Crowd breeding of Danish apple cultivars

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Abstract

At the University of Copenhagen a gene bank of app. 800 apple cultivars is situated. In order to breed new, robust apple cultivars, we invited volunteers to participate in a "Crowd-breeding project" in 2013. The 136 people sowed out 10.000 open pollinated apple seeds from the 54 most robust and tasty cultivars of Danish origin from the gene bank. In 2019 we visited the 45 growers, who had succeeded in growing trees. 1422 trees got screened, and 54 % was rated very robust towards the diseases scab, mildew, cancer and Elsinoe fruit and leaf spot. 11 % got discharged due to diseases. Only 5 % of the trees got fruits in 2019. 39 % of the 33 tested fruits had a good or very good taste. The trees will be evaluated again in 2020 and a final selection will be made in 2023.

Keywords: Apple, Breeding, Participatory, Robust, Cultivar

Introduction

"The Pometum", the national fruit gene bank in Denmark, is hosting app. 800 apple cultivars. The gene bank collection is a part of NordGen. The apple cultivars represent all the different kinds of apple cultivars which have been cultivated in Denmark in gardens and orchards through history. App. 350 of the cultivars are of Danish origin.

In 2013 we posed the question: "Why should only Kazakhstan have apple-forests, why not apple-forests in Denmark?" That initiated the project "Apple oasis" aiming to spread the genes from the gene bank, increase biodiversity and apple plantings in the landscape and to develop new robust apple cultivars with a local history.

Apple breeding requires a lot of work, space and time, and has never been a national task in Denmark. To succeed in breeding apples at a low budget, we therefore invited volunteers for help. That's why we call it "Crowd breeding".

Material and Methods

We distributed 10.000 apple seeds in 2013. The seeds were sown out by 136 engaged volunteer gardeners and farmers from all parts of Denmark.

The seeds were selected from the 54 most robust and tasty old Danish cultivars, evaluated under unsprayed conditions. The selected mother cultivars are the following: Annas æble, Blangstedgård 157, Barritskov madæble, Bredsteds æble, Brøndæble, C.J.H. 7-27, C.J.Hansen 603, Dansk Rosenhæger, Degneæble, Dronning Louise, Edle Wendelborg, Elmelund, Fejøæble, Filippa, Filippa anka, Flaskehalser, Flintinge, Fynsk udvalg II, Grænseæble, Guldborg, Guldæble, Hans Mathiesen, Harreslev, Henrik Jensens æble, Herman, Hvidkilde voksæble, Hyltofte æble, Højbjerg kalvil, Ildrød Eilstrup, Kyholm reinette, Langeland hvid pigeon, Lise Legind, Lundbytorp, Lyngbyæble, Maren Nis, Marieæblet fra Hjortholm, Mikkel Peders æble, Nonnetit Bastard, Nørregaards æble, Ondrup Sommeræble, Ormslev æble, Oudrupgårds høstæble, Pigeon Maribo, Rasmus Hansen, Ringkloster Kammerjunker, Rødbyæble, Sildig Sandholt, Skarridsø æble, Spilmose, Spiseæble fra Vejle, Stjerneæble II fra Samsø, Søbjerg æble, Vallekilde,

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Vallekilde sommeræble and Yduns æble. The cultivars are described in the Pometum apple key. The mother cultivars were selected for their good taste and robustness towards apple scab, mildew and cancer. Many of the mother cultivars are offspring of the old cultivars Pigeonnet blanc d´hiver, Cox´s Orange, Nonnetit, Maglemer and Filippa. (Larsen et al 2017).
The seeds were open pollinated. The potential 800 father-cultivars include:

- International cultivars, known or commercially grown in Denmark during history
- Danish local cultivars
- Wild apples from Kazachstan
- Ornamental apples (crab-apples)
- Columnar apples
- Cider apples

Results

In 2019 we evaluated the initial outcome of the project. About 45 participants succeeded, now having app. 1700 new apple trees from seedlings. 18 participant lost all trees due to attacks by dear, voles, mice, dogs, hens or they had moved away. We never heard from 50 participants and we lost track of 37 participants in the period from 2013-2019.
121 trees were flowering in 2019, but due to spring frost only 71 got fruit. 30 of these turned out to be small crab apples and 41 were normal sized apples. The robustness of the new trees towards fungus diseases was screened as well as the fruit quality.
The screening shows, that we have obtained a high proportion of robust trees. 766 trees (54 %) had no or small attacks of both apple scab, mildew, cancer and Elsinoe spot. At the other end 171 trees (11%) were not thriving, mainly due to attack of fungus diseases.

Table 1: Percentage of new apple seedlings attacked by apple scab and/or apple mildew and/or cancer and/or Elsinoe leaf and fruit spot. Screening in 2019 at 30 Danish locations.

