Pre-publication version
Presented at the 58th Annual Meeting of the Western Region of North America – International Plant Propagators' Society, October 17-20, 2017, Wilsonville, Oregon, USA

Highlights of the IPPS 2017 Western Region/New Zealand Region exchange and ornamental plant breeding in New Zealand

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TOURING THE PACIFIC NORTHWEST

When I found out that I had been awarded the IPPS Exchange scholarship, I had no idea how many places I would get to visit outside of the conference. My journey started in Vancouver, British Columbia, with Valerie Sikkema from Van Belle Nursery, and I was lucky enough to arrive on the day of the Cranberry Festival. Valerie and her husband, Arnold, took me sightseeing to Lynn Canyon and Stanley Park where I learned a lot about the native trees of the Pacific Northwest. I was able to attend a lecture by Douglas Justice at the University of British Columbia on woody plant identification which helped me feel less disoriented by the flora that was so different from New Zealand flora. I had an extensive tour of the UBC Botanical Garden and Japanese Tea Garden. I toured several nurseries around the Chilliwack area before crossing the border to stay with Todd Jones of Fourth Corner Nurseries near Bellingham, Washington. We then headed south and toured Sakata to see the breeding programmes for beets, broccoli, cabbage, and spinach; and Floret Flower Farm, a cut flower grower and mail order business. I then stayed with Sarah and Jim Brackman in Olympia, Washington, and toured Weyerhaeuser to see large-scale propagation of conifers. In Eugene, Oregon, I met Tony Shireman and toured Fall Creek Farm & Nursery and saw both their tissue culture laboratory and blueberry breeding programme. My last stops before the conference were at Oregon State University, the USDA National Clonal Germplasm Repository, and Dr. Ryan Contreras' ornamental breeding programme.

BECOMING AN ASSISTANT PLANT BREEDER

I was born in New Zealand and grew up in the country's largest city, Auckland (approximately 1.5 million people). Most Aucklanders live within a short drive to the ocean as the city sits between two harbours which lead to the Tasman Sea to the west and the South Pacific Ocean to the east. Auckland has a subtropical to temperate climate with mild winters (light frosts inland), humid summer temperatures around 30°C (86-90°F), and much rain throughout the year.

Auckland is home to around 52 volcanoes. As a brief glimpse into our flora and geography, I will mention Rangitoto Island, which erupted around 600 years ago. It is a beautiful place to spend the day walking, but also provides a great example of plant succession. After dust settled and bacteria colonised its a'a lava surface, organic matter formed and tough pioneering plant species such as pohutukawa (*Metrosideros excelsa*) landed and grew on the island. Rangitoto Island and Motutapu Island (behind it) now hold the largest forest of pohutukawa in the world. Pohutukawa is also known as the New Zealand Christmas tree, and many families go to the beach for Christmas and picnic under these trees!

I attended the University of Auckland and chose to study biology and classical studies because I could not decide between science and arts. Biology as a major was very broad, but I was drawn to the world of plants and completed a summer studentship studying the effects of different nutrient concentrations on the flowering time of the model legume, *Medicago truncatula*.

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After graduating I spent 6 months at Seedling Systems, the biggest seedling propagation nursery in South Auckland. Seedling Systems supplies seedlings of vegetables, herbs, ornamental flowers, ginseng, native plants, tomatoes, and more. I was involved in watering several plastic houses, loading orders, and pricking out seedlings. With no practical horticultural background, this job was a bit of a challenge at first. My boss introduced me to Antony Toledo of Multiflora Laboratories (tissue culture), who talked to me about horticultural careers, plant breeding, and IPPS!

I decided to take two plant breeding papers (courses) at Massey University to gain some basic understanding of plant breeding theory. In July 2016, I began working with renowned ornamental plant breeder Dr. Keith Hammett.

Dr. Keith Hammett began his career as a trained plant pathologist, but was always interested in breeding and showing ornamental plants. Now, as a professional breeder of ornamental plants, he has recognised that he is a visual artist. Novel colour, flower form, plant habit, foliage shape, and foliage colour are all important in creating a piece of art that is three dimensional and living; plants change with time and in space.

FUNDAMENTALS OF PLANT BREEDING

Plant breeders sit in a network of people in the plant propagation industry. We rely on taxonomy and botanical science to understand the breeding systems and breeding possibilities of the species we deal with. Once we have a new cultivar, it needs to be made available to fellow plant enthusiasts; this requires growers, marketers, intellectual property agents, and retailers.

All plant breeders must always have a goal. Inspiration may come from looking at colours or flower forms of other genera, or the range of foliage or colour in wild species. On the path to improving or creating a new cultivar, a large population of offspring is usually produced each generation. It often takes decades to develop a new cultivar from beginning to commercial release, meaning that thousands of plants will be discarded during the selection process. Each breeding cycle must be a refining process that takes the breeder incrementally towards the clearly defined goal that was set at the beginning of the programme.

