Hydrangeas for the Future©

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INTRODUCTION

The genus *Hydrangea* is comprised of approximately 80 species (McClintock, 1957), the most widely cultivated of which are the bigleaf (*H. macrophylla*), panicle (*H. paniculata*), oakleaf (*H. quercifolia*), and smooth (*H. arborescens*) hydrangeas. The increasing popularity of these species has created a demand for new and improved cultivars. This paper summaries the breeding projects in this genus that are currently underway at the U.S. National Arboretum.

INTERSPECIFIC HYBRIDIZATION

The popularity of *H. macrophylla* is primarily due to its large, brightly colored inflorescences, which range from pink to blue depending on soil pH and cultivar. Unfortunately, most *H. macrophylla* cultivars are rated as hardy only to Zone 6 (Dirr, 1998). The most cold-tolerant *Hydrangea* species, *H. paniculata* or panicle hydrangea, has white flowers that turn pale pink as they age and is rated as hardy to Zone 3. The smooth hydrangea, *H. arborescens*, has pure white flowers and is hardy to Zone 4. Both of these species flower on the current year's growth. Oakleaf hydrangea, *H. quercifolia*, is hardy to Zone 5 and has white inflorescences that age to a deep, dull rose-color. Like *H. macrophylla*, *H. quercifolia* flowers on the previous year's growth.

In 1997, we began a project to develop a cold-hardy *Hydrangea* with brightly colored flowers via interspecific hybridization. Reciprocal crosses of *H. macrophylla* with *H. paniculata*, *H. arborescens*, and *H. quercifolia* were made using numerous combinations of parental cultivars. Included among the *H. macrophylla* cultivars were mopheads (*H. macrophylla* var. *macrophylla*), lacecaps (*H. macrophylla* f. *normalis*), and members of subsp. *serrata*. Viable seeds were obtained for each species combination when *H. macrophylla* was used as the maternal parent (Table 1). All of the seedlings died shortly after germination (Reed, 2000a).

Over 4400 *H. macrophylla* × *H. paniculata* crosses, representing 37 combinations of parental cultivars, were made in 1999. Approximately one-half of these set fruit. Ovaries were collected from 5 to 20 weeks after pollination, surface sterilized, and the ovules removed and placed into culture. Preliminary experiments had shown that Gamborg's B-5 medium with 2% sucrose was capable of supporting the growth and development of *H. macrophylla* intraspecific embryos cultured in ovolo as early as 5 weeks after pollination; therefore this medium was used in all interspecific experiments (Reed, 2000b). In early experiments many of the ovules resulting from the interspecific crosses were found to be contaminated with an endogenous bacterium. The inclusion of a broad spectrum biocide (PPM™; Plant Cell Technology, Washington, D.C.) in the medium at the rate of 0.05% (v/v) eliminated this contamination problem.

Table 1. Results of three reciprocal sets of *Hydrangea* interspecific pollinations.

Hybridization	No. of crosses	No. of seed collected	No. of seeds germinated
H. arborescens × *H. macrophylla*	210	178	0
H. macrophylla × *H. arborescens*	192	37	2
H. paniculata × *H. macrophylla*	1008	0	-
H. macrophylla × *H. paniculata*	2212	2112	50
H. quercifolia × *H. macrophylla*	108	0	-
H. macrophylla × *H. quercifolia*	193	65	10

During the course of a series of experiments, approximately 7100 ovules were extracted from the *H. macrophylla* × *H. paniculata* ovaries and placed into culture. Over 15% of these ovules germinated (Table 2). Some of the plants died shortly after germinating, while others were very abnormal in appearance (e.g., fused cotyledons, callus formation) and were discarded. However, 44% of the plants that germinated were sufficiently normal and healthy in appearance to be transferred to fresh medium 6 weeks after being placed into culture. Some plants developed roots following subculture, and were placed directly into soil. Some of the plants that did not produce roots were transferred to a medium containing 1 $mg \cdot ml^{-1}$ IBA to encourage rooting. Other plants were placed onto a shoot multiplication medium containing 1 $mg \cdot ml^{-1}$ BA. Various efforts, involving combinations of liquid medium, IBA, and half-strength basal medium, were made to root the plants obtained from those cultures. Approximately 16% of the 616 plants that were obtained either directly from ovule culture or following culture on the shoot multiplication medium formed roots and were transferred out of in vitro conditions. Only 21 plants survived transfer to the greenhouse. All but one of these plants were from *H. macrophylla* 'Kardinal' × *H. paniculata* 'Brussels Lace' crosses (Reed et al., 2001). Hybridity of all of these hybrids was verified using molecular markers.

Table 2. Summary of results of a series of experiments involving *Hydrangea macrophylla* × *H. paniculata* embryo rescue.

Ovules cultured	7117
Plants germinated	1113
Plants transferred to fresh medium	490
Plants produced on multiplication medium	126
Plants transferred to soil	100
Plants surviving transfer to greenhouse	21

Most of the surviving hybrids were very small and abnormal in appearance. One of the 'Kardinal' × 'Brussels Lace' plants was more vigorous (Fig. 1). It has not yet flowered, but we have been propagating it so that we can test different environmental conditions to try to induce flowering. We made more *H. macrophylla* × *H. paniculata* crosses this summer, and have started culturing these ovules. Hopefully, we will obtain additional vigorous hybrids from these cultures that, if fertile, can be used to produce F_2 progeny that display various combinations of desirable traits from the parental species.