	% with no attack (1)	% with small attack (3)	% with middle attack (5)	% with severe attack (7)	% with total attack (9)	Number of trees evaluated
Apple scab on leaves (*Venturia inaequalis*)	74,9	17,4	5,2	2,5	0,1	1261
Apple Mildew (*Podosphaera leucotricha*)	75,3	16,1	4,4	1,7	2,5	1305
Apple Cancer (*Neonectria ditissima*)	96,4	1,7	1,2	0,6	0,2	1249
Elsinoe leaf and fruit spot (*Elsinöe pyri*)	35,4	30,9	19,7	7,7	6,3	1309

The distribution of the attack of different diseases in 2019 is shown in table 1. The main problem vas Elsinoe leaf and fruit spot (also known as Topaz spots), where 33% of the trees were suffering from a middle attack or more.
The diversity in fruit appearance and in tree growth is very large. 17 of the seedlings (5 ‰) have inherited an interesting columnar growth.
The evaluation of the taste of 33 new apple cultivars is shown in figure 1. 13 cultivars (39 %) of the new apples had a good or very good taste. The apples with a “very good” taste was shared and tasted by a group of 30 participants at a workshop, and everyone agreed on this high score in taste.

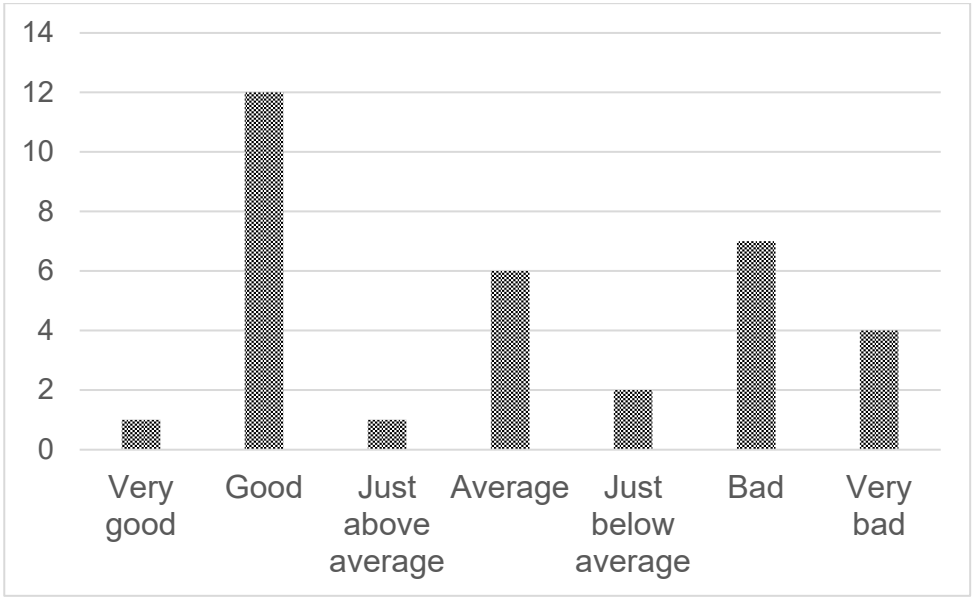

Figure 1: Number of apples with a certain taste.
Apples from 33 new seedlings, tasted fresh by 2-3 persons.

Discussion

We have chosen to work with open pollinated seeds to gain the highest possible diversity. Only very few places in the world are having 800 different potential apple fathers within the flight range of a bee. We wanted to explore this great potential of new combinations in this project. One drawback of this strategy is, that many seedlings apparently were fertilized by ornamental apple trees, and has inherited their very small fruit size. On the other hand, we have got some beautiful new ornamental apple cultivars from the project.

The growing conditions are very different within the group of Crowd-breeders. That was part of the idea, that the seedlings should struggle in different environments, and the most robust should survive. There was though quite a big loss due to attack by voles, and we might have lost valuable cultivars due to that. One of the growers lost 59 out of 60 trees to voles. The one tree surviving the attack turned out to have apples with a taste like a bitter-sweet cider apple, which might explain why the voles didn't eat it. But even with this drawback in natural selection we are optimistic, while the ratio of well-tasting cultivars until now is good.

The rather big proportion of cultivars with crab-apple size we expect to go down. We also expect the proportion of late cultivars to go up, while there is a correlation between short juvenile period and early maturity (Hanke et al 2007).

Future actions

We hope for more flowering trees in 2020 and no spring frost. We repeat the evaluation of trees and fruits in 2020. The best cultivars will then be grafted on both a weak and a strong rootstock and cultivated at The Pometum for a final evaluation in 2023. We hope and expect to obtain a selection of robust, tasty and diverse new Danish apple cultivars in 2024.

We do not expect, that our new cultivars will compete with the standard market cultivars. But we hope and expect to achieve several good cultivars for gardening and organic production. Our new cultivars are meant for the customers, who appreciate local origin and surprising apples that offer more than just being red, crisp, sweet and juicy.

Acknowledgements
Thanks to the 136 Danish gardeners and farmers, that voluntarily have offered their time to try the task of breeding new Danish apple cultivars. Especially thanks to the 45 of these, who had the patience, skills and luck to succeed in growing trees. Thanks also to the employees at the Pometum at The University of Copenhagen and to the funding bodies: Fonden for Økologisk Landbrug and Promilleafgiftsfonden for frugtavlen og gartneribruget.

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