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수국 품종 개발 역사와 방향성

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Trend of hydrangea cultivar development

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ABSTRACT

In the genus Hydrangea, *H. macrophylla* is the most popular species because of its large and brightly colored inflorescences. Hydrangea breeders have been focused on the development of new cultivars for sale as flowering potted plants. Breeding efforts in hydrangea have involved interspecific and intergeneric crosses attempted to introduce useful characteristics. In hydrangea, incongruity prevents interspecific crosses within the genus. In vitro methods allow developing an integrated procedure for overcoming fertilization barriers.

Additional key words: Hydrangea, interspecific crosses, incongruity, in vitro, fertilization barriers

Introduction

The genus Hydrangea includes at least 23 species naturally found in temperate regions of Eastern Asia, North America and in subtropical Central and South America (McClintock 1957; Mortreau 2003). The genus is divided into the sections Hydrangea, which contains mainly temperate climate species, and Cornidia, which consists of climbing species from tropical and subtropical area. The section Hydrangea has a number of ornamentally attractive characteristics and commonly cultivated (Kudo et al., 2008). *Hydrangea macrophylla* is the most popular member of the Hydrangeaceae (McClintock, 1957; Dirr, 1998). The species is valued for its large, brightly colored inflorescences, which range in color from white to pink through blue, and which contain a combination of perfect and imperfect flowers. Flower color in *H. macrophylla* is dependent on cultivar and availability of aluminum in the soil (Takeda et al., 1985).

Hybridization between distantly related species

has been used in ornamental crop breeding to move desirable genes from one species to another (Langton, 1987). Distant hybridization is an important tool for broadening genetic variability in commercial cultivars of *H. macrophylla*. Distant hybridization such as interspecific hybridizations have been made successfully in Hydrangea. Some examples of interspecific hybridization are *H. macrophylla* x *Hydrangea paniculata* were produced using in ovolo embryo rescue (Reed, 2004), *H. macrophylla* x *Hydrangea arborescens* L. hybrids were also produced via embryo rescue, following regeneration from callus derived from cotyledon tissue (Kudo and Niimi, 1999) and embryo rescue was used to produce putative *H. macrophylla* x *Hydrangea quercifolia* Bartr. hybrids (Kudo et al., 2002).

1. Economic important of hydrangea

The genus Hydrangea is expansive and includes hybrids and cultivars, which can be deciduous or evergreen shrubs, small trees or climbers. Hydrangeas commonly produced commercially are selected for their showy inflorescence. The floral display of hydrangea is largely due to sterile florets, grouped into large rounded corymbs or conical panicles, and ranges from white to pink, purple and blue colors. Hydrangea is a significant crop and offers tremendous opportunies for nursery producers. Four species are commonly produced in nursery cultivation including, *H. macrophylla*, *H. paniculata*, *H. quercifolia* and *H. arborescens*.
(https://extension.tennessee.edu/publications/Documents/PB1840-B.pdf)

2. History of hydrangea breeding

Hydrangea was systematically described in McClintock's 1957 'A Monograph of the Genus Hydrangea'. McClintock included 23 species distribution in both temperate and tropical regions of eastern Asia, eastern North and South America. *Hydrangea macrophylla* is the most popular of these species, and it is one of the most commercially important flowering shrubs grown worldwide. *Hydrangea macrophylla* is native to southern China and Japan, and was cultivated there long before introduction into Europe in the 1800s (McClintock, 1957; Wilson, 1923).

The genetic diversity among *H. macrophylla* cultivars is limited due to the restricted native distribution and multiple breeding programs that utilized the same taxa and employed similar breeding goals (Haworth-Booth, 1984). Most of the cultivars in existence today are derived from plants bred in the early 20th century through controlled crosses, open pollinations, or introductions of wild collected germplasm in the 19th and 20th centuries (Haworth-Booth, 1984; McClintock, 1957). Although over 1000 cultivars of *H. macrophylla* exist, many of them are similar in growth habit, floral characteristics, and disease susceptibility (Dirr, 2002).

Historically, breeders have focused on the development of new cultivars for greenhouse forcing and sale as flowering potted plants (Lawson-Hall and Rothera, 2005). Plant breeders in Europe and the United States have been breeding hydrangeas since the late 19th century. Hydrangea breeding programs also focus on incorporating remontant flowering, earlier flowering, inflorescence type, new or improved flower colors, attractive foliage, fall color, strong stems, stem pigmentation, compact habit, cold hardiness, drought tolerance, insect and disease resistance into new cultivars.