We have also evaluated embryo rescue for obtaining *H. macrophylla* × *H. quercifolia* hybrids. While 71 plants germinated from *H. macrophylla* × *H. quercifolia* ovule cultures, none of the plants survived long enough to attempt transfer from in vitro conditions. Japanese researchers attempting to produce *H. macrophylla* × *H. arborescens* hybrids via ovule culture also encountered difficulties (Kudo and Niimi, 1999a; 1999b). All seedlings died in culture; therefore they induced cotyledonary tissue to produce callus and attempted to regenerate plants from the callus. One callus line produced plants, whose hybridity was verified using molecular markers.

INTRASPECIFIC BREEDING PROJECT

A breeding project was started in 1997 with the objective of developing compact oakleaf hydrangea cultivars. We are currently working with two sets of materials. The first group is derived from open-pollinated seed that were collected from 'Pee Wee', a compact *H. quercifolia* cultivar. Progeny were evaluated in the field in 1999; while variation in plant habit and flowering were observed, no compact plants were identified. Superior plants among these 'Pee Wee' open-pollinated seedlings were intercrossed. We are currently evaluating these second-generation progeny. Several plants with compact plant habit have been identified, but not all have flowered. These plants were recently transferred from containers to the field and will be carefully evaluated next summer. The second set of material is derived from 'Pee Wee' × 'Flemygea', Snow Queen® oak-leaf hydrangea controlled pollinations. Again, no compact plants were observed among the F_1 progeny. During Summer 2001, F_2 crosses were made so it will be at least 2 years before these plants can be evaluated for flowering and growth habit.

While we have not been actively pursuing a breeding project in *H. paniculata*, some interesting plants of this species have been observed. An experiment to determine if *H. macrophylla*, *H. paniculata*, *H. arborescens*, and *H. quercifolia* are self-fertile resulted in *H. paniculata* 'Unique' self-pollinated progeny. Three of these plants were planted in the field this spring, while two others were kept in containers. All appear to be much more compact than most of the *H. paniculata* cultivars. They have flowered heavily this year, and have very attractive flowers. We have begun to propagate these plants for further evaluation.

EVALUATION OF COLD HARDINESS IN H. MACROPHYLLA

In 1997, replicated field plots of 21 *H. macrophylla* cultivars were established at the Tennessee State University Nursery Crop Research Station in McMinnville, Tennessee (Zone 6b) and the University of Missouri Horticulture and Agroforestry Research Center in New Franklin, Missouri (Zone 5b). The following cultivars, which were selected based on their popularity and/or anecdotal reports of cold hardiness, were evaluated: 'All Summer Beauty', 'Alpenglühen', 'Blauer Prinz',

Figure 1. *Hydrangea macrophylla* 'Kardinal' × *H. paniculata* 'Brussels Lace' hybrid plant 99-209B.

'Blue Billow', 'Blauling' (syn. 'Bluebird'), 'Mariesii Perfecta' (syn. 'Blue Wave'), 'Coerulea', 'Général Vicomtesse de Vibraye', 'Grayswood', 'Horben', 'Madame Emile Mouillère', 'Maréchal Foch', 'Mariesii', 'Masja', 'Mousseline', 'Nikko Blue', 'Pia', 'Pink Lacecap', 'Preziosa', 'Todi', and 'Tokyo Delight'.

In 1999, 2000, and 2001, the number of inflorescences produced by each plant was recorded and statistically analyzed. While rankings of cultivars differed somewhat between years and locations, a few cultivars stood out as having overall better flowering performance than the others. 'All Summer Beauty', 'Coerulea', and 'Nikko Blue' were consistently among the best cultivars. In contrast, 'Blue Wave', 'Mariesii', and 'Todi' performed poorly all years at bothlocations.

In 1999 and 2000, flowering was heavier in Missouri than in Tennessee, even though during both years the average daily mean temperature and the yearly minimum at the Missouri site were considerably lower than at the Tennessee planting. Extended periods of warm weather in late winter to early spring, prior to the last freeze of the season, are thought to have been responsible for reduced flowering in Tennessee.

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Rootstock Selection and Graft Compatibility of *Chamaecyparis* Species©

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INTRODUCTION

The genus *Chamaecyparis* includes many desirable and commercially important taxa. Although there are only 6 to 7 species in the genus, there is considerable variation among taxa including over 240 cultivars of *Chamaecyparis lawsoniana* alone (Krüssmann, 1985). Unfortunately, many of the *Chamaecyparis* spp. are native to cool, temperate climates and often perform poorly in stressful landscape situations, particularly under conditions of poor drainage (hypoxia), high temperatures, and *Phytophthora* spp. pathogens (Dirr, 1998; Hunt and O'Reilly, 1984). *Chamaecyparis lawsoniana* and *C. nootkatensis*, for example, are both native to the mountains of the Pacific North West and often have poor survival in less than ideal landscape settings.

Grafting poorly adapted plants onto superior rootstocks is one approach for engineering compound plants for greater environmental adaptability. Since *Chamaecyparis* species exhibit considerable ecological latitude, with some species found in cool, mountain climates (e.g., *C. nootkatensis*) while others are native to hot, boggy conditions (e.g., *C. thyoides*) (Harlow, et al., 1978), this approach (selection of tolerant rootstock) may have particular merit. There are also considerable differences in disease resistance among species of *Chamaecyparis*. *Chamaecyparis lawsoniana* is extremely susceptible to *Phytophthora lateralis* whereas *C. formosensis*, *C. nootkatensis*, *C. pisifera*, *C. obtusa* var. *formosana* (syn. *C. taiwanensis*), *C. thyoides*, and ×*Cupressocyparis leylandii* were found to be resistant (Hunt and O'Reilly, 1984). *Chamaecyparis lawsoniana* is also known to be susceptible to *P. cinnamomi* (Sinclair et al., 1987).

Opportunities for rootstock selection for *Chamaecyparis* spp. also extend beyond this genus. Limited experimentation has found that *Chamaecyparis* spp. can be