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Bridging traditional and new commons: the case of fruit breeding

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Abstract: The recent system of fruit breeding and fruit cultivation faces a range of sustainability challenges, specifically genetic erosion, consequences of an increased privatization of former common goods, and an overall loss of resilience in the face of environmental change. We argue that a commons-based organization of fruit breeding could potentially meet these challenges. By (1) describing the specific collective action challenges for designing governance arrangements in the context of fruit breeding, and (2) conducting a case study of a commons-based organic apple breeding project in Germany, we develop a comprehensive picture of commons-based fruit breeding and its potential to meet core governance challenges in this sector. Our analysis shows that ‘fruit breeding commons’ are a form of ‘Hybrid Commons’: They bridge Traditional Commons and New Commons (Knowledge Commons and Global Natural Resource Commons) and involve two interacting layers of commons organization. The inner layer encompasses the norms, rules and institutions governing the variety breeding process itself within a clearly defined decentralized breeding community. The outer layer encompasses the usage and protection rules regarding the resulting fruit varieties and knowledge about its characteristics referring to a more open community. The empirical findings further reveal that fruit breeding commons can (potentially) resolve the public-good dilemma including the under-provision of innovations in breeding and agrobiodiversity.

Keywords: Agriculture, case study, fruit breeding, governance, global commons, knowledge commons, new commons

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I. Introduction

1.1. Purpose of research

Plant breeding is an activity that has accompanied agriculture since the dawn of the Neolithic revolution thousands of years ago. Originally, crop seeds and different varieties were treated as common goods with no clearly allocated property rights (Shiva 1997; Mgbeoji 2006; Halewood et al. 2013). Seeds were further developed by farmers, for example in sharing systems (Pautasso et al. 2013), always on-farm and resulting in many varieties and a high agrobiodiversity (Cleveland and Soleri 2002). The 19th century saw the beginning of modern scientific plant breeding as part of the industrialization of agriculture in the Global North. Since then, plant breeders have concentrated on the development of a small number of high-yielding varieties that are suitable for mass markets (Banzhaf 2016). These significant technical and societal changes weakened the role of farmers as breeders and shifted the breeding process largely to professional research institutions. Because industrialized agriculture has high standards on varieties for large-scale cultivation (e.g. in terms of uniformity, stability, and yield), costs of breeding activities increased and private property regimes for varieties emerged to give further incentives for plant breeding. As a result, the former common goods of seeds and varieties experienced a transformation into private goods (Kloppenborg 2008; Halewood et al. 2013). These are based on extensive intellectual property rights on newly developed varieties and, more recently, molecular-biological breeding techniques and isolated gene sequences (e.g. patents, plant variety protection¹, and club goods (UPOV 1991; WTO 1994)). However, the cultivation of few, genetically similar varieties, partly resulting from the outlined economization and privatization processes, has led to a “genetic erosion” (van de Wouw et al. 2010) and to the continuing loss of biodiversity – threatening the resilience of agricultural systems (Urruty et al. 2016; Tendall et al. 2015). Overall, these general developments also influence fruit breeding as a distinct section of plant breeding, which is the topic of this paper.

¹ The term “plant variety protection” refers to the legal system that grants intellectual property rights to new plant varieties, whereas the term “plant protection product” refers to the agricultural treatment of plants, e.g. with pesticides in conventional fruit growing or copper in organic fruit growing.

A possible way to address the raised concerns regarding the direction of modern plant breeding could be a re-orientation to commons principles. Commons-based approaches can potentially enable a sustainable, collective development and management of varieties (cf. Ostrom 1990; Hess 2008), preventing exclusive control (Benkler 2003), and emphasizing aspects of responsibility (Hess 2008). This paper shall give insights into these topics, concerning a commons-based organization of breeding activities and its potential effects. In the sector of plant breeding in general, several studies have already studied certain elements and principles of commons, albeit a detailed conceptualization of commons-based breeding is missing. Previous studies have already investigated commons-based principles. These include participatory breeding approaches (Murphy et al. 2005; Galiè 2013; Chable et al. 2014), seed exchange systems (Pautasso et al. 2013), community-based seed banks (Francis 2015), institutions regarding global genetic resource commons for agriculture (Byerlee and Dubin 2010; Dedeurwaerdere 2012), commons in the field of organic breeding (Wirz et al. 2017), and a first outline of a ‘Seed and Variety Commons’ conception for the field of plant breeding (Kliem and Tschersich 2018).

However, most published works have concentrated on grain or vegetable seeds and not on fruits and fruit breeding. A separate investigation of the fruit sector is necessary because of the distinctive characteristics of fruit breeding and cultivation. First, tree fruit breeding is characterized by a breeding cycle that typically takes 15–20 years, compared to one or only several years for the breeding cycle of most other crops. This stark difference in breeding timescales directly influences the required organizational structures of breeding programs. Second, reproduction of fruit trees for farming functions purely asexually (by cuttings) in contrast to the mainly generative (by seeds) reproduction of vegetables or grains. Therefore, technological enclosure, for example through hybrid seeds², is not relevant in this case. Third, the planting of an orchard is a much more long-term investment than in vegetable or grain cultivation, due to the perenniality of fruit trees. Hence, farmers are more strongly confronted with economic risks and infrastructure costs.

With this paper, we aim to develop a comprehensive picture of commons-based fruit breeding and its potential to meet core collective action challenges in achieving sustainability in agricultural systems. Further, we connect our empirical findings on commons-based arrangements in fruit breeding to theoretical categories in commons research (Traditional Commons, Knowledge Commons, and Global Natural Resource Commons), thereby aiming to reveal interlinkages between Traditional and New Commons conceptions in practical application.

