'Sensation Lilac' provides vibrant flowers in the spring.

'Grefsheim Spirea' is an excellent spring flowering shrub that does well with renewal pruning every few years.

'Beauty Bush' is an attractive, large spring flowering shrub that benefits from frequent renewal pruning following flowering.

Spring Garden Checklist

LESLIE YOST, HORTICULTURIST

Spring has sprung! Use this checklist to create the most ideal conditions for your garden and landscape.

- ☐ Pull mulch away from planting beds or work it into soil if it's well composted.
- ☐ If you didn't divide perennials in the fall, it can easily be done before new growth appears. Once the new growth appears, you can still divide, but it just won't be as tidy.
- ☐ Clean up any debris from plant dieback.
- ☐ Review garden plans and double check catalog order ship dates.
- ☐ Walk through the landscape to see if plants or hardscape materials have heaved. Replant or replace anything that is out of place.
- ☐ Prune spring flowering trees and shrubs after they complete their bloom cycle. Pruning sooner will remove this spring's bloom buds.
- ☐ Vegetable gardeners will want to put out onions, lettuce, radishes, and other cool season crops early in the spring.
- ☐ Start annual seeds inside for planting in the garden once the threat of frost passes.
- ☐ Bring out any tender rhizomes and bulbs, such as canna lilies or gladiolas, that were stored for the winter.
- ☐ If necessary, fertilize and put down a pre-emergent herbicide on your lawn.
- ☐ As the season warms and the threat of frost passes, enjoy planting all the wonderful selections you've made from catalogs and your spring shopping.
- ☐ Don't forget to mulch! Mulching helps reduce weeds and maintains soil moisture.
- ☐ Begin a gardening journal. Marking the date and weather conditions of gardening tasks in a notebook this year will help you decide when to tackle some of your gardening chores next year.

Enjoy this wonderful time of year!

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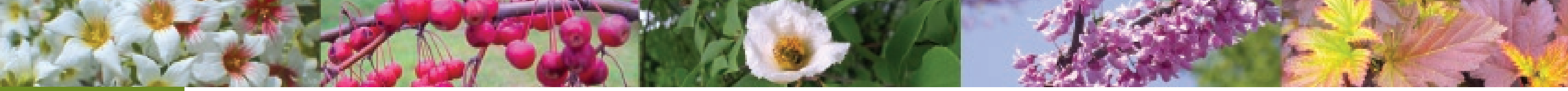

Landscape Plant Development Center

A national, non-profit research institute dedicated to developing durable plants

SPRING 2007

VOL. 18, NO. 1

Landscape Plant News

Seeking Volunteers in Oregon and Minnesota

The Center is preparing for its busy spring planting season, and we need your help. If you are interested in volunteering with planting or other tasks, please call Teri Line at 952.443.1505, or email her at tline@landscapecenter.org.

With your help, we will increase our productivity at our research stations!

Oregon
We need volunteers at the Oregon Research Station to help with:

- Planting
- Plant maintenance
- Potting
- Plant evaluation
- Making plant crosses

Minnesota
We need volunteers at the Minnesota Research Station to help with:

- Planting
- Watering
- Weeding
- General maintenance

Evaluation of Cold Hardiness and Ornamental Characteristics of Korean Provenances of *Camellia Japonica*

BY ANTHONY S. AIELLO, SHELLEY DILLARD, ELINOR I. GOFF, AND MICHELLE CONNERS

For the past quarter century, one of the primary missions of the Morris Arboretum has been domestic and international plant exploration and evaluation. Since the late 1970s, Arboretum staff have participated in 19 plant collecting trips, including trips to South Korea, China, the Caucasus Mountains, and the United States. This paper reports on 20 years of evaluation of *Camellia japonica* with known provenances collected on the 1984 expedition to northwest South Korea.

On all of our expeditions, seed is collected and returned to the Arboretum for propagation. These plant collecting expeditions have resulted in a living collection that contains approximately 4,000 plants of wild-collected and documented origin, representing just over 900 taxa. Our collection has broad holdings in woody plants suitable for the Mid-Atlantic region of the United States and particular strengths in conifers, *Hamamelis*, *Acer*, *Magnolia*, *Ilex*, and *Quercus*.

The goals of the Arboretum's plant exploration and evaluation program are to:

- Broaden the genetic pool of known species, including,
  - Extend hardiness and increase vigor
  - Broaden adaptability to difficult microclimates
- Increase insect and disease resistance
- Conserve rare and endangered species
- Select improved horticultural forms
- Evaluate and introduce appropriate new species

Anthony S. Aiello is The Gayle E. Maloney Director of Horticulture and Curator at Morris Arboretum. Elinor I. Goff is a Plant Recorder at Morris Arboretum. Shelley Dillard is a Propagator at Morris Arboretum. Michelle Conners is a Curatorial Assistant at Morris Arboretum.

Figure 2. Close-up of *Camellia japonica* foliage and flower.

