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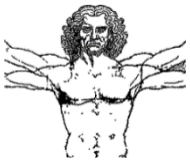

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CASE STUDY

Cherry growing in Germany, science and education - a field trip summary

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Abstract – Sustainable land use needs basic and applied research as well as new teaching methods. In order to connect the different demands collaboration with leading research institutes was combined with a field trip to practical land users. The cherry orchard "Obsthof Schwitzky" in Germany was visited including cherry testing in order to inform students about the most advanced production opportunities and research gaps as a case study of the SUMCULA project (**Su**stainable **M**anagement of **Cu**ltural **La**ndscapes). The article reports collected information by the student participants about local production specifics and development opportunities. A literature search of two databases completes the summary of practical cherry cultivation with current relevant research questions. The area cultivated with cherries decreased from 1992 to less than 8,000ha in Germany. Still, researchers conduct experiments on cherry growing in Germany, but the United States publish most studies. The amount of articles concerning cherries increases since 2004/2005 and can be subdivided into the main topics growth, yield and rootstock. The field trip revealed a high interest of students on local fruit production, their innovative cultivation methods, weed and pest control as well as its opportunities to support wild fauna and flora.

Keywords – cherry growing, education, field trip, cherry research, land use

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INTRODUCTION

The current use of pesticides and mineral fertilizers is often mentioned in public media as a factor hampering sustainability and product quality. This is particularly true for seasonal and regionally distributed horticultural products such as cherries. Its sustainable production requires an extraordinary understanding and experience of the interactions of the fruit trees with the environment in order to protect natural resources, ensure the highest possible cherry quality, and compensate gaps in scientific knowledge by long-term professional experience. As a result, the daily practical work on an orchard should be driven by a balance between the growth of high-quality fruits, several ecological and social requirements.

With the SUMCULA project (**Su**stainable **M**anagement of **Cu**ltural **La**ndscapes) we like to develop sustainable land use. This includes the teaching of students about demands in regional fruit production, continuously enlargement of their knowledge base, and the initiation of new scientific projects to answer practical questions. In order to connect these demands, we combined close collaboration with leading research institutes in agriculture in Germany with literature studies in international databases with a visit of a cherry farm as SUMCULA case study.

Seeking for one of the most progressive and open-minded farms in the region we selected the orchard "Obsthof Schwitzky". This farm had already provided guided tours for our students by the owner Uwe Schwitzky with excellent didactics.

This article communicates an overview of cherry production in Germany collected by student participants' experience during the cherry orchard visit with cherry testing. Furthermore, the role of cherry growing in science will be examined, which countries conduct research, and which topics are currently in the focus of attention.

METHOD

The information provided on how the Obsthof Schwitzky cultivates its cherries and uses the natural resources were collected and summarized. The topics covered during the guided tour are rootstocks, fertilizer, irrigation, weed and pest control, integrated farming standards, pollination, marketing, sales, workforce, and so on. A selection of topics dealing with impacts on the natural resources was done in this article. The literature research was conducted on the two databases Scopus and Science Direct. To find the number of studies the keywords "cherry" and "orchard" were used. A more detailed picture of the current challenges in cherry growing experiments was given in a list of all keywords used in the found studies in Scopus. Some latest study outcomes are added to the discussed topics from the field trip.

CHERRY CULTIVATION IN GERMANY

The area cultivated with cherries in Germany is decreasing since 1992 from 12,400ha to less than 8,000ha in 2018 (see Figure 1). Its share of the total German agricultural area in 2018 was about 0.05%, the share at the total tree fruit cultivation area about 16% with 7,941ha. The area for organic cherry cultivation accounted for 470ha in 2017 (Federal Statistical Office, 2018&2019a).