The paper is structured as follows: Section 2 outlines the specific collective action challenges for designing governance arrangements in the context of fruit

² Hybrid seeds are the result of inbreeding and are, in general, highly productive. However, this productivity only lasts for one generation and therefore reproduction is economically not feasible. Consequently, farmers need to buy new seeds for every cultivation period to obtain the desired high productivity.

breeding and the potential of commons-based solutions to meet these challenges. In Sections 3 and 4, we present a case study served to analyze and reflect the actual implementation of commons principles in fruit breeding. Thereby, we investigate apple breeding in Germany inductively as an example of fruit breeding in general³. An organic breeding project named Apfel:gut⁴ serves as the empirical case. Apfel:gut is an organization of farmers and breeders, focused on organic fruit breeding with non-profit goals. Due to its special organizational characteristics, this project could be a blueprint for commons-based fruit breeding. Finally, in Section 5, we develop a definition of commons-based fruit breeding by interpreting the empirical findings in light of the present literature on different commons conceptions (Traditional Commons, Knowledge Commons and Global Natural Resource Commons) and assess the contribution of a commons-based organization to solve the identified collective action problems in fruit breeding.

1.2. Problems of current apple breeding for organic cultivation

Mainly, three critical aspects challenge the sustainability and resilience of the current apple breeding and cultivation system in Germany:

- (i) Biological aspects: The most widely grown commercial apple cultivars in both organic and non-organic cultivation are primarily derived from five progenitors, resulting in low (internal) genetic diversity and low vitality (Banner 2011). This shallow genetic diversity coupled with a focus of many breeding programs on monogenic dominant resistances (which means the allocation of a specific resistance on only one single gene) makes most apple cultivation vulnerable to pests and diseases (Ristel et al. 2016). For example, some monogenic dominant resistances in modern market-dominating apple varieties against some races of apple scab (*Venturia inaequalis*) have broken down (Bus et al. 2011). Apple scab is economically important because the disease affects the quality and appearance of apples.
- (ii) Strategic aspects: Robustness in apple breeding and farming is a neglected issue. We define robustness as a low rate of susceptibility against a broad spectrum of environmental conditions and diseases, created by high internal genetic diversity of cultivated apple varieties (Wolter et al. 2018). Cultivating robust varieties leads to a minimized use of plant protection products. In Germany, several underutilized and heirloom (often local and 'old') cultivars exist that can be characterized as robust. However, because of their shape, taste, etc. they have no economic importance for

³ Although there are certain differences between pomes, stone fruits and berry fruits as well as between different geographic areas, fruit crops share the same main biological characteristics (Janick 2005).

⁴ For more information see the project website <http://www.apfel-gut.org/>.

the large apple retail market. To obtain cultivars with market-desired traits, breeding is largely conducted using major commercialized cultivars that lack robustness. Plant protection products are constantly used in both breeding and farming to suppress scab and other diseases on trees and fruits (Roßberg and Harzer 2015). This seems a problematic issue as the usage of chemical-synthetic fertilizers and pesticides has negative effects on ecosystems and the overall sustainability of agriculture (Power 2010).

- (iii) **Market and legal aspects:** The access and distribution of many new apple varieties is exclusive and limited. Newly bred apple varieties are increasingly privatized through club concepts (Hanke and Flachowsky 2017), meaning some cultivars with variety and brand protection are only cultivated by selected farmers (the club) following specific criteria. In practice, farmers and breeders have very limited access to these club varieties. Regarding the exclusion of farmers, this is exactly the function of club concepts. However, albeit theoretically, the breeder's exemption⁵ holds true, breeders outside the club probably do not have access to budwood and pollen of club varieties, since they need to be members of the club to get this material. According to Hanke and Flachowsky (2017), cultivation of apples is also partially characterized by short-term economic thinking: With the aim of not missing any trends, most apple farmers try to cultivate newly introduced varieties every few years. However, most of the regularly introduced apple varieties fail to gain widespread market acceptance, because either they show undesired traits in productivity or fruit quality after a few years of cultivation, or market demand is too low (*ibid.*). Overall, these developments lead to a limited access of fruit farmers and breeders to existing and newly developed apple cultivars and prevent a long-term sustainable development of robust varieties.

Organic apple farming as an alternative concept to conventional and intensive farming has multiple benefits in terms of ecological and economical sustainability (Reganold et al. 2001), but is directly affected by the critical aspects described above. Whereas organic farming aims to minimize the usage of plant protection products, the non-existence of robustness among the mainly commercialized apple cultivars undermines the finding of suitable cultivars for organic cultivation. A solution could be the re-introduction of robust and underutilized apple varieties in the breeding process, using their polygenic resistance characteristics (which means the allocation of the resistance to a specific disease on several genes) (Ristel et al. 2016). This potentially strengthens the robustness of future apple varieties and softens the loss of biodiversity (Banner 2011). The international guidelines of organic agriculture (IFOAM 2014) emphasize the need for robust varieties and

⁵ The "breeder's exemption" gives breeders access to all breeding materials, including modern varieties, landraces, and wild species (UPOV 1991).

breeding under organic conditions. Moreover, organic farming aims at ensuring free access to genetic resources and at new organizational structures, based on cooperation between farmers, traders and breeders (Lammerts van Bueren 2010).

However, most organizations conducting apple breeding in Germany do not fit organic farming requirements as well as commons principles. In Germany, apple breeding lies partly in the public domain, carried out by the state-funded Julius Kühn Institute (JKI). At JKI, scientists largely rely on molecular and biotechnological approaches to develop new apple varieties and innovative breeding methods. New varieties are legally protected through plant variety protection and can be used for farming with license-contracts (JKI 2015). In addition to state-funded breeding, a few private breeding groups develop new cultivars. These are either independent individual breeders or groups of organic and conventional farmers cooperating with trading and research partners, who are performing the actual breeding. In the latter case, farmers do not actively participate⁶ in the breeding process and are just the benefactors. By often using the instruments of variety and brand protection (club concepts) for newly developed varieties, the main purpose of those initiatives is to gain profits by marketing of exclusive varieties (e.g. ZIN 2017). Both organizational forms—public and private breeding—do not consider the common-good character of cultivars and either do not include participatory elements in their breeding activities or impede access to varieties. Further, they do not directly breed for farming in organic settings. This underlines the necessity to investigate alternative structures for apple breeding.