Between 1979 and 1991, Arboretum staff participated in five collecting expeditions to South Korea. These trips were planned to sequentially cover different geographic regions of South Korea. The 1984 Expedition to Korea Northwestern Coast and Islands (Korea Northwest Expedition–KNW) visited areas along the northwestern coast and inland to the Kwangnung Arboretum (now Korea National Arboretum) of South Korea (Figure 1; Meyer 1985, Yinger 1989). It is from this 1984 expedition that the Arboretum holds a number of accessions of *Camellia japonica* collected on Taechong and Sochong Islands, off the west coast of South

Camellia Japonica continued on page 8

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Landscape Plant Development Center Research Update

BY HAROLD PELLETT

Research activities during the winter months are quite varied. Peter Podaras, the Landscape Plant Development Center's plant breeder at Cornell University, continues to make many crosses with *Buddleia* and *Weigela* in the greenhouse as seedlings and selections come into flower. It is also a time when seed from successful crosses made the past summer are stratified and germinated. Some require warm followed by cold stratification for several months before they germinate. Peter reports that he is now getting good germination from crosses between *Acer triflorum* X *Acer griseum* by *Acer maximowiczianum* hybrids that were made in 2005. Bob Riley at Washington State University-Puyallup is growing many of the seedlings for us. Those plants are then transported to our station in Oregon for field planting.

Peter also does a lot of screening of the *Buddleia* and *Weigela* seedlings in the greenhouse to reduce population sizes to a number that fit within our research budget. He selects plants with shorter internodes and more compact growth habit. He also selects *Buddleia* plants that have heavier flowering. Each generation of *Buddleia* produces progeny that is more exciting. We now have a large number of selected plants that have a very dwarf, compact plant habit in a range of flower colors. A few of these also appear to be sterile or at least have a very low fertility level.

We have also asexually propagated selections for broader testing. Some of these will be planted at our Oregon Research Station, some at our new Minnesota Research Station and some will be evaluated by cooperators in various geographic regions.

Winter is also a time when we plan for spring planting. At the Center's Oregon station, we will expand our irrigation system and install a two-wire control system to make it much easier for future expansions. At the Center's Minnesota station, we will be installing a permanent connection to city water to facilitate irrigation. Last summer we were able to hook up to a fire hydrant when we needed to irrigate, which was very frequent during our dry summer. A permanent hookup to city water will make things much easier.

***Buddleia* selections**

We will be increasing our plantings at the Minnesota station. The Center will add additional pear selections and our more recent selections of *Buddleia* and *Weigela*. We will also plant newer selections of several shrub genera to evaluate their adaptation in a northern climate and to establish plants for use as parents in potential future breeding efforts.

It will be interesting to see how many, if any, of the *Buddleia* selections planted in 2006 at the Minnesota station will survive the winter. Although we have not had any extremely low temperatures this winter, late January and the first half of February produced 20 straight days of below normal temperatures without much snow cover. Many days had low temperatures in the -10 to -17 degree F. range, and often the daily high temperature never reached zero. These low temperatures should have created conditions that will determine whether some of the *Buddleia* is cold hardy.

Dwarfism Genes for Modifying the Stature of Woody Plants: A Case Study in Poplar

BY ELIZABETH ETHERINGTON, HARISH GANDHI, VICTOR BUSOV, RICHARD MEILAN, CATHLEEN MA, KEVIN KOSOLA, AND STEVEN H. STRAUSS

Farmers and arborists have been selecting trees with a diversity of shapes and sizes for millennia. Generally, the tendency has been to choose smaller, narrower trees that can most easily fit in fencerows, around crops, and in urban yards where space is at a premium. Smaller trees often have other advantages as well, such as early and heavy flower and fruit production, increased wind-firmness, and higher general stress tolerance.

A similar trend has occurred in agricultural crops over the last 50 years, where cereals have been bred with semi-dwarfism genes to keep them short and stout to avoid lodging and to maximize allocation of energy to seeds rather than stems. These "green revolution" varieties of rice and wheat have had dramatic benefits for crop yields and have been credited with preventing the starvation of many millions, and improving national economies (Silverstone and Sun 2000).

The interest in semi-dwarf varieties has led to considerable activity in basic science toward identifying the genes that are responsible for control of plant height. This creates the potential for gene-directed "trait engineering,"[1] a complement to the purely form- and selection-based approaches common to traditional breeding. The extraordinary power of "genomics science" has allowed a number of the genes, and the associated physiological mechanisms for genetic control, to be described in detail. The genomic paradigm relies on model organisms to speed analysis of basic mechanisms and discovery of genes, uses sequencing and analysis of genes by the thousands via "gene chips" and other high-tech tools, and references genetic information across all plant species by a computer in the blink of an eye. The genes for height control that have received the most attention are those from the class of hormones known as gibberellic acids (GAs). The active forms of GA promote the elongation of plant cells. When active GA synthesis, or signaling caused by GA, is disrupted, cells do not fully elongate and plants remain short and stocky. When the activity of genes that degrade active GA are elevated, plants similarly remain short (Salamini 2003).

Figure 1. Field view of pairs of trees of the same gene insertion type during the second year after planting showing strong dwarfism (foreground) or changes in crown shape (to left of the 1.5-m woman).

To study how these kinds of genes might be used to control the stature and form of a tree, we inserted a variety of GA-related genes into a test variety of a hybrid poplar (*Populus tremula* x *P. alba*). This poplar variety was selected because healthy, uniform plants can be readily obtained from cells that have been genetically modified in tissue culture using the gene-transfer agent *Agrobacterium*. *Agrobacterium* is widely used because it is a natural plant genetic engineer that is effective on a wide range of plant species. Most of the genes were obtained from the model plant *Arabidopsis*, but one also originated from pea and from poplar itself. Most of the genes were strongly active throughout the plant because a generic kind of a gene expression controlling element was used (the *35S* promoter). The products of these genes metabolized active GA faster than usual (*2-oxidase*), or inhibited the cellular signal needed for GA to activate the metabolic pathways required for cell growth (*gai*, *rgl2*).

