Breeding of Pot Plants in Denmark: A Survey©

Kell Kristiansen
Department of Horticulture, Danish Institute of Agricultural Sciences, Årslev, Denmark

John Larsen and Henrik F. Brødsgaard
Department of Integrated Pest Management, Danish Institute of Agricultural Sciences, Flakkebjerg, Denmark

WHAT IS PLANT BREEDING?

Breeding is the creation of new cultivars and is in principle very simple. First, the wanted characteristics of the new cultivar are described. Among existing cultivars, those closest to the desired are selected and used to create genetic variation. Most often, the variation is made by controlled hybridisation, but mutagenesis, transformation, and protoplast fusion may be alternatives. The genetic variation can be recognised as differences among the offspring obtained after, e.g., crossings. The most interesting plants among the progeny are selected for further testing. Selection and testing are repeated and for each time the number of genetically different clones/lines are reduced and the number of plants within each clone/line is increased. Plant patenting and commercial production can be initiated after completion of testing. The principles and the actual way of breeding pot plants of *Aster novi-belgii* are shown in Table 1.

THE PLANT BREEDING PROCESS

Actual Plant Breeding. Despite the fact that the principles in breeding are the same for all plant species, this of course, does not hold true in practise. The optimal

Table 1. The principles in a breeding programme of vegetatively propagated plants and the actual content and timetable for the breeding of the first cultivar, 'Purple Viking' of the Viking Asters series.

Principle	Viking asters	Time table
Determine breeding goals	Improved cultivar with blue/purple flowers	Spring Year 0
Selection of parents	'Royal Ruby', 'Royal Blue', 'Gurney Slade' and 'Purple Glory'	Summer Year 0
Creation of variation	Hybridisation between 'Royal Ruby' and the other parents	Autumn Year 0
1st selection	Selection among seedlings	Spring Year 1
2nd selection	Selection after vegetative propagation among clones	Autumn Year 1
3rd selection	Small-scale testing in commercial production	Year 2
Plant patenting	'Purple Viking' and 'Violet Viking'	Winter Year 2–3
Large-scale commercial production	'Purple Viking'	Year 3

method depends on the plant species and the skills and facilities of the breeder. One of the most important factors determining the actual content of a breeding programme is the propagation method — either vegetative or by seeds — of the new cultivars.

The goal of plant breeding is to produce new cultivars, and a new cultivar has to be different from other cultivars, homogeneous, and stable after propagation. The difference in breeding of vegetatively propagated and seed reproduced plants is due to the way homogeneity and stability is achieved.

Vegetatively Propagated Plants. The genetic characteristics of a plant are maintained by vegetative propagation, thus homogeneity and stability are achieved directly after vegetative propagation. Therefore new clones can be selected after just a single hybridisation event, thus breeding of vegetatively propagated plants is relatively fast.

A majority of the pot plants produced in Denmark are vegetatively propagated and most of the Danish breeders are working with vegetatively propagated plants. Breeding of seed reproduced pot plants in Denmark is mostly done in companies specialised in breeding without commercial production of the final pot plants.

Seed-Reproduced Plants. In order to produce new cultivars of seed-propagated pot plants several generations of inbreeding are needed. During inbreeding homogeneity and stability are gradually increased and at least five generations of inbreeding are necessary before homogeneity and stability are achieved. During inbreeding, selection for the desired traits is done simultaneously. Inbreeding is most efficiently done by selfings but in some species, other systems of inbreeding are necessary due to, e.g., self-incompatibility. As several generations of inbreeding are needed, breeding of seed-reproduced cultivars is not as fast as when propagation can be done vegetatively.

Resistance Breeding. To produce resistant cultivars, a selection method that can differentiate between susceptible and resistant cultivars is necessary. Resistant cultivars still have to fulfil the same standards as susceptible cultivars, thus resistance breeding adds a further trait to the selection programme. During selection, it is necessary to test the obtained offspring for both resistance and other traits simultaneously.

If resistance genes are available, genetic transformation may be a possibility to obtain resistant cultivars. The bacterial Bt-gene is widely used in commercial breeding with several cultivars from different crops being introduced to the market. If resistant plants that can be crossed with the crop are available traditional hybridisation is the breeding method to use. If the resistant plant is very different from that desired for the new cultivars several generations of crossings are needed in order to obtain resistant cultivars with all the other desired characteristics. If neither resistance genes nor resistant plants are present, mutagenesis may be a possibility. Both hybridisation and mutagenesis have been used to produce resistant cultivars.

HOST PLANT RESISTANCE RESEARCH

In a Danish research programme (<www.resourceminimering.dk> resource minimization) a project "Host Plant Resistance" investigated the possibilities of breeding *Kalanchoe* and *Argyranthemum* resistant towards the pathogen *Phytophthora* and thrips (*Frankliniella occidentalis*). In the project methods giving the possibility to differentiate between resistant and susceptible cultivars were developed. For *Kalanchoe* the possibilities of transferring the resistance by hybridisation were also investigated.

Selection Methods. Resistance towards *Phytophthora* was determined after infecting the basal part of cuttings with the pathogen and after 5–6 days the growth of the pathogen could be measured as a purple colouring of the cutting. The reaction of whole plants of *Phytophthora* infection was tested to confirm the results.

