Cite as: Korsgaard, M., Toldam-Andersen, T.B. (2024). Participative breeding of unique Danish apple cultivars. *Proceedings of the 21st International Conference on Organic Fruit-Growing*, Filderstadt 2024.02.19-21. Ed. FOEKO e.V. 2024: 19-23

Participative breeding of unique Danish apple cultivars

M. Korsgaard[1] and T.B. Toldam-Andersen[1]

Abstract

The project began in 2013 with a dual purpose: to promote more apple trees in the Danish landscape and to develop robust apple cultivars for organic growers. We collected 10.000 open-pollinated apple-seeds from 52 robust and tasty old Danish apple cultivars from our National apple gene-bank. Then we invited volunteers to sow the seeds in their private farms/gardens. More than 100 volunteered to the project in 2013. In 2019, we followed up on the trees. Approximately 50 volunteers had succeeded to grow about 2000 apple-seedlings. Since 2019, we are evaluating the robustness of the trees, disease tolerance (Apple scab (Venturia inaequalis), Apple mildew (Podosphaera leuchotricha), Apple canker (Neonectria ditissima) and Elsinoe fruit and leaf spot (Elsinoe piri)) and the quality of the fruits, as soon as the trees are fruiting. In 2020-23 we have selected for further investigations: 74 dessert apples, 17 ornamental apples, 6 cider apples, 1 columnar apple and 1 rootstock. In total 99 interesting new apples. The preliminary results of our screening of robustness and fruit quality are described.

Keywords: Apple, breeding, participative, cultivar, genetic resource

Introduction

In 2013 at the Danish National Fruit-Genebank called “The Pometum” we planned to “release” the apple-genes from our genebank and invited volunteers to join our project. The objective of the project was from the beginning to promote more apple trees in the Danish landscape and to develop a diverse range of new robust and tasty apple cultivars for organic growing. The project was initially named “The apple-oasis”, later the project was renamed “Development of unique Danish Apple Cultivars”.

Material and Methods

In “The Pometum”, we have a collection of nearly 800 apple cultivars (*Malus domestica*), of which some 280 are original Danish cultivars. In 2006-2009 we screened the robustness towards apple scab, apple mildew and apple canker of the old Danish cultivars under unsprayed conditions. Based on this information and on the taste of the apples, we selected 52 robust and tasty old Danish apple cultivars as mother-cultivars for our project. The selected mother cultivars represent a wide range of diversity in season, shape, colour and taste. (Korsgaard & Toldam-Andersen, 2020)

In 2013 we took out open-pollinated seeds of the selected cultivars from “The Pometum”, dried them and packed them in bags of 10 seeds. These seeds represent a unique mixture of genes from more than 800 apple cultivars, (both Danish and international cultivars) and including ornamental apples, *Malus spp.* (about 40 cv.) as well as a small collection of *Malus sieversii* (17 genotypes) and *Malus sylvestris* (10 genotypes).

Then we invited volunteers to join the project. They were gathered to learn about growing apple trees from seed, and they took home the apple seeds to sow in their own gardens/farms. They were asked to discharge seedlings with fungus attacks. Approximately 130 people from all over Denmark joined the project and received in total 10.000 apple

[1] Department of Plant and Environmental Sciences, University of Copenhagen, DK-1871 Frederiksberg, mkor@plen.ku.dk

seeds. The participants were mostly amateur gardeners having larger home gardens or small, organic farms.

In the years 2019-2023 we visited the 50 volunteers, which had succeeded in growing apple trees from seed. In total they had about 2000 seedling-trees, all of them raised under unsprayed conditions.

On location we have screened the trees for their disease tolerance towards Apple scab (*Venturia inaequalis*), Apple mildew (*Podosphaera leuchotricha*), Apple canker (*Neonectria ditissima*) and Elsinoe fruit and leaf spot (*Elsinoe piri*).