We also used two "milder" gene forms, one with the native, wild-type *GAI* gene promoter and a mutant version of the strong GA inhibitor gene gai and another with the native *GAI* gene promoter and the native *GAI* gene. In total we used seven distinct kinds of GA-inhibiting genes and generated more than 160 different types of insertions

The interest in semi-dwarf varieties has led to considerable activity in basic science toward identifying the genes that are responsible for control of plant height.

Elizabeth Etherington is a Biotechnology Program Manager at Oregon State University. Harish Gandhi is a Genetic Information Manager at Syngenta. Victor Busov is a Assistant Professor at Michigan Technological University. Richard Meilan is a Associate Professor at Purdue University. Cathleen Ma is a Senior Faculty Research Assistant at Oregon State University. Kevin Kosola is a Assistant Professor at University of Wisconsin, Madison. Steven Strauss is a Professor at Oregon State University; this work took place in his laboratory.

Dwarfism Genes continued on page 4 continued from page 3

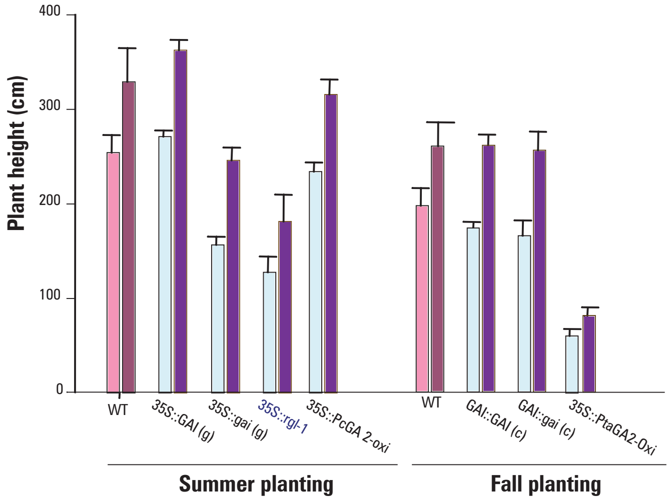

Figure 2. Genes differ greatly in the strength of dwarfism they impart. Pairs of bars are based on measurements taken in 2004 and 2005; trees were planted in summer or fall of 2003. Brackets are standard errors of the mean, g=genomic DNA, c=cDNA source.

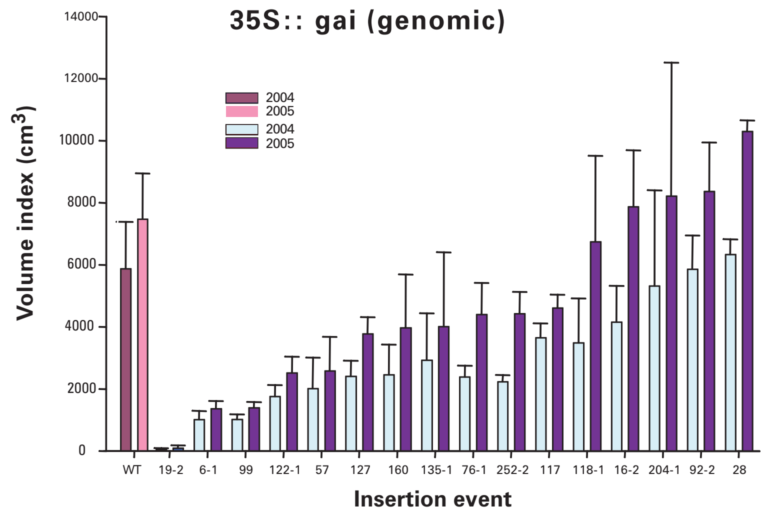

Figure 3. The gai gene gave a wide range of dwarfism among insertions, allowing the extent of semi-dwarfism to be "customized" by breeders. WT = wild-type.

of these genes into poplar DNA (each insertion, even with the same gene, can produce somewhat different effects). In 2003, we planted more than 600 genetically modified trees in the field after authorization from USDA and assessed them several times for variation in size and appearance. Identical ramets (i.e., copies of the same variety) of each gene insertion type were planted in pairs in the field to assist in visualizing their genetic differences.

Large modifications to size and form

Though most were not from poplar, the majority of genes we inserted had a dramatic dwarfing effect on tree growth. This shows that the genetic mechanisms we targeted—fundamental GA metabolism and signaling—are highly conserved among plants species that differ greatly in form and evolutionary history. This was obvious in the field, where there were many pairs of trees with the same DNA insertion that had similar and dramatic reductions in size or changes in crown form (Figure 1). The intensity of dwarfing varied greatly, from genes that gave rise to trees that appeared essentially the same as wild type, to those for which nearly all regenerated trees were extremely small, making it difficult to find them if weed control was not very intensive (Figure 2). Trees ranged in height from 3 m to shorter then 20 cm. The poplar *GA2-oxidase* gene had the most dramatic dwarfing effect, followed by the *rgl1* gene from *Arabidopsis*. The highly dwarfed trees also regenerated in tissue culture very slowly, making the process of tissue culture regeneration difficult and slow. Due to the strong negative effect of high *gai* overexpression, only 11 gene insertions with the *35S::gai* transgene were recovered.