1.3. Object of investigation

Apfel:gut is a project of the German non-profit association Saat:gut e.V.⁷ Its main goals are the promotion of organic plant breeding, the preservation and development of plant varieties suitable for organic farming, as well as the enabling of open access for crops and seeds. In 2010, farmers, plant breeders, and distributors in the organic farming sector founded Saat:gut e.V. as a counter-reaction to the increasing privatization and commercialization developments in the seed sector. Besides the Apfel:gut project, the association carries out the project ‘Saat:gut’ (named after the association itself), in which they develop new organic varieties of cauliflower, broccoli, and carrots. Results and developments of both projects are made available for the public through the release of new cultivars, lectures, field trips, and publications.

Apfel:gut’s breeding of apple varieties takes place on seven different organic farms and two further locations in Germany. Despite its status as a project of the association Saat:gut e.V., Apfel:gut is an independent organization because the breeding is conducted autonomously and some funds are raised independently. Apfel:gut wants

⁶ With “participation” of farmers in the context of fruit breeding, we mean that breeding takes place on-farm and that farmers are being involved in the maintenance and cultivation of seedlings.

⁷ For more information, see the association’s webpage <http://www.saat-gut.org/>.

to carry out organic apple breeding on-farm, using the genetic diversity of robust and underutilized existing varieties to develop new cultivars suitable for organic farming with a minimum use of plant protection products (Ristel and Sattler 2014). The members aim for a transparent and non-profit work. By now, they can see first results of the breeding process with the harvesting and evaluation of first fruits (Ristel et al. 2016). However, since apple breeding processes usually take 15 to 20 years, the final evaluation of the project will only be possible in the next decade.

2. Collective action challenges in the context of fruit breeding

From a governance perspective, every fruit breeding process consists of two interacting layers of institutions that concern different actors. The inner layer includes the norms, rules, and institutions governing the variety breeding process itself within a clearly defined breeding organization. The outer layer describes the usage and protection rules regarding the resulting cultivars and knowledge about its genetic composition referring to a more open (global) community of users of the new fruit cultivars (e.g. fruit farmers, breeders, retailers, consumers) (Sievers-Glotzbach and Wolter 2018). Further, the outer layer encompasses the access rules to the existing pool of plant genetic resources (being conserved in gene banks, in-situ or researchers' collections) as input for the fruit breeding process. The inner and outer layer of the institutional setting are in a constant interaction, posing challenges and opportunities for designing governance arrangements. Two challenges are of particular importance: the public-good dilemma and the anti-commons dilemma (Frischmann 2008; Heller 1998).

Without specific regulations, outputs from innovation processes, such as new cultivars, are in principle public goods, which are non-rivalrous and non-depletable (Frischmann et al. 2014). A "Public-good dilemma" (Frischmann 2008, 2156) may arise in the creation of varieties: Free access to newly developed fruit cultivars can reduce mainly economic incentives of individual breeders and, subsequently, lead to an under-supply of new varieties. This is specifically relevant in the sustainability context, as breeding efforts contribute to the maintenance and improvement of plant genetic resources (Dedeurwaerdere 2012; Halewood et al. 2013), a global common good with central importance for the functioning and resilience of agricultural ecosystems.

Intellectual property rights on varieties, a theoretically plausible and practically pursued solution to the public-good dilemma, however, may create a "tragedy of the anti-commons" (Heller 1998; Heller and Eisenberg 1998; Hess and Ostrom 2007). This 'tragedy' implies that too many actors hold individual rights for exclusion that lead to the underuse of a specific resource. Following this, intellectual property rights hamper the use of varieties as an input for further breeding programs – thereby increasing the societal cost and possibly lowering the pace of breeding innovation.

The collective action challenge in fruit breeding is thus to balance the protection of innovation processes and the openness of varieties to further use and

development by farmers and breeders. Plant variety protection as a common means for fruit varieties allows the earning of profits under restrained market competition. Still, these institutional structures strongly limit the rights of farmers and breeders to access seeds and plant genetic resources (Kloppenborg 2014), further symbolized by the increasing use of club concepts in apple cultivation.

Beyond the binary of intellectual property rights or government subsidies, which are generally proposed government interventions to solve the public-good dilemma, we argue that a commons-approach would be a promising way to investigate in the case of fruit breeding governance for several reasons: First, commons-based governance arrangements directly oppose the dilemma of the anti-commons. The commons-based governance of varieties can potentially promote innovation dynamics in the breeding sector and preserve agrobiodiversity in cultivation because affordable access and extensive user rights to a broad pool of varieties is given (Sievers-Glotzbach and Wolter 2018). Second, commons arrangements in the field of knowledge production and use are currently discussed as a potential solution to the public-good dilemma of underprovision (Benkler 2003; Benkler and Nissenbaum 2006; Frischmann et al. 2014). Commons-based production activities create an arena of autonomy for fruit farmers to actively build up alternative breeding structures that are tailored to their specific needs (Sievers-Glotzbach and Wolter 2018; cf. also Benkler 2003; Benkler and Nissenbaum 2006). Third, a decentral and polycentric community governance in fruit breeding potentially increases genetic diversity of future fruit cultivars that are in common (organic) cultivation. Using different environments for the seedling selection, as possible in a decentralized governance approach, is likely to result in more diverse outcomes and hence in a comparably wider genepool in the resulting new cultivars (Ristel and Sattler 2014).

