The Principles and Practices of Breeding Hydrangeas©

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INTRODUCTION

Hydrangea includes approximately 23 species with a disjunct distribution in temperate and tropical regions of eastern Asia, Eastern North America, and South America (McClintock, 1957). Of these 23 species, *Hydrangea anomala* subsp. *petiolaris, H. arborescens, H. macrophylla, H. paniculata, H. quercifolia,* and *H. serrata* are the most common in cultivation. *Hydrangea macrophylla*, with over 500 extant cultivars, is one of the most important flowering shrubs, and its popularity is due to its versatility as a garden shrub, florists' pot plant, and cut flower (Griffiths, 1994).

HISTORY OF HYDRANGEA BREEDING

Historically, hydrangea breeding has involved intraspecific crosses within *H. macrophylla, H. paniculata,* or *H. serrata*. Interspecific crosses within the genus have resulted in minimal success. Intraspecific crosses involve two plants from the same species, while interspecific crosses involve plants from two different species in the same genus. Of the three above-mentioned species, the primary focus has been improvement of *H. macrophylla*; which was first bred by the French in the early 1900s. Dutch, Belgian, Swiss, English, German, and Japanese breeders followed. Most of the early breeding focused on the production of cultivars with improved flower size and color for the pot plant or florist market (Lawson-Hall and Rothera, 2005). In recent years, the popularity of hydrangeas as garden shrubs has increased due to the introduction of new cultivars such as 'Bailmer' (Endless Summer™ hydrangea). Breeders should strive to develop plants that are adapted to garden culture and provide multiple seasons of interest. Traits of interest for *H. macrophylla* breeding include: the ability to rebloom (remontancy), inflorescence type, improved flower colors, fragrance, showy fruits, improved foliage, fall color, pigmented stems, strong stems, compact habit, cold hardiness, drought tolerance, disease resistance, and pest resistance.

TOOLS AND CRITERIA TO CONSIDER

New sources of genetic diversity and unique characteristics are needed in future cultivars to sustain the current enthusiasm and excitement, thus enhancing sales. Interspecific crosses may prove important sources of genetic diversity and unique characteristics. Recently, Rinehart et al. (2006) developed simple sequence repeat or microsatellite (SSR) markers for hydrangeas. These markers may reveal genetic relationships among species, assess genetic diversity among and within species, verify hybridity of progeny from intraspecific and interspecific crosses, and analyze parentage. Research is ongoing to identify markers linked to traits of interest, such as remontancy and disease resistance, for use in marker-assisted selection (MAS).

Several researchers have determined chromosome number, genome size, and ploidy level for many different species and cultivars of *Hydrangea*. See Cerbah et

al. (2001), Demilly et al. (2000), and Zonneveld (in van Gelderen and van Gelderen, 2004) for more information. Consult Reed (2004 and 2005) for excellent discussions on self-incompatibility, stigma receptivity, and pollination biology in hydrangeas and Dirr (2004), Lawson-Hall and Rothera (2005), and van Gelderen and van Gelderen (2004) for detailed information on species and cultivars of hydrangeas. Dirr (2004) presents a detailed summary of recent hydrangea breeding programs.

SO YOU WANT TO BREED HYDRANGEAS!

A comprehensive breeding strategy should be developed that includes the goals, a plan to achieve those goals, a list of supplies, equipment, and facilities that will be required, and protocols for selection, evaluation, and introduction of new cultivars.

Determine Goals. Two general types of goals are improvement of existing traits and introduction of new traits. Existing traits, such as remontancy and disease resistance, are already present in the species of interest. New traits, such as fragrance and showy fruits are not present in the species of interest and are often introduced through interspecific crosses. How the trait is inherited (quantitative vs. qualitative, dominant vs. recessive) must also be considered. Quantitatively inherited traits are controlled by multiple genes and are difficult to breed for. Qualitatively inherited traits are controlled by one or two major genes and are easier to breed for.

Select Parents. The genotypes that are selected for use as parents depend on the goals and should be based on a review of the literature and field observations. Field evaluations in Athens, Georgia (Dirr, 2004) and Fletcher, North Carolina (Bir, 2000a; Bir, 2000b) have identified taxa that are disease resistant and cold hardy and that flower consistently. When selecting genotypes for use as parents, remember that superior parents yield superior progeny and inferior parents yield inferior progeny.

Facilities Required. A typical nursery setup is needed for growing seedlings to flowering plants. Required facilities include a heated house, overwintering structures, breeding cages, and a mist system. While crosses can be made outside, it is easier to make controlled crosses inside a greenhouse where the plants can be isolated from insects and where water and temperature can be controlled. If using interspecific crosses, it is necessary to synchronize flowering of the different species or to collect and store pollen. A walk-in cooler may be useful for synchronizing flowering of different species. Pollen can be successfully stored for up to 11 months (Kudo and Niimi, 1999), which will eliminate the need for a walk-in cooler. A shade area will be necessary, especially in the South, for growing most species of *Hydrangea*, with *H. paniculata* being the most obvious exception.