Some forms of the *gai* gene gave a wide and near continuous range of semi-dwarfism, enabling intermediate dwarf trees to be identified to reduce tree size, but not produce highly reduced "bushes" that are slow growing and difficult to manage in a landscape (Figure 3). The wild-type *GAI* genes had no substantial effects on height growth, regardless of the promoter employed; however, these trees did flower precociously in the largest numbers, as discussed below.

Trees planted in the field during the summer of 2003 were analyzed for mean internode distance by measuring the number of nodes in a section of the stem. The association of internode distance with height was strong (Figure 4). This shows that, as expected, the main effect of GA inhibition was to reduce cell elongation, rather than cell division. The higher cellular and leaf-node density in GA-modified trees may affect other physiological traits, such as leaf area index, water flow through the stem, and crown photosynthesis. The dense crowns may also be of increased ornamental value.

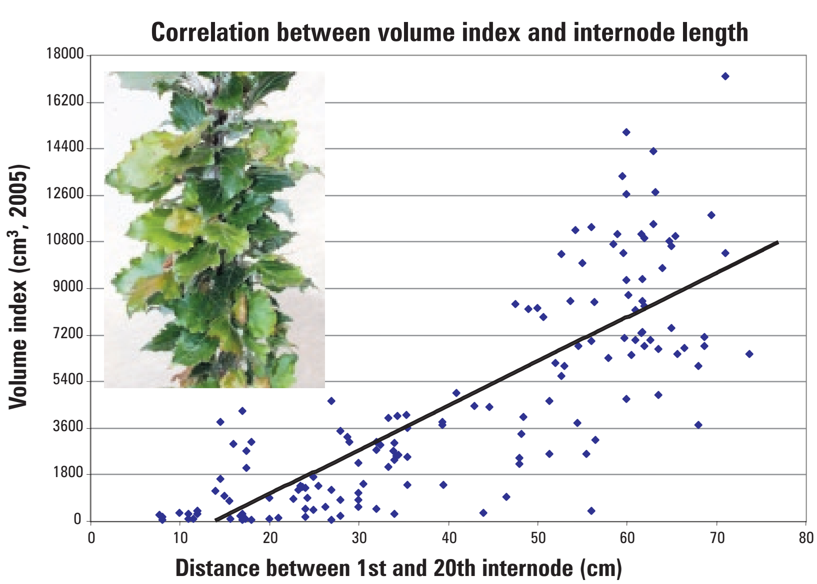

Figure 4. Correlation between plant size and internode length was strong, giving dense and bushy trees (inset).

Figure 5. Examples of variation in leaf morphology observed, including during leaf-out (left); dark green, pubescent foliage (upper right); and small-leafed, sage color foliage (lower right).

Figure 6. Precocious and unusual upright catkins formed during late summer on semi-dwarf poplars.

In addition to crown density, another feature of potential ornamental value is the striking variation in foliage color and leaf shape that we observed. Some of the genes employed gave rise to trees that had colorful foliage during leaf flush, a high degree of pubescence, or very diminutive leaves with a strong sage type of coloration (Figure 5). Most of the semi-dwarf plants in the study had very dark green leaves at maturity compared to wild type. This suggests that the use of GA-modifying genes directed specifically at leaf development could impart even more striking variation in morphology of ornamental value.

Early Flowering

During August 2005 we noticed that trees from 13 gene insertions were flowering at an abnormal time of the season (late summer), earlier than usual in their life span, and that the catkins had an unusual upright morphology (Figure 6). Additional flowering was observed during normal spring flowering in 2006, their third growing season. Controls had also begun to flower at this time, but the transgenics had significantly greater numbers of flowers than did the non-transgenic trees. All of the flowers appeared normal and female, as expected for this variety. Although dwarf trees are not expected to pose any significant environmental risks, due to regulatory requirements all catkins were manually removed from the field trial prior to catkin dehiscence. The wild-type *GAI* genes driven by the *35S* promoter gave rise to the highest frequency of flowers; approximately 80% of the 57 events in two *GAI*-based constructs included at least one flowering tree. In contrast, the strongly dwarfed *35S::rgl1* and *35S:poplar-GA-2 oxidase* trees flowered very little. This suggests that the early onset of flowering results from a combination of specific GA inhibition and growth to reach a minimum size.

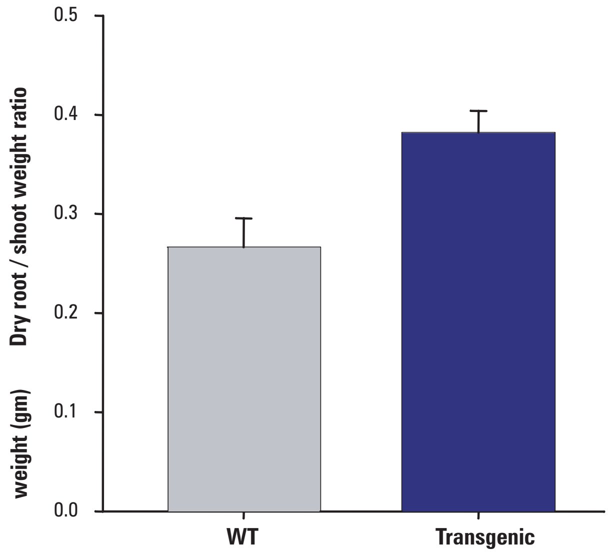

Figure 7. Increase of root:shoot biomass ratio in semi-dwarf poplars from a raised-bed study.

