

## Research Project EGON: Development of organically bred fruit varieties in commons-based initiatives

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### Abstract

*The inter- and transdisciplinary research project EGON (2017-19) gives scientific support to the development of organic fruit varieties in the project Apfel:gut. Genetic diversity of heirloom and/or underutilized apple and pear varieties is used in a community of breeders and farmers in this project. The breeding approach is conceptualized as ‘commons-based organic fruit breeding’. Ecological-economic, organizational, and genetic evaluations are carried out to assess the ecological, societal, and economic impacts of this breeding approach. The specific needs of organic fruit breeding require strategies that are especially designed for the development of organic varieties. These strategies include a focus on the use of robust, heirloom and underutilized varieties as parental varieties, on-farm breeding, and selecting solely under organic agricultural conditions.*

**Keywords:** Commons, apple breeding, organic fruit breeding, transdisciplinarity, SNP analysis

### Thematic background and goals of EGON

Conventional apple breeding in Germany is mainly characterized by three aspects:

(a) Breeding takes place under rather intensive plant protection conditions and tends to rely more and more on laboratorial approaches. A missing focus on robustness as breeding goal challenges organic fruit farmers to find suitable varieties for cultivation. Robustness means less susceptibility against a wide range of environmental conditions and diseases through high genetic diversity inside the apple.

(b) Modern apple cultivars bred in the last few decades are primarily derived from five progenitors. This close genetic basis negatively influences the vitality of current apple varieties. Consequently, this leads to inbreeding (Bannier 2011). One result of these conditions and the past breeding strategies is the breakdown of the monogenic dominant resistance against apple scab (Parisi et al. 1993; Bus et al. 2011).

(c) Newly developed apple varieties experience an increasing economization and privatization through club concepts and short-term thinking. An increasing number of varieties are regularly introduced into the market and fail to gain widespread market acceptance (Hanke & Flachowsky 2017, pp. 154). For apple farmers, this leads to a limited

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access to a part of existing varieties and contrasts with an alternate approach of long-term sustainable development of robust varieties.

These characteristics of modern conventional apple breeding contrast with the specific needs and aims of organic apple production as well as a sustainable development of fruit breeding. Following the guidelines of organic agriculture (IFOAM 2014), there is a need for robustness of germplasm and testing of breeding material in organic production conditions. Additionally, there is a linkage of organic breeding to the concept of Commons as a more sustainable variant of resource management. We hypothesize that a commons-based organic fruit breeding approach, including the use of underutilized and robust cultivars, testing in an organic production setting, and treating varieties as Commons, will be preferable for the development and introduction of apple cultivars suitable for organic production over conventional methods and channels. We also hypothesize that this approach will be preferable for a long-term sustainable organization of apple breeding for organic production

The research project EGON (runtime: 2017-2019) examines this hypothesis through the lens of participatory organic fruit breeding carried out by the initiative Apfel:gut under the umbrella of the Saat:gut e. V. (Ristel & Sattler 2014). Since 2010, Apfel:gut is conducting organic apple and pear breeding on-farm on different locations all over Germany. Within EGON, researchers from the University of Oldenburg (UOL) and Öko-Obstbau Norddeutschland Versuchs- und Beratungsring e. V. (ÖON), as well as practical partners from Apfel:gut, are working together to observe and evaluate this breeding initiative from social science, plant science, and practical perspectives. Thereby, a detailed and coherent look on the special social and economic character as well as the ecological effects of the breeding approach is possible. Because of these different perspectives, the research project is split into three sub-projects: (1) Practical organic and participatory breeding; (2) Assessment and analysis of the genetic diversity of the used varieties; (3) Conceptualization, ecological-economic analysis and evaluation as a commons-based breeding approach.

EGON wants to discuss the following overarching research questions, which connect all sub-projects:

- How can sustainable regional fruit farming be secured, innovative organic breeding concepts be developed and established, and the access to fruit varieties be kept open?
- What are differences of the conducted participatory organic fruit breeding approach in comparison to other breeding approaches?
- What ecological, societal, and economic impacts will the conducted participatory organic fruit breeding approach have?
- What are the implications of the genetic diversity regarding the used varieties in the breeding process?