The strategy is the overarching plan – what is the germplasm available to you? Do you have to source seed or plant material from a seedbank or a national or international plant collection? In New Zealand, we have strict biosecurity rules under the Hazardous Substances and New Organisms Act of 1996, so it is now very difficult and expensive to bring in new species or plant material.

From among the available germplasm, the breeder must select plants to create a gene pool of parent plants to use in their specific programme. For example, dark-leaved, compact dahlia might be the goal, so all the dark-leaved plants below a certain height that we hold in our gene pool would be included in the parent block.

The breeding method relates to the reproductive cycle of the plant, and this is where botanical knowledge is useful. It is essential to understand the reproductive system of the plants you are working with. Is your plant an out-breeder or in-breeder, or can it be both? Can it hybridise with other closely related species? What is its chromosome number and ploidy?

POLYANTHUS BREEDING PROGRAMME

History

Polyanthus primrose is a traditional florist flower. By the mid-1600s, plants were being specially raised for their aesthetic value and to certain criteria for showing and competing within 'florist' societies. Gold laced polyanthus was prized for certain characteristics by florists: the gold eye must be round, not hexagonal, and of a certain proportion; the gold lace must be the same colour tone as the eye; and the gold lace must be the same width all the way around.

Florence Bellis of Oregon started Barnhaven Primroses, supposedly buying seeds from an English catalogue of a friend. She ended up growing primula commercially, studying them at university, and founding the American Primrose Society in 1941.

Dr. Keith Hammett's original breeding goal was to breed a silver laced polyanthus with a silver eye, as well as a silver laced blue polyanthus. This goal was achieved, but when I began work in 2016 there were few blue plants still alive. This year, my goal has been to revive the gene pool and preserve the blue ground colour silver picotee cultivar 'Blue Mountain' (a good plant breeding training exercise for me to practice on).

Breeding system

Polyanthus are out-breeders with two mechanisms of self-incompatibility. One method is spatial separation of the male and female organs. The pin form is when the female stigma is held visible and above the anthers. The thrum form is when the anthers are visible and above the stigma. This encourages cross pollination and is termed heterostyly. The second method is a difference in pollen grain size and stigma surface structure. Large pollen (from a thrum plant) gets caught on a stigma with long papillae/hairs (of a pin plant) and small pollen (of a pin plant) gets caught in the short hairs of the thrum plant's stigma.

Last year, I started by crossing three parents (one blue ground colour, the only blue plant left in our gene pool, and two crimson parents). The method of crossing is the same method Florence Bellis used over 50 years ago at Barnhaven Primroses in Oregon. Anthers are removed from the mother plant (emasculation) and pollen from the pollinator plant is dabbed onto the stigma (making sure the parents are a pin and thrum complementation). The outcome was plants with a mixture of flower colours from crimson to blue ground with silver picotee or lacing.

The next crosses will be using selections from the F_1 population to continue to improve the circularity and whiteness of the eye, revive the blue ground gene pool, improve the white eye on blue ground, increase the flower size of blue ground, and move full lacing onto blue ground from a red parent. I have made over 30 selections and crosses for various goals!

SWEET PEA BREEDING PROGRAMME

Breeding system

Sweet peas (*Lathyrus odoratus*) are obligate inbreeders; pollen is mature when the bud is still closed and fertilisation happens early on before the bud opens. *L. odoratus* can be made to outbreed with other *L. odoratus* cultivars (an intraspecific cross). This is done by emasculation at the bud stage – opening the bud and removing the anthers, coming back a few days later and transferring pollen of a different cultivar onto that flower's stigma. Careful labelling and recording is essential.

One of our long-term breeding programmes has been to produce a yellow flowered sweet pea. *Lathyrus belinensis* was introduced as a parent after it was first discovered in the late 1980s because it contains a yellow pigment; other species had so far been unsuccessful. The cross *L. odoratus* 'Mrs. Collier' × *L. belinensis* (an interspecific cross) was one of the few successful combinations. 'OB1' was the result – a smaller weaker plant than the parents, with flowers of intermediate size between the parents, and with pink standard and violet wings (the original sweet pea wild-type colours which are dominant traits). *L. belinensis* × *L. odoratus* 'Orange Dragon' produced 'A18', another pink and violet hybrid. Both 'OB1' and 'A18' were self-sterile, but produced some male pollen which could be used for further crossing with other cultivars of *L. odoratus*.