Strong Root Development

We noticed during initial tissue culture studies that the dwarf trees in culture boxes had very strong root development. This observation was published last year in the journal *Planta* (Busov et al. 2006). We followed up on this observation by growing plants in a raised bed. We planted 15 trees from each of the 7 different constructs and a non-transgenic control and harvested trees at monthly intervals, estimating shoot and root weights. We found that the semi-dwarf trees indeed had a statistically higher root:shoot ratio (Figure 7). The transgenics were 25% smaller than the controls in height, but had an investment in roots (vs. shoots) that was 30% greater than the controls. The preferential allocation to roots over shoots may be a large reason why an increase of stress tolerance, or recovery from poor health, has been attributed to trees treated with the GA inhibitor paclobutrazol

Dwarfism Genes continued on page 6

Dwarfism Genes continued from page 5

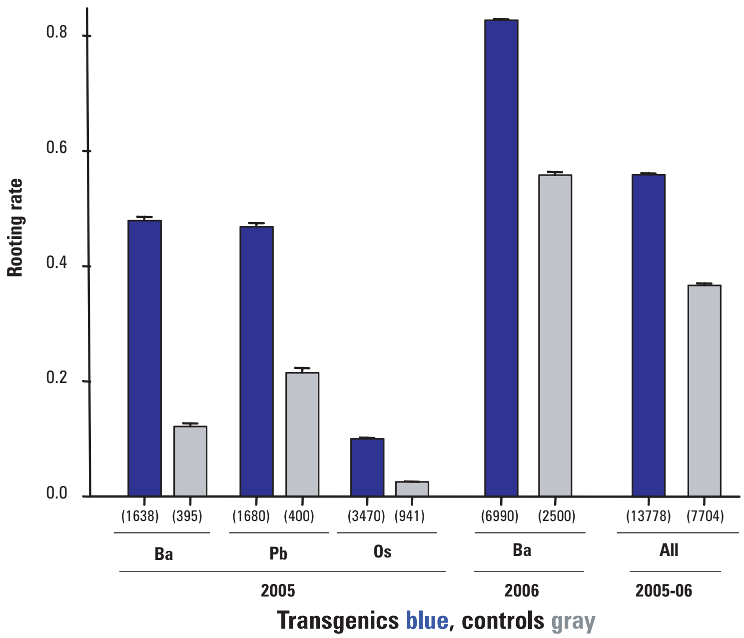

Figure 8. Improved rooting percentage of sticks from dormant trees in three nurseries (Ba, Pb, Os) over two years. Sample sizes given below bars, transgenics to left for each pair (blue), controls to right (gray).

(Watson 2000). The significant increase in root proportion suggests that these dwarfing genes may be useful when extensive root development is needed, such as for bioremediation of polluted soils, in very windy environments, or where there is limited soil moisture.

We also found that, when propagated at the University or at commercial nurseries, the semi-dwarf transgenic plants rooted at a much higher rate than wild-type plants (Figure 8). Based on our large sample size of 18,014 cuttings, we found that the transgenics rooted at a rate that was approximately 50% higher than for the non-transgenic controls. The mutant *gai* gene driven by the wild-type *GAI* promoter had the highest rooting rate. The *rgl1* and poplar *GA2-oxidase* genes, both driven by the *35S* promoter, had the poorest. Thus, it appears that one consequence of semi-dwarfism—usually desirable for the nursery industry—is plants whose root activity, both growth and redifferentiation, is improved.

Prospects and Challenges

Our results suggest that trees with semi-dwarfism genes directed at the GA pathway could be used to bolster the diversity of sizes, forms, and physiological properties of trees. This may be of value to arborists, horticulturists, foresters, landscapers, and homeowners. With the rapid growth of genomics, there are many new possibilities for choosing and controlling genes in order to more precisely modify target traits such as crown width or root growth. Thus, we have just gotten a look at the "tip of the iceberg" in the studies described above.

Our results suggest that trees with semi-dwarfism genes directed at the GA pathway could be used to bolster the diversity of sizes, forms, and physiological properties of trees.

The main scientific challenges are the need for more research into effects of different genes in the field and for improved gene-transfer methods so these kinds of genes can be readily produced in the most important landscape species and varieties, not just poplars. Current gene-transfer methods are not up to the task of efficiently transferring genes into the diversity of species and varieties used by the nursery industry. On the social side, because GMO methods were used, there are considerable and costly governmental (regulatory) hurdles, and market issues, given that some consumers are likely to be unwilling to purchase trees produced via GMO processes. Some of the genes and gene-transfer processes are also patented, requiring special licenses and fees to use them.

From an environmental viewpoint, dwarfed trees are unlikely to be a threat to spread because they will compete poorly with normal or wild trees. In fact, one advantage of the use of semi-dwarfism genes is that they should retard the spread of the exotic, and potentially invasive, trees that are commonly sold by nurseries. The genes would also provide a strong barrier to spread of more ecologically novel genes with which they may be intentionally linked by genetic engineers, such as genes for pest resistance derived from distant species. Given their potential value and safety, it seems likely that semi-dwarfism genes will find use in ornamental trees in the not-too-distant future.