When seedlings were found to be susceptible to canker or being more than just a little susceptible to scab, mildew and *E. piri*, the growers were asked to discharge them.

As soon as the trees were fruiting, we have described the fruits and evaluated their taste together with the growers. Based on these data we have selected the best seedlings within the categories: ornamental apples, cider apples, rootstock, columnar apples and dessert apples. The best seedlings are now growing at The Pometum, grafted on M9 and M7 for further investigations. They are now being DNA-tested to identify their parentage.

Results

In the period 2013-2019 the 10.000 seeds, sown by 130 volunteers, had resulted in approx. 2.000 trees cultivated by about 50 persons. The reasons for the loss of 8000 seedlings were plenty, and in addition to the requested removal of diseased plants often of both personal and technical character: divorce, change of address, death, illness, lack of time and space, attacks by mice, voles, pheasants, roe deer, dogs, hens, slugs and drought.

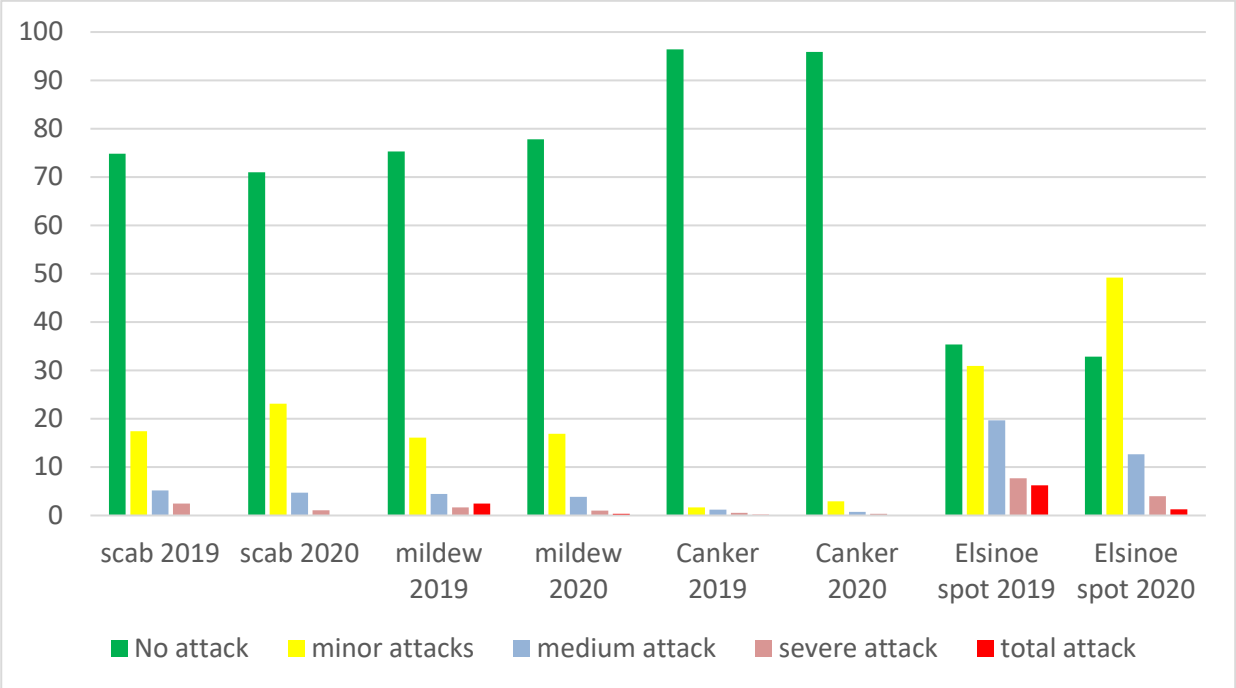

Figure 1: Percentage of apple seedlings in 2019 and 2020 attacked or not attacked by Apple scab, Apple mildew, Apple canker and Elsinoe fruit and leaf spot.