### **Research Approach**

Overall, the research approach of EGON is characterized by inter- and transdisciplinarity, particularly involving the close and integrated cooperation of scientific and practical partners as well as the collaboration of natural and social scientists. The definition and the development of the research approach in the preliminary stage of the project took place in close consultation with and on an equal level between the partners (Bergmann et al. 2010). This “co-design” and the following “co-production” of scientific and practical knowledge is a valid characteristic of transdisciplinary research (Mauser et al. 2013). As mentioned above, EGON is separated into three sub-projects. and a regular exchange between these different

sub-projects takes place. Excursions, seminars at the UOL or conference visits are regularly made together. In the following, the three sub-projects will be described in detail.

(1) Practical organic and participatory breeding (applied science sub project): The ÖON and the project Apfel:gut perform crosses, cultivate seedlings, and conduct accompanied investigations. The working steps, which are necessary for the accompanied investigations, are the following:

Modern and heirloom varieties are evaluated phenotypically to gain information useful in parental selection on a quantitative scale for scab (*Venturia inaequalis*), canker (*Nectria galligena*), mildew (*Podosphoera leucotricha*), aphids (*Dysaphis plantaginea*), and Elsinoe leaf spot (*Elsinoe pyri*). Seedlings are then evaluated for the same diseases and pests with a connected negative selection in the first three or four years, where they are grown in nursery fields. Then, the seedlings are transplanted from the nursery to the field with a distance of 1 m between each seedling. Positive selection starts through grafting of non-juvenile budwood after first promising fruit results. The resulting trees from this propagation are then distributed to the Apfel:gut farms and, as part of the project EGON, to the fruit research station ESTEBURG. The performance of the genotypes is compared on their own roots to the performance on different rootstocks: For apples on the rootstocks M9 and M25, for pears on quince A and Pyrodwarf. First larger numbers of Apfel:gut genotypes will get planted as two year old trees in spring 2018. One pear selection is of higher interest because of its very nice fruit qualities and a high yield level of the original seedling. Young trees will be planted soon and be evaluated for pear scab (*Venturia pyrina*), pear psylla (*Cacopsylla pyri*), pear sawfly (*Hoplocampus psylla*), quality, and yield.

(2) Evaluation of the genetic diversity of a broad and diverse array of apple cultivars (natural science sub project): The Apfel:gut breeding project makes use of heirloom and underutilized apple cultivars in order to utilize sources of disease resistance and robustness that are not present in modern apple varieties. In order to gain a better understanding of the genetic diversity of these heirloom and underutilized apple cultivars, a sub-project has been developed to identify pedigree relationships between a large and diverse collection of apple cultivars. This project includes partners from other apple institutes studying apple genetics and several apple germplasm collections from across the world. A brief methods outline is as follows:

- Genotype a large number of apple germplasm accessions on the 20K SNP (Single Nucleotide Polymorphism – a type of DNA marker) array (Bianco et al. 2014).
- Use newly developed genetic tools available (Di Pierro et al. 2016) to create a high-quality SNP dataset following a rigorous data curation protocol used by the RosBREED (Lezzoni et al. 2010) project (manuscript in preparation).
- Identify parent-offspring and grandparent-grandchild relationships among germplasm (similar to as described in Howard et al. 2017)
- Use existing literature and historical documents to help organize and validate identified relationships.
- Use identified relationships to illustrate the diversity of underutilized apple germplasm and alongside existing literature on marker-trait associations to improve parental selection for future cultivar development in Apfel:gut.

(3) Conceptualization, ecological-economic analysis and evaluation as a commons-based breeding approach (social science sub-project): First, the initiative Apfel:gut will be analysed under the theoretical lens of Commons (e.g. Ostrom 1990, Hess 2008). ‘Commons elements’ shall be identified to allow an elaboration of the initiative’s organizational

structures, rules and norms, and to bring fruit breeding into the scientific discourse of Commons. Second, the conducted breeding approach of Apfel:gut will be evaluated with an ecologic-economic approach in terms of its sustainability effects. Third, the relevant political and legal framework of fruit breeding as well as the organizational field of Apfel:gut will be analysed and compared to the demands and requirements of commons-based fruit breeding. Eventually, possible business models and communication strategies for commons-based bred apple and pear varieties will be developed. To reach these goals, a set of social science methods will be applied: Expert interviews throughout the different working steps, focus groups with the participants of Apfel:gut, a two-step Delphi study to analyse and evaluate the political and legal framework, and a transdisciplinary workshop to discuss the possible market implementation.

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