Challenges

Challenges include embryo abortion and seedling failure where weak, chlorotic plants fail to mature, and often produce inviable seed if they do. Embryo rescue and in vitro tissue culture is required. Close examination of the leaves of hybrids should show the characteristic pigmented spots of *L. belinensis*, a good phenotypic tool to indicate that the genetics are being carried in the plant.

In other subsequent results, backcrossing the F_1 hybrids to other *L. odoratus* cultivars produced a range of new commercial cultivars with new colour combinations never seen before. 'Blue Shift' is the first cultivar to morph colour as it ages from maroon/violet to blue. 'Porlock' has a distinctively large standard petal and marbling. 'Erewhon' is a distinctive reverse bicolour; the standard petal is paler than the wing petals. This was inspired as a goal by seeing the colour of

another pea, *Pisum elatius*. Although you may have a set, long-term breeding goal, some tangent lines are worth pursuing along the way.

Seed yield of cultivars can vary widely between and within cultivars, years, and locations. Increasing the fecundity may have a genetic control component, but seed set and seed viability are also influenced by the environment, such as temperature and nutrition [phenotype (what you see) = genotype (nature) + environment (nurture)]. This year, challenges also included a lot of rain and some herbivory by rabbits and pukeko (a native wetland bird).

Contributions

On rainy days, I update pedigree family trees and breeding histories so that we have a clear understanding of the material available to us. We need a clear understanding of which lines are not worth continuing in a breeding direction.

Up-to-date records are essential to find accessions of seed in the freezer storage that might be useful, for example, looking at records of cultivars that have increased the fecundity (seed yield) of a cultivar in the past and sowing them for use as a parent again. This is especially relevant to those new cultivars with hybrid blood that do not produce a lot of seed and would benefit from crossing with a highly fecund cultivar.

DAHLIA BREEDING PROGRAMME

Breeding programme

Dr. Keith Hammett was inspired by the variety of foliage forms in *Dahlia* species as seen in their natural habitats in Mexico. As a flower exhibitor, foliage is not of interest as many dahlia shows exclude leaves from the display. However, gardeners like foliage and texture! We have a large collection of *Dahlia* species and cultivars stored as tubers and seed, with a range of flower and foliage forms, foliage colours, and plant habits.

Dahlias are out-breeders, so we use open pollination by bees (and butterflies and maybe others!) in randomised block designs. Each parent block contains a set of plants selected from our gene pool with the desired characteristics we want to cross. For example, parent plants might be selected for a combination of any of these: foliage colour, flower form, height, or foliage shape. Each parent block is separated by a reasonable distance so that most of the pollen is expected to have come from the neighbouring plants in that block. There is definitely cross-contamination, especially when erratic monarch butterflies are involved, but most of seed would have developed from pollen within close proximity of that plant.

Collerette dahlias show the huge potential for variation. The collar can be the same colour as the ray florets (self collerette), a paler colour (standard bicolour collerette), or darker than the ray florets (reverse bicolour collerette). Dr. Keith Hammett has also developed a darker disc colour; we have variation from yellow to amber to pink to red to black. When you think outside the box and move away from defined rules (e.g., those set by flower exhibitors), many possibilities open up. There are 72 possible categories for collerette dahlias based on categorising them into collar colour, foliage colour, foliage shape, plant height, and disc colour!

Contributions

I began my job in winter, so I was digging up tubers and washing them for storage over the winter (they get waterlogged in our rainy winter and heavy clay soil). I also clean seed using a homemade seed cleaner consisting of a vacuum cleaner, a heat pump, and a wooden slide. The heavy seed falls down the slide into the collecting container and the hot air blows the light plant material up the slide which is can be vacuumed up. We deal with small quantities of seed, so we do not need anything fancy.

This year, we are evaluating over 120 plants that we selected from the field last summer and planting the seed harvested from the parent blocks last summer. During the past month (early spring), I've been sowing seed and pricking out the dahlias that will be ready to be planted out when the weather is warmer.

Challenges

Viruses and disease can be obstacles in shipping dahlia material (both tubers and cuttings) overseas. Soil tests need to be done and tissue culture is required to clean up the cuttings. The plant breeder is also in a network of people that have different expectations. In large retail centres, where plants are sold in pots and in flower, a 1-meter-tall dahlia will not be suitable. In contrast, the grower wants a uniform cultivar that will flower early and at the same time, and be a compact height so as many plants as possible will fit on shelves or trolleys for distribution. The gardener might want a nice, tall perennial border plant. It's a challenge to please everybody.

ACKNOWLEDGEMENTS

Thank you to the IPPS-Western Region and their Exchange Committee for organising and hosting my exchange. I am so grateful to my hosts who looked after me: Valerie and Arnold Sikkema, Todd and Allison Jones, Sarah and Jim Brackman, and Tony Shireman. Thank you to all the nursery owners for taking time out of your day to show me your nurseries and answer my questions.

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