The outlined collective action challenges reveal that fruit breeding cannot solely be described with a single conception of commons. The literature mainly differentiates between “Traditional Commons” and “New Commons”⁸ (Hess 2008). Traditional Commons are physical common-pool resources like fisheries, forests, grazing lands or practiced agriculture in general and their locally adapted common-property regimes, as it has been described and conceptualized by Ostrom (1990, 2005, 2008). New Commons apply to “uncharted territories” (Hess 2008) that reach beyond the sector of natural resources, as well as beyond analyzing property right regimes, highlighting questions of governance, participatory processes, trust, and assurance (Hess and Meinzen-Dick 2006). They aim to resolve a variety of social dilemmas beyond the over-use of natural resources, often encouraging the active, collective creation of certain goods and the re-conversion of currently private, commodified resources into commonly governed resources (Hess 2008, Hess and Ostrom 2007).

⁸ This differentiation was first made by (Hess 2000), referring to Traditional and Non-traditional Commons and rather criticizing the term New Commons. Later, she reevaluated her definition, distinguishing now between Traditional Commons and New Commons (Hess 2008).

3. Operationalization and methodology

Established frameworks for the study of commons (Ostrom 2005; Frischmann et al. 2014) do not fit precisely in our study because Traditional and New Commons are entangled in the context of fruit breeding. We argue that it is necessary for a first step to gain a fundamental understanding of this new type of commons (fruit breeding) and its “underlying factors” (Hess and Ostrom 2007, 44). We have classified these factors into three clusters of variables that are used in the study of both Traditional and New Commons, specifically Knowledge Commons: resource characteristics, attributes of the community, and rules (Ostrom 1999, 2005; Hess and Ostrom 2007; Stern 2011; Frischmann et al. 2014). In the following, we use these three clusters as analytical categories for a structured investigation of fruit breeding as commons. To account for the specifics of commons in fruit breeding, relevant aspects from both Traditional and New Commons must be considered together with the two existing institutional layers. In Traditional Commons, the inner layer is described by the biophysical characteristics of the resource, the actors inside the community, and the existing rules (Ostrom 2005). However, by adding New Commons elements, non-material resource characteristics as well as normative aspects regarding the community attributes become relevant factors. Furthermore, the community’s degree of openness has to be analyzed for a better understanding of the outer layer of the commons (Figure 1).

The resulting analytical main categories are (1) Resource Characteristics, (2) Community Attributes, and (3) Rules-in-form and Rules-in-use. The main categories (1) and (2) as well as (2) and (3) mutually influence each other (Frischmann et al. 2014, 19).

- (1) **Resource Characteristics.** Different natural resources (fruits, seedlings) and knowledge resources (varieties, breeding knowledge, plant genetic diversity) are relevant in a fruit breeding organization as “the world being acted upon” (Ostrom 2005, 22). The special connections between these biophysical and non-material resources go beyond the categorization in resource system and resource (flow) units (Hess and Ostrom 2007) and suggest a more open approach, such as applied for the study of Knowledge

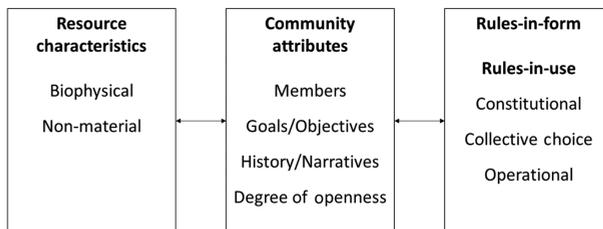


Figure 1: Analytical categories for studying fruit breeding commons.

Commons. Describing the characteristics of the resources individually includes analyzing what they exactly are, how and for what reasons they are created or obtained, what technologies and skills are used, and what effects they have on one another (Frischmann et al. 2014).

- (2) **Community Attributes.** Building upon this, a range of community attributes need a detailed analysis. Hence, the community members in the inner and outer layer, who use, contribute and manage resources in the commons as well as their respective roles are described. Other aspects are goals and objectives of the commons (Frischmann et al. 2014). Especially in the field of New Commons, communities are often not build, but emerge out of a defined social or economic context (Hess 2008). Closely connected to this are the history and narratives of the commons, emphasizing “the importance of contextual details that are ignored or marginalized in an overly rationalist account of institutional design” (Frischmann et al. 2014, 27). Finally, the community’s degree of openness regarding the access to the community and the sharing of resources needs to be described.
- (3) **Rules-in-form and Rules-in-use.** According to Hess and Ostrom (2007, 50), we differentiate between rules-in-form and rules-in-use. Rules-in-form concern written formal documents (e.g. contracts) not known or enforced by community members. In contrast, rules-in-use can be formal or informal and are known and enforced. Rules-in-use are distinguished on multiple levels: operational (day-to-day decisions), collective-choice (rules on the operational level), and constitutional (rules for collective-choice decision-making) rules-in-use. By analyzing rules-in-form and rules-in-use, a clear picture emerges of how individual and collective decision-making and behavior is (not) formalized in the commons.

To gain insights for the analysis of Apfel:gut, we used three sources of data: a qualitative interview⁹ with two leading members of Apfel:gut, relevant formal documents of the organization, and a focus group¹⁰ with the members of Apfel:gut. We did the qualitative interview with the formal project coordinator and a breeder of Apfel:gut to gain a fundamental understanding of the resource characteristics and basic information about the decision-making processes as well as formal rules, especially concerning the interrelations with Saat:gut e.V. The interview revealed that the following documents contain formal rules: The statute of Saat:gut e.V. (Saat:gut e.V. 2018), a formal contract between Saat:gut e.V. and the Apfel:gut members, submission agreements between Apfel:gut and cooperation partners, and written formal breeding goals. We analyzed all documents regarding possible rule mechanisms that govern the organization of Apfel:gut.

⁹ The qualitative interview took place on 15.05.2017 on telephone, took 1.5 hours and was recorded and transcribed. Word-for-word quotes are set in single quotation marks.