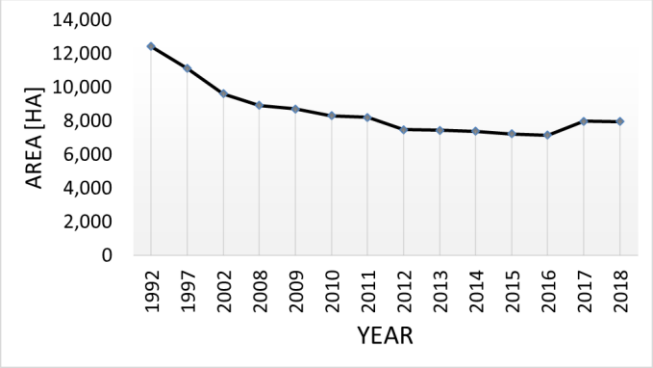

Figure 1: Cherry area cultivated in Germany from 1992 till 2018 (values in hectares), data source: German Federal Statistical Office (2019)

Harvest volumes vary greatly from year to year. In 2017 the harvest for *Prunus avium* (sweet cherries) amounted to 165,365dt (27.4dt per hectare); 442,229dt (73.4dt*ha^{-1}) were achieved in 2018. The 2017 harvest of 82,671dt (43.1dt*ha^{-1}) for *Prunus cerasus* (sour cherries) was also much lower than the harvest in 2018 with 159,023dt (83.0dt*ha^{-1}) (German Federal Statistical Office, 2019b).

The reasons for high variations in yield are different but frequently connected with weather conditions. For example, the low yield in 2017 was caused by the late frost period during fruit tree flowering.

Cherry cultivation in scientific publications

The search for research literature about cherry cultivation was explicitly limited to cherry fruit plantations in order to focus on practical questions of cherry production and exclude basic research. For example, with the keyword "cherry" many articles about forestry articles will be found as well as articles on tomato cultivation.

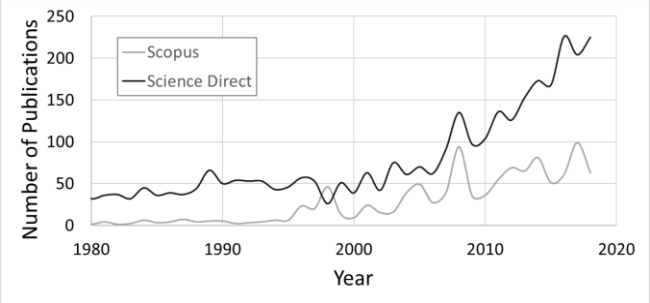

Figure 2: Number of publications in database Scopus and Science Direct with the keywords "cherry" and "orchard" until 2018.

The Scopus database registers 1,144 publications on cherry cultivation from 1915 until 2018. Figure 2 indicates an interest increase of research in cherry orchards from 1996 till 1998 and again from 2004. Since then, a continuous rise of publications per year is visible. 66.1% of the documents are thematically related to agricultural and biological sciences. The rest is divided amongst 9 disciplines (29.3%) and others (4.6%). In contrast, Science Direct counts 3,360 publications between 1972 and 2018 (numbers before 1972 were not available). The publication increase starts around 2005 and is higher than the annual rise in Scopus.

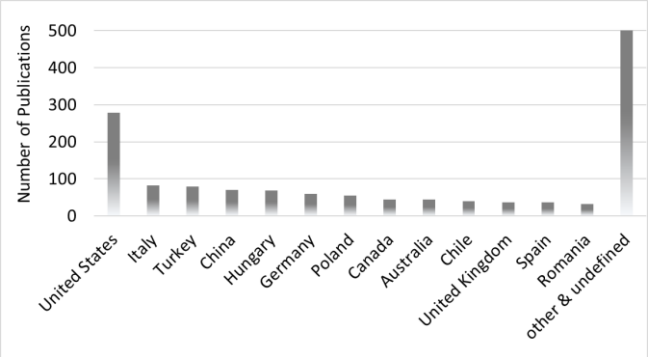

Figure 3: Number of publications with keywords "cherry" and "orchard" per country until 2019 found in database Scopus.

Many countries worldwide have conducted research on cherry growing. Figure 3 shows that the United States is the most research-oriented country. Compared to other countries, they are also a large cherry producer. The research in other countries seems to be limited. Some European countries publish traditionally on this topic. China with increasing research activities is currently in 4th place, Germany for comparison among the top 10 countries.

Most subjects are connected to *Prunus avium* (n=455), much less are dealing with *Prunus cerasus* (n=141). Other publications do not specify the species in their keywords. Further, they deal with growth, yield and rootstock. This can be subdivided into fruit quality, pollination, irrigation,

different plant diseases, *Diptera* (especially *Rhagoletis*), *Coleoptera*, *Lepidoptera*, and many more subjects.

