite scab susceptible, especially in comparison to quite healthy and vital progenies of ‘Seestermüher Zitronenapfel’, ‘Gelber Münsterländer Borsdorfer’, ‘Karmina’ and ‘Beauty of Bath’.

Out of the fruiting seedling hedges from the tested pear lines, only one is still in focus. It is a high yielding autumn pear, with a very sweet taste. Its harvest time is similar to that of ‘Conference’. Pear scab can occur, but still with a lower level than in ‘Conference’. On the quince A rootstocks, the trees fruited in the second year after planting. The original seedling has reached a height of nearly 10 m and has been harvested five years in a row since observation started in 2011, without a tendency to biennial bearing. Stored together with apples in rather high temperatures, the B 30 pears were fine until November. Further tests for storage of pears are planned for 2016, i. e. to what extent the fruits can be kept in lower temperatures and in a controlled atmosphere, e.g. like ‘Conference’.

The quality of the open-pollinated apple seedlings is a bit lower than quality of the pear seedling's. The most interesting apple seedling has an interesting aroma, a balanced sugar acidity ratio, is widely russet, and slightly colored. The shaft is too short, so up to the half of the yield is on the ground before full maturity. In the last 5 years it has been harvested every year, without a tendency to biennial bearing. Jan Bade, well known pomologist in Germany considered it as an offspring of cv ‘Graue Herbstrenette’ and cv ‘Gelber Richard’ (Bade, 2015).

Discussion

Monogenic dominant resistance genes are not sufficient to protect the plant from pathogens in the long term. Vitality and loss of susceptibility are the keys for an organic breeding strategy. It is tremendously important to achieve a system of growing and breeding vital, healthy fruits, particularly in an agricultural world, which is increasingly industrialized and puts great effort in introducing GM-fruits into the orchards.

It remains yet to be understood why some varieties that do not have any of the identified genes responsible for scab-resistance, remain practically scab-free. Examples for this effect have already been presented in traditional cultivars, e.g. ‘Seestermüher Zitronenapfel’, ‘Gelber Münsterländer Borsdorfer’, and in more modern cultivars like ‘Alkmene’ or ‘Discovery’. Obviously, the plants' health is determined by a much more complex system than we know so far.

The above described favourite apple seedling from open pollination won’t be interesting for commercial growing, because of it’s too short shaft, but it gave interesting results for the parental selection in the project. ‘Gelber Richard’ has an extremely short shaft. This variety is not likely to be chosen as parent variety. ‘Graue Herbstrenette’ does not produce a lot of pollen nor seeds. Some think that it even might be triploid (Lateur, 2015). Anyway it has at least the ability to give a good fruit quality to its offspring. Russet and red-colour apples have a high consumer attractiveness (Schell, 2016) and at least for direct marketing fruit producers there are gaps to fill. 2016 crosses will go on with this seedling and compared with crosses of ‘Graue Herbstrenette’.

A lot of work in the Apfel:gut project is basic research. It is, for example, important to evaluate the breeding value of ancient varieties for the use of their resistance in organic breeding. One motivation for the active Apfel:gut partners is to develop alternatives to technocratic approaches. Though it is still a long way until we can offer sustainable apple and pear varieties to fruit farmers, we are very convinced that the project is on a good track.

References

Agroscope (2015). Feldversuch geplant mit Cis-Genen Apfelbäumen, die gegen Feuerbrand resistent sind. Online: https://www.news.admin.ch/message/index.html?lang=de&msg-id=59229 (15.1.16).

Bade J. (2015). Personal communication.

Bannier H.-J. (2011). Moderne Apfelzüchtung: Genetische Verarmung und Tendenzen zur Inzucht. *Erwerbs-Obstbau* **52**: 85-110.

Barret, P., Marq, P., Mayer, C. & Padel, S. (2015). Research for transition: Europeans deserve a better agricultural and food policy. Université catholique de Louvain and Organic Research Centre.

BÖLW (2015). Position zu neuen Züchtungstechniken - Vorsorgend handeln bei neuen Züchtungstechniken! Das EU-Gentechnikrecht muss konsequent umgesetzt werden. Bund Ökologische Lebensmittelwirtschaft. Berlin.

Baumgartner, I.O., Patocchi, A., Frey J.E., Peil, A. & Kellerhals, M. (2015). Breeding elite lines of apple carrying pyramided homozygous resistance genes against apple scab and resistance against powdery mildew and fire blight. *Plant Molecular Biology Reporter* **121** (3): 647-656.

Bergstedt, J. (2010). Monsanto auf Deutsch – Enzyklopädie deutscher Gentechnikseilschaften. Gießen: SeitenHieb-Verlag.

Eurobarometer (1991 (35.1) - 2010 (73.1)). Europeans and Biotechnology. Online: http://ec.europa.eu/COMMFrontOffice/PublicOpinion/index.cfm/Archive/index (15.1.2016).

Glogger, B (2008). Das hohe Cis im Apfelbaum. *Horizonte* **6**: 20-21.

Haug, P. (2014). „Resistente“ Sorten Teil 3; *Ökoobstbau* **1**: 21-22.

Haug, P. (2015). AK Sorten und Züchtung; *Ökoobstbau* **4**: 34.

Krens, F.A., Schaart, J.G., van der Burgh, A.M., Tinnenbroek-Capel, I.E., Groenwold, R., Kodde, L.P. *et al*. (2015). Cisgenic apple trees; development, characterization, and performance. *Frontiers in Plant Science* **6**.

Lateur, M. (2015). Personal communication.

Noiton, D.A.M. & Alspach, P.A. (1996). Founding clones, inbreeding, coancestry and status of modern apple cultivars. *J. Amer. Soc. Hort. Sci.* **121**: 773-782.

Patocchi, A. & Bus, V. (2016). Vinquest. Online: http://www.vinquest.ch (13.1.2016).

Ristel, M. & Sattler, I. (2014). Apfel:gut – Participatory, organic fruit breeding. Ecofruit Hrsg. FOEKO. Proceedings of the 16th international congress on organic fruit growing, Hohenheim 17.-19. Februar 2014: 158-161.

Schell (2016). Sorteneigenschaften und Kirschessigfliege im Fokus. *Obstbau* **1**: 53-55.

Waltz, E. (2015). "Nonbrowning GM apple cleared for market." *Nature biotechnology* **33** (4): 326-327.