¹⁰ The focus group took place on 19.06.2017 in Kassel, took 1.75 hours and was recorded and transcribed. Six Apfel:gut members participated in the focus group.

After that, we conducted a focus group with the members of Apfel:gut. In the focus group, we discussed the community attributes and rules-in-use. To capture rules-in-use, we let the members debate about relevant rules and mechanisms in their breeding and working process and discussed the relevance of formal rules that we identified in the previous interview. In the course of the focus group, two assistants additionally observed emotional or facial expressions of the participants regarding e.g. approval or rejection of discussed aspects.

Recorded data of both the interview and the focus group have been analyzed with a qualitative content analysis to soundly analyze the data in light of the developed analytical categories.

4. Results and discussion: Apfel:gut as an example of commons-based fruit breeding

4.1. Resource characteristics

The biophysical resources around which the organization is centered are the apple seeds and seedlings, which are cultivated to grow into apple trees to eventually farm apples.

The development, cultivation, and registration of new apple varieties in Germany is a multi-step process taking place over several years (Figure 2). Apfel:gut performed crosses with about fifty robust and underutilized cultivars, as well as with modern apple cultivars, in different combinations, depending on the location of the respective farm and the preferences of the farmers. The apple seeds and later seedlings are pre-raised on two especially suitable locations (regarding human and technological resources) for a certain period. Afterwards, they are distributed to the different farms, where they are further grown and evaluated. These seedlings pass through three selection steps where poor-performing seedlings are culled (between 1st–3rd, 4th–8th and 6th–13th year of cultivation at intensively managed locations). The selection steps only describe a scheme and the exact timeline can differ. Seedling evaluation is taking place in open fields to include environmental factors in the selection process to simulate a realistic organic setting for the breeding process. In the first selection step, healthy seedlings (e.g. without leaf diseases and canker) are identified. Moreover, they are replanted to give them more room for growing. In the second selection step, scions are taken from the positive selected seedlings to reproduce and fix the selections on rootstocks at the different farming locations. In the third selection step, the quality of the fruits is evaluated and the selected varieties are tested under commercial farming conditions for at least three years. To register the variety at the German plant variety administration (Bundessortenamt), the variety has to be multiplied virus free for two years and then evaluated over four years following official rules by the administration according to UPOV (1991). If the evaluation is positive, the variety holders get the permission for commercial farming and distribution. With this permission, the holders are able to apply for the German legal instrument of variety protection (Sortenschutz), where income can be generated through license fees from every farmer who cultivates the protected variety.

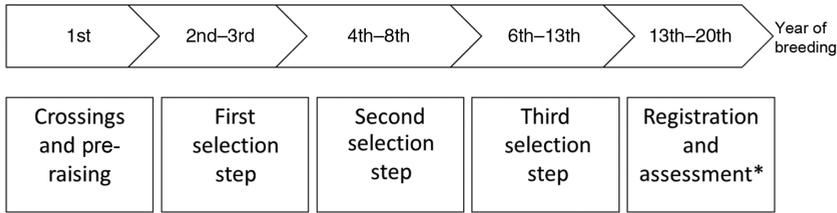


Figure 2: Schematic process of apple breeding. *Necessary legal steps to allow the commercial distribution of the variety.

The Apfel:gut members describe the seeds, seedlings and their scions as common goods belonging to all members of their organization. This principle is integrated in the polycentric character of their breeding process: The seedlings are cultivated individually on the farms and therefore every farmer has the responsibility for them as a common good that is not his or her private property.

For the raising, selection, and cultivation of the seedlings, two types of non-material resources are of relevance: breeding knowledge and farming knowledge. Breeders and farmers have different areas of expertise, which are necessary for a successful breeding process. Experience and professional breeding and farming knowledge is shared within the Apfel:gut community.

Breeding knowledge includes expertise in the identification of varieties for crossing, planning, performing and documenting of pollination as well as the evaluation of seedlings and fruits in the selection steps. This knowledge is documented in two forms of virtual documents: crossing plans and 'breeding books'. Crossing plans define which cultivars are crossed with each other and the quantity, as well as the distribution, of the respective crossings across the breeding locations. They are regularly updated and discussed on telephone conferences or during annual personal meetings. Discussed crossing plans are documented in the form of virtual documents and shared via Email by the breeders or the project coordinator. For every breeding location, the breeders are keeping breeding books where they document the (local) process of pollination and thereby crossing. In the breeding book, every seedling is listed with its specific location, selection results, possible disease problems, etc. Breeding books are kept on electronic devices of the breeders and respective farmers. Access to members can be given via request. Complementary, the breeders record weather and blossom details for selected seedlings at different locations when they do the crosses in an additional virtual document. These notes are kept on the breeders' electronic devices and access to members can also be provided via request.

Farming knowledge is included in the context of Apfel:gut expertise in the cultivation and protection of the seedlings with organic farming methods. Additionally, farming knowledge is also relevant for the identification of varieties, possibly through chance discoveries of seedlings on the farms, and for all selection steps, where farmers and breeders discuss the selections together.



Figure 3: Testing of fruit quality as part of the selection process (photograph by Inde Sattler).

By combining seeds and apple seedlings as biophysical resources with breeding and farming knowledge as non-material resources, Apfel:gut aims to create new apple varieties for organic farming (Figure 3). Hereby, the cultivation of the seedlings is affected by the breeding and farming knowledge and skills of the community as well as by the accessible genetic diversity of apple varieties. All aspects influence the selections and finally the success of the breeding process. Of special interest is the long-term nature of this interlinkage between biophysical and non-material resources, leading to a blurring of lines between these resources and culminating in a new resource, which is both biophysical (apple) and non-material (variety).