Impacts of cherry growing on natural resources

The establishment and management of an orchard change the landscape and have several impacts on the flora, fauna, soil and water. Of course, orchards have less impact compared with coal mining or agriculture land use. Nevertheless, most advanced farmers try to reduce the negative effects of fruit cultivation and to use the natural regulation processes, e.g. for pest or weed control.

The visited orchard "Obsthof Schwitzky" is located in Saxony-Anhalt in Beesenstedt around 25 km from Halle (Saale) to the East in a region with most productive soils on loess deposits in Germany and with relatively dry climate conditions (in mean around 484mm (Merbach & Schulz, 2012) and in the year 2018: 217 mm annual precipitation).

The orchard was founded as a family enterprise in 1991. On 17 hectares the main crops are sweet cherries and apricots. Pears, sour cherries, peaches, plums and nectarines are also grown on a smaller scale. As a buffer for unexpected crop failure and for economic safety, apples are grown as well. The company is GLOBAL G.A.P (Good Agricultural Practice) certificated and works according to the principles of the Integrated Farming Standards, which pursue the goal of combining sustainable strategies from organic and conventional cultivation. The aim of the farmer is to provide and sell big and high-quality sweet aromatic cherries in the whole cherry season during the vegetation period. This is possible due to a large selection of different varieties, including early and late ripening ones. This makes a cherry tasting a challenge and a rare but impressive event (Figure 4). The sales and marketing company Veos organizes sales and logistics to the retail industry in Germany and Europe, and also a small amount worldwide.

Figure 4. Successful cherry tasting of 10 varieties at the visit 3rd July 2019 (Photo: Ina Krahl, 2019)

Cherry trees

All cherries and the other crops are grafted on dwarf rootstocks (e.g. GiSelA5, GiSelA3, M9, M27, etc.) because of their good growth performance and economic advantages (Gjamvoski et.al. 2018, Zimmermann 1994). GiSelaA5 is the commonly used rootstock in Germany due to its good adaption to the soil and climate conditions (Franken-Bembenk, 2005). Fruit trees that are grafted on dwarf rootstocks reach the required yield volume faster, offer a comfortable picking height due to their small tree size and provide a higher yield due to the shift of the leaf-fruit ratio toward fruits. In Hungary, experiments showed a good performance of the rootstock GiSelA6 on yield and gross crop value efficiency, even without irrigation. But the fruit sizes were significantly lower than Egervar, Cemany and Magyar (Bujdosó et.al., 2019). The usage of weak growing rootstocks allows more trees to be planted per hectare because of their smaller and shallower root volume. This might, in turn, increase the yield. Sour cherries have fruits on one-year-old branches, sweet cherries on 2-year old branches. One tree can grow up to 20 years, due to the frequent entry of new and better varieties, shorter rotations are common (see Figure 5). Obsthof Schwitzky is a variety location tester for stone fruit trees for cultivators from all over the world (e.g. Chile, Canada, USA, France, Czech Republic etc.). This work implies the record of tree growth, health and yield in a dry environment.

Figure 5. Cherry trees on orchard Schwitzky (Photo: Ina Krahl, 2019)

Irrigation

The region where the plantation is located is rich in soil fertility, but relatively poor in precipitation with around 484mm per year (Merbach & Schulz, 2012). It is recommended to install an irrigation system if the annual precipitation rate is lower than 450mm (Franken-Bembenk, 2005). The plants are watered with a drip irrigation system installed 30cm above ground. During harvest season the irrigation system waters 24 hours and 7 days a week. Another possible system is surface irrigation. Li et. al. (2019) investigated the influence of those two mentioned irrigation systems on the root growth. The root excavation revealed that root length density and root surface area was increased in shallow depth and more concentrated in the horizontal range under drip irrigation. They found no significant difference in root biomass density and root volume ratio. A study from Juhász et. al. (2013) in Hungary showed that cherry trees start its intensive water uptake from 6 am until 8 pm. The minimum holds until 10 pm. They calculated a water

requirement of 700-800l for the whole vegetation period in intensive sweet-cherry orchards.

