Perspectives on European organic apple breeding and propagation under the frame of LIVESEED Project

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Abstract

Apples are the most prominent fruits produced in Europe. However, their organic production is very challenging and most cultivars can only be produced economically with copper application to combat fungal diseases. Therefore, the existing cultivars need to be replaced by more resilient genotypes also considering improvement of the rootstocks for better adaptation to organic soil, fertility conditions and new diseases. The objective of LIVESEED Horizon 2020 project is to improve the performance and sustainability of organic agriculture by boosting organic seed and plant breeding efforts, and increasing the availability of cultivars adapted to organic growing conditions. LIVESEED apple task aims to improve breeding for organic apple production through a network that will join forces, share knowledge and genetic resources. Organic apple breeding priorities until today should concentrate on several key issues, the main ones being: high quality and regularly bearing apple varieties with durable disease and pest resistances. Ongoing initiatives will be connected and a European network for testing candidate genotypes under organic conditions will be established to join forces, breeding strategies and share knowledge and genetic resources.

Keywords: Organic breeding, apple, adaptation, cultivars, genetic resources

Context

One of the key areas for successful establishment of truly sustainable fruit orchards is the choice of cultivar and rootstock (Jamar *et al*., 2012). This will strongly influence disease and pest management, which is one of the bottlenecks and main challenges in organic apple production (Trapman and Jansonius, 2008). Disease resistance in north European countries and south countries with Atlantic influence seems to be crucial for organic apple breeding, whereas southeastern countries mostly target pest resistances.

Yet, modern cultivar breeding and selection has mainly prioritized yield, fruit size, fruit texture and color. Criteria deemed especially important by organic growers, such as global rusticity and tolerance to pests and diseases, have been neglected for years. This situation has led to a market that is completely dominated by modern cultivars mainly selected for intensive systems (Warlop *et al.,* 2010; Bannier, 2011). However, old cultivars and landraces were bred in times of low-input agriculture and, therefore, the relevance of many of them to organic systems might be much better than modern materials.

In addition, the contribution of old local varieties to broaden the genetic basis in breeding, was also highlighted by Urrestarazu *et al.* (2016). In France, some trials have permitted evaluation of old and new apple cultivars grown under very low input level (Parveaud *et al*., 2011) whereas apple cultivar selections have been conducted at the Lithuanian Institute of

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Horticulture for organic farming conditions (Lanauskas *et al.,* 2009). In Portugal, some collection trials were established with 149 clones of 'Bravo de Esmolfe' (a Portuguese traditional variety) with the goal of study production and conservation technologies maintaining the quality and providing new options for farmers. Two main national collections existed with 300 accessions. The traditional landrace 'Maçã Riscadinha de Palmela' is now a Protected Designation of Origin (PDO). In Switzerland in the frame of the projects 'Description of fruit genetic resources' 600 traditional apple accessions were phenotypically screened from 2008 to 2015 for scab and powdery mildew incidence in an orchard not sprayed with any fungicide. The cultivars have also been tested regarding fruit quality attributes and other diseases as fire blight (Kellerhals *et al*. 2012). Another set of 600 old national cultivars have been planted and will also be tasted for quality and resistances traits by Agroscope. In the scope of the National Action Plan for conservation and sustainable use of plant genetic resources, a joint project of FiBL, Agroscope and Poma Culta has been initiated in 2016: "use of apple gene resources for organic farming".