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Footnote

1. We use the terms trait engineering, genetic engineering, transformation, GMO, and transgenic to refer to the use of recombinant DNA and asexual methods to modify and insert genes into plants. For the studies described here, plant genes are being used to modify native plant physiological processes (in contrast to the widely-grown GMO soy and maize crops).

Plant Portrait: *Disporum uniflorum* (Korean fairy bells)

BY MARY HIRSHFELD

I am always on the lookout for herbaceous perennials that provide a long season of interest with minimal effort on my part. Because my garden is large and my time and energy limited, I find myself drawn to perennials that are aesthetically engaging, long lived, sturdy, minimally afflicted with pest or disease problems, and require nominal supplemental watering, fertilizing or regular division to maintain their vigor.

Disporum uniflorum, previously known as *D. flavens* and *D. sessile* subsp. *flavens* is high on my list of favorite low maintenance perennials. I especially enjoy its architectural form as it emerges and matures over several weeks each spring. As the soil warms in April, plump, pointed buds push through the soil and slowly unfurl like a fern crozier to reveal the tips of tubular yellow bells peaking out from a pair of enclosing leaves. As stems elongate, the handsome stem-clasping, ovate leaves expand, displaying their distinctively impressed parallel veins. By May, the wiry, branched stems have reached their full 2 feet in height and are topped with few-flowered, pendant clusters of tubular butter yellow bells. Flowers are followed by a pair of blue-black berries that are subtle rather than showy, but contrast nicely with the golden fall foliar color.

Disporum uniflorum is native to China and Korea where it inhabits moist woodlands. It is fully winter hardy in zone 5, and those who have grown it farther north report it survives winters well in zone 4. More southerly growers report it does not perform as well in the hot humid summers of zone 7 and warmer, growing with more vigor in the cooler northern summers. In cultivation it performs best in a partially-shaded site in moist yet well-drained soil rich in organic matter. Once established it develops a strong network of sturdy rhizomes, and is quite drought tolerant, but initially requires adequate supplemental watering to get settled in.

An individual plant of Korean fairy bells will not make much of a visual impact in the garden as the stems are thin and bare at the bottom, the stem branching occurring primarily on the upper half of the stem. It is stunning, however, when used in a mass planting, the stems rising so thickly that the colony has remarkable visual impact. Plants spread slowly, so it is best to start off with a grouping of individuals spaced 6 to 8 inches apart and allow them to gradually spread out and fill in the planting. Once you have a few plants it is a simple matter to increase your planting by lifting and dividing several rhizomes in spring or fall. Here at Cornell, a mass planting has been performing admirably in the rhododendron garden for the past 15 years. It has not been thinned, nor have individual plants been lifted and divided, and fertilization has been episodic at best, yet the planting has not lost its vigor. *Disproum uniflorum* makes an effective remarkably weed-proof groundcover in the woodland garden and combines nicely in mixed plantings with ferns and hostas.

Mary Hirshfeld is the Gardens Curator at Cornell University Plantations.

Left: Korean fairy bells is native to China and Korea where it inhabits moist woodlands.

Above and Below: Korean fairy bells provide remarkable visual impact in mass plantings.

As the soil warms in April, plump, pointed buds push through the soil and slowly unfurl…

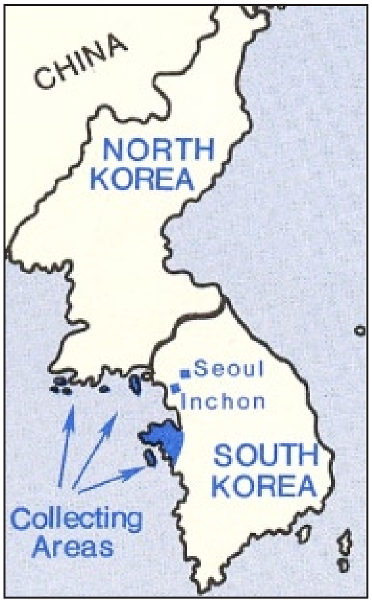

Figure 1. Areas visited on the 1984 Korea Northwest collecting expedition.

Korea. The island collections represent some of the most northern collections ever made of common camellia.

From the late 1970s into the early 1980s, a series of extremely cold winters devastated camellia collections at the U.S. National Arboretum and elsewhere (Ackerman and Egolf 1991; Ackerman and Egolf 1992). These severe winters, and the damage to large numbers of cultivars, inspired Dr. William Ackerman and others to undertake breeding programs to develop truly cold-hardy camellias (USDA zones 6 and 7). In light of this research, the northern collections of *Camellia japonica* from South Korea were thought to have potential to expand the hardiness of common camellia, generally considered to be reliably hardy in USDA hardiness zone 7b (Flint 1997), but historically not reliably cold hardy in the Philadelphia area (zone 6b).

Evidence from freezing tests supported the hypothesis that the Korean accessions of *Camellia japonica* possessed greater cold hardiness than other selections of this species. Dirr et al. (1993) reported that one of the Korean accessions of *Camellia japonica* (MOAR #86-050 /KNW 352) had stems that were cold hardy from -24º C to - 30º C, indicating that these collections held promise for extending the potentially useful range of this species.