4.2. Community attributes

4.2.1. Members of the community

Apfel:gut as the clearly defined breeding organization is located in the inner layer of the institutional setting. The members of Apfel:gut are actors in this inner layer. All 13 members, including two breeders, eight farmers, one pomologist and farmer, one orchard consultant, and one biologist, actively participate in the overall apple breeding process. Farmers follow strict organic farming rules (Bioland or demeter¹¹) and have their farms in different German regions. One farmer has a particular role as the project coordinator and is particularly invested in the breeding. The orchard consultant contributes with his farming knowledge and advises the farmers in the cultivation process. The biologist is an active supporter of the

¹¹ Bioland and demeter are organic farmers' associations which certify farmers after certain guidelines. As a result, their farming products can be marketed under the respective labels.

project and contributes with her knowledge. The orchard consultant and the biologist do not use and manage the biophysical resource(s). Overall, the community in the inner layer can be described as diverse and heterogeneous. They are deliberately performing participatory plant breeding (Ceccarelli 2012) and characterize themselves as a “community of practitioners” (focus group interview 2017).

The outer layer consists of a wide range of different stakeholders. In principle, every organic and conventional fruit farmer, breeder, and other fruit expert around the world is a stakeholder because specific knowledge resources like crossing combinations are published open access and developed varieties shall be open for the use of everyone. Some stakeholders have only indirect connections, like fruit breeders in other countries who are informed by publications of Apfel:gut. Others have direct and personal connections, like several individuals in the German organic fruit breeding and cultivation sector and cooperation partners from science and praxis. However, this ‘community’ in the outer layer varies a lot because breeders, farmers and experts constantly change their level of involvement.

4.2.2. Goals and objectives

In accordance with the main goals of Saat:gut e.V., four specific goals can be identified for Apfel:gut:

- (1) Development of vital and healthy fruit cultivars for organic farming with a minimized use of plant protection products. Genetic engineering is rejected and selections take place regarding the outer appearance (phenotype), trusting the “farmer’s and breeder’s eye” (focus group interview 2017).
- (2) Preservation and enhancement of biodiversity through the introduction of robust and underutilized apple cultivars and the creation of new cultivars out of this larger gene pool.
- (3) Promotion of organic farming and breeding through publications of results and common positions as well as participation on regional and national events (e.g. trade exhibitions or farming conferences).
- (4) Transparency and public benefit through the publications of results and open access to the developed cultivars.

Regarding (1), the community defined specific breeding goals for the new fruit cultivars they wanted to develop (e.g. robust, medium sized and nicely formed fruits with an attractive color gradient). Not all members of Apfel:gut were involved in the development of these breeding goals. They were developed before the project was implemented by a small group of eventual members in cooperation with other breeding experts from across Europe. Nevertheless, all members agree with the goals and had the opportunity to give statements and opinions on these at the start of the project.

In the case of goal (4), disagreement exists in the community regarding future challenges. Apfel:gut is bound to the statute of Saat:gut e.V. which rejects any kind of legal protection mechanisms for developed plant varieties. Every Apfel:gut member agrees to this aspect and rejects patents and club varieties, largely due to their normative values. However, the legal instrument of variety protection is seen differently among the community members. Some reject this instrument because they see it contradicting the open access statutes and the non-profit character of the association. Others see it as a possibility to finance further breeding and the commons itself. Nevertheless, everyone acknowledges the difficulty of the control of compliance (holders of variety protection are responsible for the control of possible illegal cultivations of ‘their’ varieties) and therefore the suitability of this instrument in general. Because a new variety has yet to be developed, this discussion is not finished and needs to be solved in the years to come when new varieties are closer to their final breeding stage.

4.2.3. History and narratives

Apfel:gut was founded out of a “societal need” (focus group interview 2017). In existing German organizations, there is a trend of apple breeding with biotechnological methods and of economization and privatization, which can be observed for plant breeding in general. Some organic farmers did not want to follow these methods, goals and practices. Although other breeding organizations also want to develop varieties with a minimized use of plant protection products, their use of genetic-engineering-based methods repels Apfel:gut members. With the founding of Apfel:gut, the organization tries to answer the need for a non-genetic engineered apple breeding aiming for apple cultivars needing a minimum use of plant protection products.

The specific motivations of the different members are diverse, albeit all members share a common fundamental understanding about certain norms. Everyone supports high ecological standards regarding breeding and (organic) farming. Moreover, everyone wants to contribute to healthy food and a healthy nature, rather than exploiting nature as a sheer resource. As a result, the members hold great respect for ecological diversity, complexity and aspects of chance, inherent to nature as an ecological system. The members emphasize that the relationship with nature plays an important role on a personal level. However, regarding the individual motivations for participating in Apfel:gut, the members stress different foci of the following motivational perspectives:

- Ecological motivation: Farming without pesticides and genetic engineering, as well as finding suitable resilient varieties for organic farming with satisfying yields.
- Political motivation: Actively stimulating social change and transformations.
- Idealistic or personal motivation: Based on the different biographies (e.g. a spiritual view on nature).

Almost all identify themselves with apples as a product and a natural resource by stating that they simply like them or even that they are fascinated by them. Especially the farmers have a strong connection to apples expressed by the development of ‘variety collections’ of apples or the family history (some have been apple farming for generations). Moreover, some feel a spiritual connection to apples.

These norms, motivations, and aspects of identity combined create a narrative. The members see themselves in a kind of “pioneer-responsibility” (focus group interview 2017) to re-establish breeding on-farm, solve problems in current apple breeding and make provisions through the usage (of robust and underutilized cultivars) and development (e.g. new cultivars) of diversity in apples.