The Apfel:gut project in Germany developed organic fruit varieties with a participative approach (Ristel & Sattler, 2014). 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 are mainly crossed with less susceptible new varieties. Additionally, old cultivars are crossed with other old cultivars 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 of organic apple cultivation. The Apfel:gut project has already worked with vital clones for five years, and the first healthy fruits have been harvested. Nevertheless, due to the length of breeding and evaluation cycles in apple, it is expected cultivar registration will not be possible before 2020. Since twenty years, Niklaus Bolliger from Switzerland is breeding new apple cultivars for and under biodynamic conditions. In the TEMA project, six of the most promising apple candidates are currently tested in several European countries. Market introducing for the first cultivars can be expected around 2020. FiBL is involved in the evaluation of new apple cultivars in Frick under organic conditions since many years. Before new cultivars will finally be recommend for organic production, a group of organic grower has tested them under field conditions and the results have been discussed with stakeholders of the hole organic apple market chain. There is another organic breeding project called Novafruits, led by Marc Lateur (CRA Gembloux) in Belgium.

Relying on monogenic resistance genes such as Rvi6 (Vf) proved to be unsustainable as resistance breakdown is frequently observed in orchards in the last decades (Parisi *et a*l., 1993). Approaches followed by Agroscope in Wädenswil to add several scab (*Venturia inaequalis*) resistances and combine them with powdery mildew (*Podosphaera leucotricha*) resistance and fire blight (*Erwinia amylovora*) tolerance look promising. In a joint effort, the EU project 'Fruitbreedomics' contributed to increase efficiency in marker assisted breeding, a highly useful approach towards successfully pyramiding of resistances. The evaluation of susceptibility and resistance to the most relevant plant diseases is an important aspect of those projects to describe and characterize the fruit genetic diversity preserved in Swiss genebanks (Kellerhals *et a*l., 2012; Gassmann *et a*l., 2014).

In France, in order to identify cultivars adapted to organic production methods, the susceptibility to scab, aphids and powdery mildew and the agronomic properties of several cultivars were assessed under different pedo-climatic conditions accompanied by fruit quality and fruit storability assessments (Parveaud *et al.*, 2010). But so far there is no coordination or harmonization in methods to assess fruit cultivars under low-input scheme (Warlop, 2016). This appears to be a growing concern, since EU launched recent H2020 calls to address these specific complex methodological issues.

Research institutes in middle Europe started trials on the comparison of rootstocks, which should be less susceptible to fire blight, in combination with the variety 'Golden 'Delicious' under conventional conditions (Ruess, 2006; Pfeiffer, 2014) presented the updated results of such a trial over seven years suggesting that the rootstock CG11 showed large advantages regarding the yield, size and colour of the fruits.

In Greece, participatory apple genetic resources evaluation and on farm conservation activities could lead to adapted organic cultivars (Koutis *et al.,* 2016).

Results on storage, conducted at the Competence Centre for Fruit Growing at Lake Constance (KOB, Germany) in 2014, with the new resistant apple cultivars 'Galant®' and 'Natyra', revealed that both cultivars show resistance to apple scab and are of interest to organic fruit growers (Neuwald *et al.*, 2016).

Another breeding target for organic apple could be selecting for high sensory quality and selected physicochemical attributes of apple fruit. Sensory and instrumental analysis of selected cultivars of apples from organic and conventional production showed that the organically grown apples showed higher content of soluble solids, total sugars and reduced sugars in comparison to conventional apples. The physicochemical parameters of fruits, however, varied depending on the cultivar (Adamczyk *et al.*, 2010)

In the Asturian (NW Spain) agrarian sector, where apple production is principally geared towards cider making, research on sustainable strategies for managing cider-apple, cultivars selected by SERIDA since 1986 are highly recommended because of their disease tolerance, productivity and juice quality (Dapena *et al.,* 2004).

LIVESEED Apple task perspectives

These aforementioned ongoing initiatives will be connected in the scope of the European Project LIVESEED. One perspective is to establish a European network for testing candidate genotypes under organic conditions in order to share knowledge and genetic resources. Therefore, a mapping of apple breeding initiatives will be conducted to establish and extent a European apple breeding network for organic agriculture. Special emphasis will be put on ancient landraces and/or the use of the genetic pool they encompass, as these materials have evolved under low-input conditions and therefore they increase the odds to find genotypes with a good response to organic conditions.

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