Given the northern locations of the Korean *Camellia japonica* populations and in conjunction with the freezing test evidence, the Arboretum undertook a long-term field and garden trial of

Collection #	MOAR Accession #	Germination	Total Planted
Taechong Island			
KNW 311	86-292	-	0
KNW 312	86-223	+	28
KNW 342	86-043	+	45
KNW 343	86-044	+	2
KNW 344	86-045	+	100
KNW 345	86-224	+	0*
Sochong Island			
KNW 348	86-048	+	114
KNW 350	86-049	+	19
KNW 352	86-050	+	455
Total=			763

* One seedling germinated but did not survive.

Table 1. *Camellia japonica* seed collected in Taechong and Sochong Islands, South Korea, October 1984. Accessions with germination (+) or no germination(-). Total number of plants planted in field trials at Bloomfield Farm (1987) or in garden settings throughout the Arboretum (1987-91).

several accessions. Since the late 1980s plants grown from these collections have been evaluated for cold hardiness and several ornamental characteristics. The camellias in this study all exhibit attractive evergreen foliage and single, red flowers (Figure 2). These plants are large shrubs, reaching up to 12 feet tall in 20 years (Figure 3).

Materials and Methods/Results

In 1984, nine seed accessions of *Camellia japonica* were collected on two islands off the coast of northwest South Korea: Taechong Do and Sochong Do (Meyer 1985, Yinger 1989). Seed were sown at the Morris Arboretum beginning in November 1984. Eight of the nine accessions germinated successfully, with varying numbers of seedlings among accessions (Table 1). Plants were accessioned in 1986 and designated for one of two parallel evaluation studies: either a replicated field trial or garden settings throughout the Arboretum. Of the eight successfully germinated accessions, six were eventually planted in the Arboretum's trials or throughout the Arboretum (Tables 2 and 3).

Field Trials and Initial Garden Trials

In April 1987, 730 seedlings were planted in a replicated field trial at the Arboretum's Bloomfield Farm research area and were evaluated for cold hardiness (Table 2). These 730 plants were planted in a randomized block design with varying light levels. Equal numbers of each accession were divided among the plots and randomly assigned to a location within a plot. From 1989 to 1993 all of these plants were evaluated for general foliage quality, vigor, and hardiness (survival) on a scale of 1-5. Ratings were described as follows:

1 - dead
2 - barely surviving
3 - growth slightly stunted
4 - occasional foliar damage
5 - excellent growth and foliar quality

By June 1990, of the 589 surviving plants, 283 had a rating ≥ 3 (growth slightly stunted (Table 2)). Three years later in August 1993, 40 of 170 remaining plants were rated as ≥ 4 (occasional foliar damage (Table 2)). The winters of 1993-94 and 1994-95 resulted in further loss of plants. By April 1995, the remaining plants were moved to our greenhouses. Between the fall of 1995 and spring of 1999, 25 of these highest rated plants from the original Bloomfield trial were planted into the Arboretum's public garden for further assessment.

In a parallel study, between 1987 and 1991, an additional 33 of the originally germinated seedlings not part of the formal field trial were planted in protected garden settings throughout the Arboretum (Table 3). By October 1999, 22 of these plants remained in the garden (Table 3).

Evaluation in Garden Settings—1999 to 2004

In October 1999 a total of 50 camellias were alive in garden settings throughout the Morris Arboretum (Table 3). These included 25 plants from the field trials (Table 2), 22 remaining plants from those originally planted in garden settings (Table 3), and three additional plants which had been cutting-grown in our greenhouse from original seedlings.

Starting in the fall of 1999 and continuing through the spring of 2004, the 50 plants throughout the Arboretum were visually evaluated. In the spring and fall of each year, the plants were rated for a variety of ornamental traits including general vigor, hardiness, and foliar and floral characteristics.

After these visual evaluations were completed in late 2004, 43 plants remained alive and each year's ratings for these plants were combined. These 43 plants were divided into three categories according to overall performance and appearance after 5 years of evaluation (Table 3). The top 15 plants ('A' rating) exhibited a consistent, positive performance in three key areas of the evaluation criteria. The majority of these plants flowered every year, maintained a desirable form, and retained glossy foliage throughout the seasons. The middle 16 plants ('B' rating) generally performed well in one or two areas of the evaluation, but performance was either not consistent, or was poor in the other categories. The lowest rated 12 plants ('C' rating) generally performed poorly in all categories. In some instances, they may have exhibited one positive characteristic, but this was overridden by the overall appearance of the plant.

Collection # / MOAR Accession #	# planted in Trials, April 1987	# rated ≥ 3 June 1990	# alive Aug. 1993	# rated ≥ 4 Aug. 1993	# moved from field trials to garden settings, 1995-99
Taechong Island KNW 312 / 86-223	23	7	3	1	1
KNW 342 / 86-043	35	15	7	4	1
KNW 343 / 86-044	0	--	--	--	--
KNW 344 / 86-045	95	46	25	3	2
KNW 345 / 86-224	0	--	--	--	--
Sochong Island KNW 348 / 86-048	114	39	18	2	3
KNW 350 / 86-049	17	8	5	1	1
KNW 352 / 86-050	446	168	112	29	14
Unknown Plants*					3
Total=	730	283	170	40	25*

* Three additional plants whose labels were lost were eventually planted in the Arboretum, to make a total of 25 plants moved from the field trials to garden settings.

Table 2. Summary of survival and ratings of Camellia japonica accessions planted in The Morris Arboretum's field trials at Bloomfield Farm, from 1987 through 1993. Plants evaluated with a rating ≥ 3 showed slightly stunted growth. Plants evaluated with a rating ≥ 4 showed occasional foliar damage.