Perform Crosses. Plants are brought into a heated greenhouse [±24 °C (75 °F) / ±18 °C (65 °F) day/night temperature] in early January. This will prevent late spring freezes from damaging inflorescences, allow complete control of temperature and water availability, and prevent pollen contamination by excluding insects from the breeding environment. Flowers are fully expressed in 10 to 12 weeks. Three to five inflorescences per plant are pollinated by hand. Reciprocal pollinations, using each parent as a male and female, are made in the morning using fresh pollen if available. If mophead cultivars are used, the sterile flowers with showy sepals must be

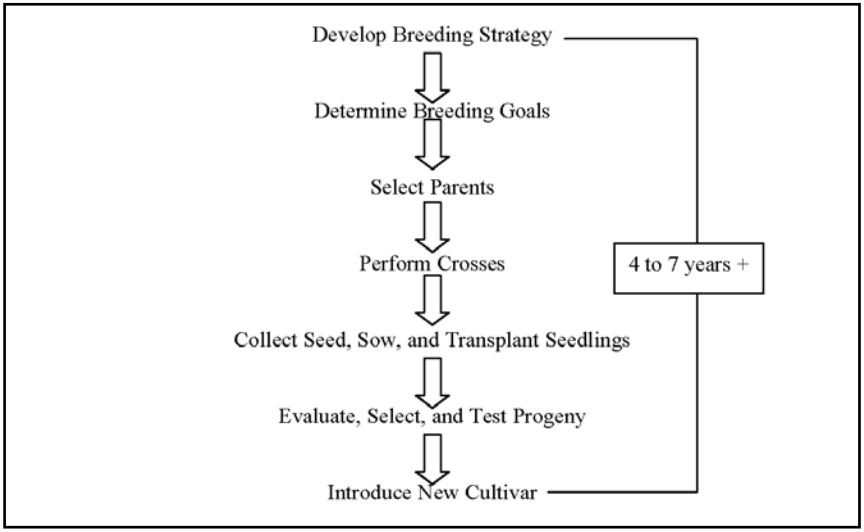

Figure 1. Flow chart and timeline for a typical hydrangea breeding program.

removed to allow easier access to the underlying fertile flowers. If lacecap cultivars are used, removal of one-third to two-thirds of the fertile flowers will reduce the number of pollinations that will be required. A lacecap inflorescence contains hundreds of fertile flowers, each capable of producing 100 or more seeds. Flowers used as the maternal parent should be emasculated to prevent self-pollination. Pollen is transferred to the stigma of the maternal parent using a small paint brush or by brushing an anther from the pollen parent directly onto the stigma of the maternal parent. *Hydrangea macrophylla* possesses a gametophytic self-incompatibility system. Therefore, emasculation may not be necessary, but a small percentage of self-pollinations may result. All inflorescences used for pollinations are labeled with the maternal parent, pollen parent, and date. Keep a logbook that details each cross and includes the parentage, date, and number of flowers for each cross. Plants are moved outside in May, and the infructescences are allowed to mature.

Collect Seed, Sow, and Transplant Seedlings. Collect the capsules in fall as they turn from green to brown. Dry them indoors in small paper bags. Crush the capsules and separate the seeds from the chaff using a small screen. Surface-sow the seeds in flats filled with soilless medium. Do not cover the seeds. Place the flats under mist or keep them moist until germination occurs. Once the seedlings have developed two or more pairs of true leaves, transplant them into individual cells and grow in a greenhouse. After the danger of frost has passed, move the seedlings outside and pot into 11-L (3-gal) containers under shade.

Evaluate and Select Progeny. Evaluate and select superior progeny according to the goals of the program. Seedlings can be screened for traits such as foliage characteristics and disease resistance during the first growing season. Flowering characteristics such as color, inflorescence type, and remontancy usually cannot be screened until the second growing season, because the plants must reach maturity before they will flower. Seedlings will flower when approximately 16 to 18 months

old. Superior and/or unique progeny that have been selected should be propagated and evaluated in multiple locations and/or for multiple years to ensure that they will remain true-to-type. During evaluation, superior seedlings may be bulked up through asexual propagation to ensure that enough plant material is available to speed the introduction of a new cultivar.

HYDRANGEA BREEDING TIMELINE

It takes approximately 12 to 14 months from the time crosses are made in the greenhouse until the seedlings are potted outside the following spring. Evaluation, selection, testing, and bulking-up of a seedling may take an additional 3 to 5 years or more. From the time an initial cross is made until a new cultivar is released may take 4 to 7 years or more (Fig. 1).

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