In the period 2019-2023 we screened the 2000 trees. Figure 1 shows the percentage of seedlings attacked by one or more of the fungus diseases: Apple scab (*V. inaequalis*), Apple

mildew (*P. leuchotricha*), Apple canker (*N. ditissima*) and Elsinoe fruit and leaf spot (*E. piri*). 71-96 % was not attacked by either scab, mildew or canker, while only 33-35% had no attack of *E.piri.* It can be explained by a lack of screening of the robustness of the mother cultivars towards *E. piri,* while *E.piri* did not occur in Denmark until around year 2000. (Glazowska et al., 2013).

After our screening for robustness in 2019-2020 we found, that 315 trees were too vulnerable to diseases and were discharged. Furthermore 43 trees died of unknown causes and 145 trees left the project because of the owners' personal causes. In total we have approx. 1550 trees left in the project in 2023.

As shown in Figure 2 the first fruiting trees were having very small apples, typical ornamental apples. None of the mother cultivars were ornamental apples, but several ornamental apple species are growing in the gene bank as potential father cultivars, so we believe, that these seedlings with small and bountiful apples are interspecific hybrids of *Malus domestica* and other *Malus*-species. This still waits to be clarified by DNA-test. The ornamental apples are showing a shorter juvenile period than the dessert apples, as shown in Figure 2.

The large number of robust seedlings with ornamental qualities were a pleasant surprise in the project, as it is a type of tree with great qualities in our original landscape diversification context. We therefore decided to include also ornamental trees in our selection process.

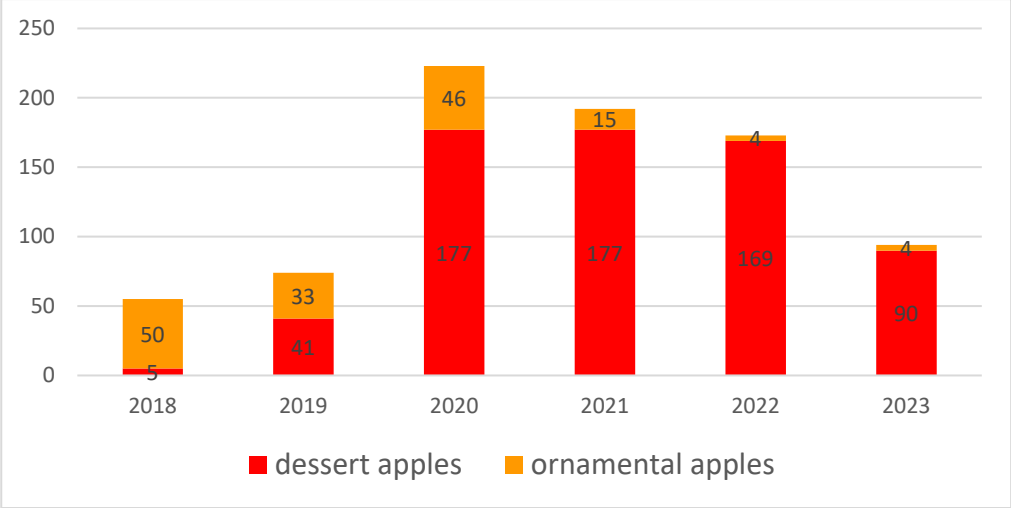

Figure 2: Number of dessert apples and ornamental apples in the first fruiting years out of 2000 seedlings, sown in December 2013.

As shown in figure 2, 152 of the trees are ornamental types.

Of these 152 ornamental apples we selected 17 trees (11%) for their beauty combined with a very good resistance to diseases.