Fertilization
After a soil investigation, the cherry grower gets an idea of the nutrient status of the soil in the springtime. On this fundamental, he starts to fertilize the soil. While the growing season the tree gets nutrients, which are solved in water from the irrigation system and nutrients by applied leaf fertilizer.

Pest control
To reduce pests and diseases, the farmer follows primarily cultural and biological control methods. This includes the approach to support beneficial organisms and useful animals. The plantation holds blooming flowers as cornflower and corn poppy. Chopped plant residues are used as mulch on the paths between the tree lines. Poles are constructed throughout the area for raptors which hold the mice population low. Great economic damage can be done by starlings, which eat in a short time a huge amount of cherries. To keep them away the farmer installed loudspeakers that play sounds of attacked or dying starlings every few minutes. Further, Uwe Schwitzky explained that it is necessary to play the sound each year the first time when young starlings leave the bird's nest. If he misses that point in time, the birds know, nothing bad happens to them on the plantation and they would not care about the sounds and eat the cherries without hesitation.

In the second instance of pest control, he observes the plantation regularly in order to identify infected trees by any pest. Before starting chemical treatments, a search for natural enemies is conducted, for instance, a finding of spider mites is followed by a search for predatory mites.

According to the farmer, the cherry fruit fly (*Rhagoletis cerasi*), is without natural enemies. This insect can cause high economic damages. To determine the degree of the infestation, sticky yellow panels are installed. Once appeared, there is no other change to conquer them than with insecticide. But there are studies dealing with biological control methods, chemical control, behavior control and quarantine treatment. Beyond that, there are further possibilities of combating such as bioinsecticides, control with natural product insecticides, mechanical control and genetic control (Dias et. al., 2018). Daniel and Wyss (2009) found promising results in combating the fruit fly (adult flies) with the fungi *Beauveria bassiana* and *Isaria fumosorosea* (90 to 100% mortality) under laboratory conditions. In the field, the application of *Beauveria bassiana* reduced the number of infested fruits by 65%.
Another insect that created damage in recent years in cherry plantations in Europe is the Spotted Wing Drosophila (*Drosophila suzukii*). Several insecticides, like cyantraniliprole, spinosad, spinetoram, phosmet, lambda-cyhalothrin and deltamethrin are successful. The effectiveness depends also on the number of applications in the field. For organic farming other formulations must be used, those showed little success (Shawer et. al., 2018).

Weed control
The farmer explained the advantage of herbicide control around the cherry trees with herbicide instead of digging/plowing. The soil remains untouched in its arrangement. Ground-breeding wild bees benefit from this as their nests remain intact. Prof. Dr. Robert Paxton, an insect evolutionary ecologist and professor for general zoology at the MLU Halle-Wittenberg, collected data about the flower-visiting bee species on the cherry plantation. He found that around 75% of flower visitors were honeybees and the other 25% were wild bee species of approx. 15-25 species (*Osmia bicornis*, *Anthophora plumipes*, several *Andrena* species such as *Andrena nigroaenea* and *Andrena fulva*, some sweat bee species) (information received first-hand via Email request).

Pollination
The earlier mentioned actions as planting blooming flowers or conservation of ground-breeding wild bee nests support the successful pollination of cherry flowers. Positive impacts on pollinator species richness and pollinator abundance are reported of semi-natural habitats and flowers in the herb layer (Eeraerts et. al., 2019). Intensive fruit cultivation in an intensive agricultural landscape lacks optimal pollination and therefore cherry production (Eeraerts et. al., 2017). Important for wild bees to complete their life cycle with sufficient offspring for the next year is not only sufficient forage except cherry pollen but also nesting places below and above ground (Wittmann et. al., 2005).

CONCLUSIONS

Despite the small proportion of cherry-growing land in the total agricultural area, cherry growing is being researched in various subject areas and this worldwide. But, diverse climate and nature conditions contradict global unified cultivation principles and require local experiments.

The students' great interest, enthusiasm and positive feedback on local fruit production during the field trip show that, in addition to education on the common field crops, less present agricultural products and their advanced production possibilities deserve a place in teaching. This may enhance interest and research on peripheral topics in agriculture.

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