Discussion and Summary

This paper reports on the results of 20 years of evaluation of *Camellia japonica* accessions collected in South Korea in 1984. From the late 1980s through the mid '90s, the study culled the vast majority of the original seedlings based on cold hardiness and survival. Subsequently, 50 plants grown in garden settings were evaluated for a range of horticultural characteristics. These 50, reduced to 43 by 2004 (Table 3), showed sufficient cold hardiness to survive Philadelphia winters from the late 1990s through the present time. As of January 2007, with two additions and one loss, 44 plants are planted throughout the Arboretum (Table 3), representing six of the original nine collections from Korea (KNW 312, 342, 344, 348, 350, and 352). These plants are a valuable genetic resource for introduction and breeding. Although their ornamental value may not compare to cultivars hardy in the southern and western U.S., our plants exhibit attractive single red flowers and glossy evergreen foliage (Figures 2 and 3). They represent a significant advancement in the hardiness of common camellia in Philadelphia and the Delaware Valley.

Along with evaluating the remaining plants in our collection, over the past several years we have been propagating them. The young propagated plants will be added throughout The Morris Arboretum. Also, cutting-grown plants from the highest rated individuals have been distributed to other public gardens throughout the northeastern United States, including Chanticleer, and the Scott, Tyler, Willowwood, Polly Hill, and Arnold Arboreta. Our hope is that distributing this material will help conserve the germplasm and provide evaluation over a broader range of climates.

Collection # / MOAR Accession #	# originally planted in 1987-91	# of original plants alive Aug. 1999	# moved from field trials to garden settings, 1995-99	additional plants added to garden settings, 1999**	Total # alive November 2004, with ratings ‡ A	B	C	Total	Total # alive Jan. 2007
Taechong Island KNW 312 / 86-223	5	1	1	--	--	1	1	= 2	2
KNW 342 / 86-043	10	9	1	1	3	1	5	= 9	11
KNW 343 / 86-044	2	0	--	--			--		--
KNW 344 / 86-045	5	3	2	--	2	3	--	= 5	5
KNW 345 / 86-224	0	--	--	--			--		--
Sochong Island KNW 348 / 86-048	0	--	3		2	--	1	= 3	2
KNW 350 / 86-049	2	2	1	1	1	2	--	= 3	3
KNW 352 / 86-050	9	7	14	--	5	9	4	= 18	18
Unknown Plants*			3	1	2	--	1	= 3	3
Total=	33	22*	25*	3*	15	16	12	= 43	44

* As of October 1999, 50 plants total were planted in garden settings throughout the Arboretum. **Plants cutting-propagated from original seedlings.

‡ These 43 plants were divided into three categories according to overall performance and appearance after 5 years of evaluation.

Table 3. Summary of Camellia japonica accessions planted in garden settings throughout The Morris Arboretum between 1987 through 1991 and supplemented by plantings from 1995 through 2006.

Camellia Japonica continued on page 10

Oregon Research Station's Spring Wish List

The Landscape Plant Development Center's Oregon Research Station continues to serve as the Center's primary growing facility for its first and second generation hybrids.

To maintain our high operating standards and to enable us to serve as a host for events in Oregon, we need the following:

- a pickup truck
- riding lawn mower
- ATV
- high resolution digital camera
- squirrel cage attachment for tractor implement
- pneumatic pruners
- 12" auger bit for tractor
- irrigation big gun (small size)
- 2" and 3" aluminum irrigation pipe
- greenhouse benches
- wood chips/mulch
- picnic table for volunteers

If spring cleaning has left you with extra greenhouse benches or an unwanted riding lawn mower, please contact us. Your in-kind donation of tools and equipment is very valuable to us. Please contact Stacy Lynn Bettison at 952.443.1505 or sbettison@landscapecenter.org.

Tour the Oregon Research Station

The Center welcomes tours of its Oregon Research Station anytime! In the spring, summer and fall, we regularly host visits to the station. A tour is an excellent opportunity to see the variety of plants we are working with in Oregon and to gain a greater understanding of the Center's research model.

If you, your group, or your employees would like to visit the Oregon Research Station, see our plantings, and learn more about our plant breeding programs, please call Sarah Doane at (503) 816-6358 or email her at sdoane@landscapecenter.org.

Camellia Japonica continued from page 9

Currently we are planning to introduce two or three individual plants from our *Camellia japonica* trials. Two plants are those that show the highest ratings for combination of plant habit, foliar quality, and flower density. In addition, one individual plant (86-050*Z9 / KNW 352) is consistently precocious, regularly blooming in late autumn compared to the normal early spring blooming time of the species. Presently there are a few introductions from the 1984 Korean *Camellia japonica* collections commercially available. These are: 'Korean Fire' (KNW 352) introduced by Mr. Barry Yinger through Hines Nursery (Bensen 2000); and 'Longwood Valentine', and 'Longwood Centennial' (KNW 350) introduced by Longwood Gardens (Tomasz Aniśko, personal communication).

In summary, after 20 years of evaluation, a number of *Camellia japonica* plants remain at The Morris Arboretum representing some of the most northern collections ever made of common camellia. This evaluation project has fulfilled the Arboretum's plant exploration goals of broadening the genetic pool of known species, extending species hardiness, conserving rare and endangered species, and selecting improved horticultural forms.

Figure 3. *Camellia japonica* plants growing in a garden setting at the Morris Arboretum.

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