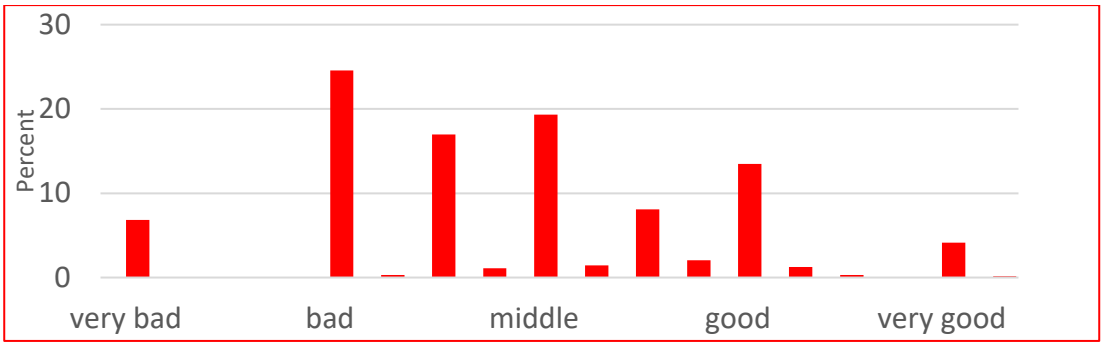

Figure 3: Percentage of apples with a specific taste in an evaluation of the overall taste of 631 new apples in the period 2019-2023.

Among the 1402 trees left, only 631 have fruited 10 years after sowing, and as shown in Figure 3. 19% of these new apples were having a good or very good taste. Among these we selected 74 dessert apples (12%) that combined good taste and robustness.

Furthermore 6 cider apples were selected for their robustness and bitter-sweet taste, and one seedling were selected for having a perfect columnar growth combined with robustness.

Last but not least, one seedling was selected for its potential as rootstock, as it has shown an interesting resistance to voles. It was the only tree alive in a plantation of 60 seedlings, where the other 59 trees were killed by voles.

The 99 selected seedlings are now growing at the Pometum for further evaluation and for further selection. We will continue visiting the volunteers in the coming years, evaluating the new apples, while more and more trees start fruiting.

Discussion

Involving volunteers as a part of a breeding programme leads to both advantages and disadvantages. When 10.000 seeds were meeting “real life” it resulted in a loss of 8.000 seedlings. Some of these losses were - as intended - due to a natural selection, both done by nature and by the grower, but many were also lost due to changes in people’s private life situations, and valuable seedlings might have been lost. The many different locations is an advantage in terms of spreading the risk of total frost damage or other climatic problems. The unsprayed conditions in the private gardens also gives a good chance of pest- and disease problems, which is necessary for the selection for robustness. In the case of the one tree, that resisted vole attack, this had probably never been discovered in a research station. On the other hand the large number of locations is a limiting factor, while we did not have the resources to visit all of the plantations at the optimal time of harvest. The very different levels of caretaking among the volunteers has probably also prolonged the span of years from seeding to fruiting. But the enthusiastic engagement among the volunteers and their joy and eager, when the trees finally fruit, is such a great experience giving energy to the project and is a good story that will help promoting the new cultivars, whenever they will be marketed.

Acknowledgements

We would like to acknowledge all the volunteers, which have used a lot of time during 10 years of their lives on raising apple seedlings. Thanks also to the staff at The Pometum genebank, especially team leader Lasse Lose and gardener Charlotte S. Riis, who are in charge of the apple collection. Also thanks to the funding bodies: in 2013: “Fonden for

Økologisk Landbrug", in 2019-2024: "Promilleafgiftsfonden for gartneriet og frugtavlen" and in 2022-2026: as a part of the project InnOBreed funded by Horizon-Europe-Biodiversity 2021.

References

Glazowska,S.E., Schiller, M., Lund, O.S., Johnston, P.R. and Korsgaard, M. (2013) First report of Elsinoe leaf and fruit spot and elsinoe pyri on apple in Denmark. *Journal of Plant Pathology* (2013), 95 (4, Supplement), S4.69-S4.77

Korsgaard, M. and Toldam-Andersen, T.B. (2020) Crowd breeding of Danish apple cultivars. *Ecofruit proceedings* 2020