4.2.4. Degree of openness

In terms of the degree of openness, limits exist for getting access to the community as a member. There is no formal agreement about a quantitative limit of the community, but no one wants “immeasurable growth” (focus group interview 2017). Especially regarding possible new admissions of farmers, members find it crucial that enough seedlings exist out of the breeding process to give every farm a substantial share. In addition, there are clear qualitative requirements for potential new members. Most important is the identification with and the implementation (in case of farmers) of organic farming. Interest in organic apple breeding is seen as self-explanatory and the identification with the goals of Apfel:gut is required. The additional required characteristics include active participation, personal initiative, teamwork, and a good availability in terms of general communication. All criteria except organic farming (mentioned in the statute of Saat:gut e.V.) are not formally documented. The members emphasize that a very diverse range of people with very different abilities is needed to reach the goals of Apfel:gut.

The resource characteristics affect the community attributes and vice versa. Apple cultivars and their connected biophysical and non-material resources are the prerequisites for the emergence of this community and mark shared norms and individual motivations. Nevertheless, the community members chose from several ways one way to use and manage these resources based on their shared values, motivations and responsibilities. As the degree of openness shows, the normative foundations are (and possibly have to be, regarding the long-term breeding process) largely fixed.

4.3. Rules

4.3.1. Constitutional level

On a constitutional level, the participating farmers are bound by the formal rules of their organic farmers’ associations. As the farmers take a substantial part in the overall breeding process with the cultivation of the seedlings, the other breeders, the biologist and the orchard consultant are also bound to these association’s rules, but merely as rules-in-form. These rules do not substantially affect or restrict the breeding but are inherent to the community’s norms because they are based on the ideas of organic farming and breeding.

Moreover, the statute of Saat:gut e.V. describes the basic goals and rules for the collective-choice and operational level, which are considered as rules-in-use. Every Apfel:gut member has to sign a formal contract with Saat:gut e.V., binding the member to the statute and recognizing control mechanisms of project coordination and finance, for example, through annual general assemblies. However, in reality this formal connection has limitations. A strong formal control regarding project coordination does not take place. Financial control of Saat:gut e.V. over Apfel:gut only happens in a limited form (part of the member fees of Saat:gut e.V. are spend for the participation on exhibitions and administration tasks). However, a strong organizational coupling exists concerning public relations, political communication and common finance. Public relations and political communication is in most cases carried out by the association and some funding sources are applied for together.

Another aspect prominent in commons literature refers to sanctions (Ostrom 1990, 1993, 2005) to control and regulate the rules-in-use. The statute formally gives the opportunity to exclude Apfel:gut members from the organization, if one violates the organization's goals and objectives. However, this possibility has not been used so far and more specified sanction mechanisms do not exist. When sanction-worthy actions occur, the respective action is always evaluated individually. Although sanctions are often described as vital elements for the functioning of a commons system in literature (Ostrom 1990), they do not play a role in Apfel:gut.

4.3.2. Collective-choice level

Regarding breeding, the formally agreed-upon breeding goals function as important qualitative objectives for operational decision-making in the whole breeding process. However, they only mark a rough plan. Breeding is merely seen as an evolutionary process, contrary to a strict scientific breeding process as carried out by other breeding organizations. The community members discuss the basic instructions as well as the framework for working and selection procedures (selection criteria). Although affecting the whole community, an inner circle (the breeders, the pomologist, and the project coordinator) developed the overall crossing plan (see Figure 4 for an example of crossing apple varieties) according to the breeding goals because they had the greatest expertise. Nevertheless, ideas from other members are welcome and every farmer is encouraged to make experiments on his or her own farm upon consultation with a breeder.

As an informal rule, members are not allowed to distribute seedlings to people outside the community. Exceptions are cooperation partners, who are not direct members of the organization, but cultivate seedlings from Apfel:gut for scientific reasons. They have to sign a formal submission agreement for the handling of the seedlings. In the case of breeding knowledge, it is informally agreed upon that the existent or created knowledge about the conducted apple breeding process in general is shared with all interested parties through publications of results or personal communication. The shared knowledge includes information on the



Figure 4: Crossing of two apple varieties with brush pollination (photograph by Inde Sattler).

crossing plans and selection results. Specific knowledge about the breeding process (e.g. the breeding books) is only shared in individual cases and the sharing is considered carefully regarding the norms and personal connections to the respective person, organization or community to avoid misuse. Feedback from actors in the outer layer to the different types of shared knowledge is greatly appreciated for the further breeding process (e.g. ideas for crossings, possible reasons for and learnings out of selection results).

4.3.3. Operational level

The operational level largely consists of the practical decentral work with the seedlings on the farms. Day-to-day-decisions regarding the practical breeding on-farm are characterized by intuition and a “willingness to experiment” (focus group interview 2017) as well as a constant exchange between the individual members in the community. The farmers, who have the relevant farming knowledge, cultivate the seedlings rather independently, overall resulting in a polycentric decentralized decision-making process.

The community emphasizes that communication between farmers and breeders is the crux in the everyday work with the seedlings. Liability and the possibility of spontaneous agreements are necessary obligations and therefore considered as important rules-in-use by the members.

4.4. Summary

The case of Apfel:gut is marked by strong influences of the analytical categories on each other. (1) The biophysical resources are only shared within the breeding community (or with cooperation partners), following a set of formal and informal collective rules-in-use. (2) The non-material resource of breeding knowledge is shared with everyone (outside the breeding community) to a certain degree.

(3) The future resulting variety will possibly be open to the use, multiplication, and development by anyone, although questions of long-term financing need to be resolved.

The evolutionary character of the breeding process and the normative attributes characterizing the breeding community are mirrored in the polycentric decentralized decision-making system, nested on different levels. Apfel:gut works with a limited set of rules-in-use or specified sanction mechanisms. A possible explanation could be the role of trust, making the under-developed rules-in-use work successfully. The community self-certifies a “basic trust” (focus group interview 2017) between the members, because they give room to one another “to develop themselves” (ibid.) and in six years of working together, no-one had the idea to exclude someone else from the community. This trust is reflected in a culture of error-friendliness, less control mechanisms, low economization, and a high intrinsic motivation of all participants. The Apfel:gut members emphasize that this trust deliberately encourages the free development of ideas, which is seen as crucial for a successful breeding process.