Insect resistance can be divided into different categories: Antixenosis determines how well the cultivar attracts the insect when they are selecting their host plant, whereas antibiosis determines how well the cultivar feeds the insect and its larvae. Both antixenosis and antibiosis resistance have been investigated. Antixenosis was determined by placing adult thrips in a cage with flowers of various cultivars and the number of thrips in each cultivar was counted after 24 h. Antibiosis was tested by placing thrips in a cage with whole plants and then counting the number of adult thrips and larvae per cultivar after 14 days.

Inheritance of Resistance. The possibility of transferring resistance against *Phytophthora* in *Kalanchoe* through hybridisation was investigated in a diallel cross without selfings using two resistant ('Fame' and 'Molly') and one ('Katharina') susceptible cultivar. The six populations obtained were then tested for resistance.

Results. Clear differences between cultivars with respect to attack of *Phytophthora* as well as of thrips (both antixenosis and antibiosis) are shown in Table 2. The values in the column *Phytophthora* show the length of attack in millimetres and the numbers in the columns antixenosis and antibiosis gives thrip numbers found after 24 h and 6 days, respectively. Antixenosis determines how well the cultivar attracts the insect when they are selecting their host plant, whereas antibiosis determines how well the cultivar feeds the insect and its larvae. The results also showed that the mechanisms for antibiosis and antixenosis were different, as 'Debbie' was the most resistant with respect to antixenosis but was in the middle group with respect to antibiosis. 'Jacqueline' reacted oppositely. The relative high resistance for both antixenosis and antibiosis found in 'Ally' shows that these two traits could be combined.

Table 2. Cultivar differences within *Kalanchoe* in resistance towards *Phytophthora* and thrips (both antixenosis and antibiosis). The values in the column *Phytophthora* show the length of attack in millimetres and the numbers in the columns antixenosis and antibiosis gives numbers thrips found after 24 h and 6 days, respectively.

	Phytophthora (mm)	Antixenosis adults	Antibiosis larvae	Antibiosis adults
'Ally'	-	8	0.5	1.5
'Debbie'	-	4	2.5	2
'Fame'	5	11	3.5	4.5
'Goldstrike'	-	24	3.5	2
'Jaqueline'	18	12	0	0.8
'Juliane'	16	16	3	1.5
'Katharina'	30	-	-	-
'Molly'	5	-	-	-
'Simone'	13	24	6.5	4.5

In resistance breeding programmes, the aim is to transfer the resistance to new cultivars. Table 3 show that resistant clones in five of the six populations investigated. Thus, it was possible to find resistant offspring also when including the susceptible cultivar as a parent in the breeding program.

Table 3. The percentage of plants in offspring after a diallel crossing involving 'Fame', 'Molly', and 'Katharina' with an attack length of less than 2 mm after infection with *Phytophthora*.

Male/female	'Fame'	'Molly'	'Katarina'
'Fame'	-	19	8
'Molly'	18	-	0
'Katarina'	5	15	-

DANISH POT PLANT BREEDING PROGRAMS

The Internet is an excellent source of information with respect to breeding programs in, e.g., Denmark. Table 4 show the breeding companies based in Denmark together with their homepage and crop(s).

Table 4. Breeders of pot plants based in Denmark with homepages and main crops.

The Pot Aster Association <www.aster.dk>	*Aster novi-belgii*
The nursery Nældebakken <www.naeldebakken.d>	*Argyranthemum, Dahlia, Gerbera,* and *Osteospermum*
The nursery Knud Jepsen A/S <www.queen.dk>	*Kalanchoe*
Poulsen Roser ApS <www.poulsenroser.dk>	*Rosa* and *Clematis*
The nursery Ib Nygaard <www.ib-nygaard.dk>	*Lantana* and *Pentas*
The nursery PKM <www.pkm.dk>	*Campanula*
Ex-Plant ApS <www.ex-plant.com>	Cineraria, *Exacum, Celosia,* and *Solanum*
Sakata Europe <www.sakata.com>	For example: *Begonia* (three species), *Campanula, Gerbera, Impatiens, Kalanchoe, Nicotiana, Phlox,* and *Primula* (4 species), *Pericallis* (syn. *Cineraria*), *Hypoestes, Tagetes, Platycodon, Browallia, Trachelium,* and *Osteospermum*
Roses Forever ApS <www.roses-forever.dk>	*Rosa*
Cactus Breeding ApS	*Schlumbergera* and *Rhipsalidopsis*
The nursery Thoruplund <www.thoruplund.dk>	*Campanula, Hatiora (Rhipsalidopsis),* and *Schlumbergera*
Global Flowers < www.global-flowers.com>	For example, cineraria (*Pericallis*), *Gerbera, Primula,* and *Eustoma,*
Sunny <www.sunnyaps.dk>	*Osteospermum*
The nursery Tingdal < www.tingdal.dk>	*Pelargonium*
The nursery Rosborg < www.rosborg-as.dk>	*Kalanchoe*
Jørgen Petersen Egholt <www.jp-egholt.dk>	*Justicia* (syn. *Beloperone*)