5. Bridging traditional and new commons

Commons-based fruit breeding as this case study illustrates involves, in its core, three different types of goods: (1) cultivars in form of budwood of selected seedlings and fruits as their physical products; (2) cultivars as the result of an innovation process and hence an intellectual, cultural resource as well as (3) genetic diversity as input to every fruit breeding process. In this final section, we connect the empirical findings to theoretical categories for analyzing Traditional Commons and New Commons (specifically the New Commons’ domains of Knowledge Commons and Global Natural Resource Commons). We argue that commons-based fruit breeding can bridge these three commons categories and can contribute to solving the collective action problems in fruit breeding.

5.1. The lens of traditional commons

For the case of Apfel:gut, the empirical results show that the seeds, seedlings, and their scions of new crossings are managed as commonly owned goods within the (inner) breeding community. Common-property regimes mark the line between the shared natural resources for the fruit breeding process and the private property of the fruit farmers and breeders. As seedlings and their scions are substractable goods and as they are managed by common-property arrangements within clearly defined group boundaries, their characteristics and referred rules-in-use can be best described in terms of Traditional Commons.

5.2. The lens of knowledge commons

Further, commons-based fruit breeding relates to the conception of Knowledge Commons. These commons arrangements are defined as the “the institutionalized community governance of the sharing and (...) creation, of information, science,

knowledge, data, and other types of intellectual and cultural resources” (Frischmann, et al. 2014, 3). Since breeding is a long-term innovation process and characterized by complex crossing and experimental procedures, the shared resource knowledge plays a major role as a common good in the inner and outer layer. The breeding community in the inner layer is, in contrast to most Traditional Commons, not determined by geographical proximity to a resource, but by specific personal values and motivations connected to fruit varieties as the knowledge resource to be created (cf. Frischmann et al. 2014, 16). Commons-based fruit breeding in the Apfel:gut project takes place on several farms, integrating the approach of participatory plant breeding (Ceccarelli 2012). As a result, the participants follow a polycentric decision-making process. Knowledge resources created in the inner layer are also shared to a certain degree with the outer layer, using different measures to address relevant actors in this layer.

5.3. The lens of global natural resource commons

Agrobiodiversity is declared to be a common heritage of humankind, based on a long history of collective conservation and development by groups of farmers (Kugbei 2003; Gepts 2004; Halewood et al. 2013). Thus, (agro)biodiversity as an essential input to every breeding process has been characterized as a Global Commons (Dedeurwaerdere 2012; Halewood et al. 2013)—referring to global collective action in international and global resource domains (Mudiwa 2002; Berkes 2007; Stern 2011). A common pool of plant germplasm from important food crops, including apples, has been established by the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA; FAO 2009). Regarding the access rules to these plant genetic resources in the outer layer of fruit breeding, this multilateral system suggests that the available apple genetic diversity, mostly from international and national gene banks, shall (in principle) be made open to the use and further development by farmers, breeders, and researchers on a global level. In practice, however, the plant genetic material seems to be rarely used by breeding programs and farmers (Louafi and Manzella 2018) and the international regimes for intellectual property rights on varieties oppose the collective rights of the ITPGRFA (Frison 2018).

5.4. Looking through all lenses simultaneously

In the example of Apfel:gut, property rights status is not the central aspect in the actions of the community. Rather, questions of community governance, participatory processes, trust, narratives and moral responsibility are main issues which are also the foci of New Commons (Hess and Meinzen-Dick 2006). In conclusion, the theoretical implications of the empirical findings show that commons-based fruit breeding is organized in a form of ‘Hybrid Commons’ that cannot be entirely grasped with single conceptions of commons.

The analysis of Apfel:gut further revealed that community governance in the field of fruit breeding can resolve the public-good dilemma of underprovision of breeding innovation and agrobiodiversity to some degree. The main motivations

for engaging in the fruit breeding commons are not economic, but personal and societal (e.g. the breeding of varieties suitable for organic apple cultivation without genetic-engineering-based methods). Establishing a commons-based organization, the Apfel:gut community creates an autonomous space beyond the currently dominating path of innovation (cf. Benkler 2003; Benkler and Nissenbaum 2006). However, the Apfel:gut project has not yet developed a solution for the long-term financing of its breeding activities, if varieties are kept open and cost-free accessible to all. On a global level, strengthening the Global Commons character of plant genetic resources would further contribute to resolve the collective action problem of underprovision of agrobiodiversity. Thereby, wide access to plant genetic material as well as their collective conservation, use, and development as pursued by the ITPGRFA would be realized (Frison 2018).

Polycentric decision-making in the development of new fruit varieties appears to be motivated by two aspects. First, by allowing people with diverse motivations but shared normative and ideological convictions to work collectively towards shared goals, and second by the rationale to increase the genepool of cultivars in overall fruit growing through breeding in diverse environments. Hence, the case of fruit breeding commons mirrors two ontological conditions of polycentric governance (Thiel 2016, 9): social heterogeneity of the community and the characteristics of the resource, here referring to biodiversity. Whether a polycentric organization of breeding leads to a wider gene pool cannot be proven with our study. However, the social heterogeneity and the premise to do breeding on-farm can be acknowledged as an ontological condition as defined above. Reversing this causality leads to the conclusion that polycentrism is a necessary principle for commons-based fruit breeding as proposed in this paper.

From a conceptual perspective on commons research, fruit breeding commons as ‘Hybrid Commons’ are an excellent research subject to analyze and discuss the interlinkages between Traditional and New Commons. Further research should study ‘Hybrid Commons’ to compare and evaluate their different (and possibly similar) resource characteristics, community attributes and rules. It would be especially helpful to observe different resource systems in different countries to get a better understanding of these organizational types across resource settings and cultures.

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Interviews

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