3. Taxonomy and plant description (McClintock 1957)

Division: Magnoliophyta
Class: Dicotyledonae
Order: Cornales
Family: Hydrangeaceae
Genus: Hydrangea

The Hydrangea genus is divided into the section Hydrangea, which contains the temperate climate species, and the section Cornidia, which contains the vining species from tropical and subtropical climates. As described by McClintock (1957) the cultivated species are all members of the section Hydrangea and have been placed into subsections Americanae (*H. arborescens* and *H. quercifolia*), Asperae (*H. involucrata* and *H. aspera*), Calytranthae (*H. anomale*), Heteromallae (*H. paniculata*) and Macrophyllae (*H. macrophylla*). The mountain hydrangea(*H. serrata*) is considered by some separated species and closely related to *H. macrophylla.*

Hydrangea macrophylla has long been the most widely grown member of the genus. It is valued

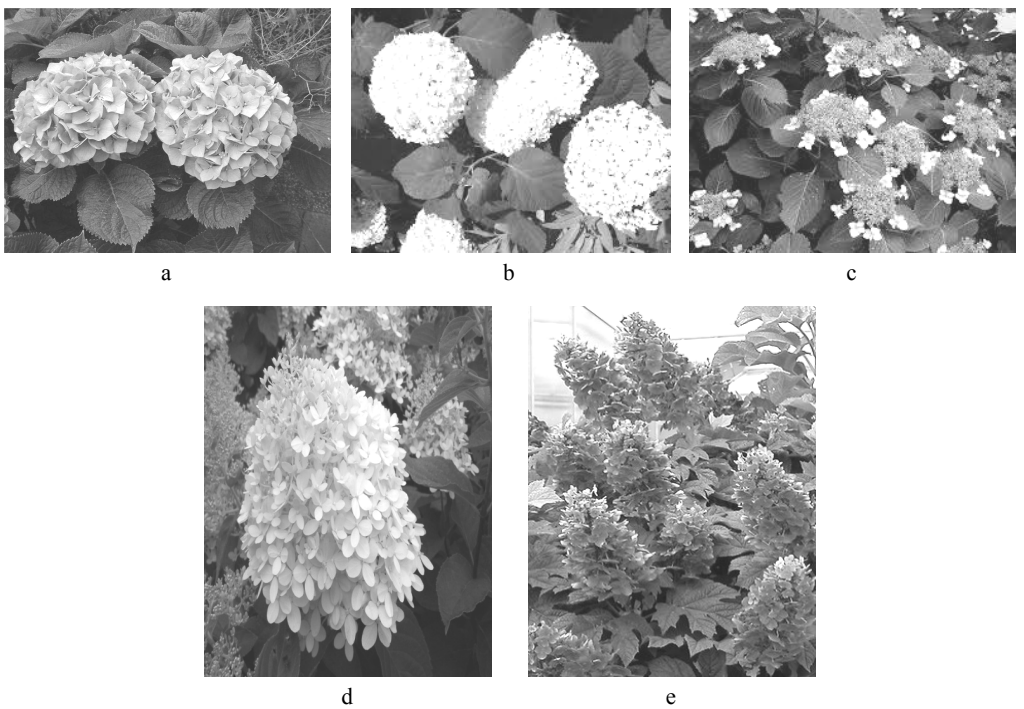

Fig. 1. Inflorescence of hydrangea species (a) Hydrangea macrophylla, (b) *H. arborescens* (c) *H. serrata* (d) *H. paniculata* and (e) *H. quercifolia*.

Fig. 2. Inflorescence of parents and interspecific hybrid (Kudo, 2008). *Hydrangea scandens* (left), the interspecific hybrid Cm1 (center) and *H. macrophylla* (right). Bars=3cm.

for its large corymbs that, depending on soil pH and cultivar, range in color from pink to blue and in intensity from pale to deeply colored. *Hydrangea paniculata* which is native to China and Japan, grows 3 to 6 m in height and spread. Inflorescences are produced in mid-summer and consist of 15 to 20 cm long panicles of white to pale pink flowers. It is the most cold-hardy member of the genus. *Hydrangea quercifolia* is native to south eastern United States. Most plants grow 2 m or taller in height with an equal to wider spread. Cream-colored conical inflorescences up to 30 cm length are produced in early summer and often turn in an attractive rose-color as they age. Inflorescence of *H. macrophylla*, *H. paniculata* and *H. quercifolia* consist of a combination of showy sterile and inconspicuous fertile flowers. Fertile flowers are small (< 10 mm in length) and have 2 to 4 styles (McClintock 1957).

4. Fertilization barriers

The difficulty of creating interspecific hybrids increases along with the phylogenetic distance between the parents (Sharma 1996). In Hydrangea, incongruity prevents interspecific crosses within the genus. Reed (2000a) tried to cross *H. paniculata* and *H. macrophylla*. Seeds were only obtained when *H. macrophylla* was used as the seed parent, but most of the seeds didn't germinate. The few obtained seedlings died during the cotyledonary stage or after the development of the first true leaves. However, by using 'embryo rescue', a few hybrids could be produced between *H. macrophylla* and *H. arborescens* (Kudo and Niimi, 1999) and between *H. macrophylla* and *H. paniculata* (Reed, 2000b). Up to now, several techniques have been used to overcome fertilization barriers: the application of exogenous growth substances, embryo rescue, intraovarian pollination in vivo and in vitro, in vitro fertilization of ovules, and somatic cell hybridization (Zenkteler 1990).

5. Way of Interspecific crosses

Some recent breeding efforts in Hydrangea have involved interspecific and intergeneric crosses. Kudo and Niimi (1999a) attempted to introduce useful characteristics (e.g., cold hardiness) of *H. arborescens* into *H. macrophylla*. For interspecific cross, firstly choose the maternal and male parents with desirable characteristics. The sterile and the already opened fertile flowers were removed from the inflorescences. Subsequently, the anthers were removed to prevent self-pollination and cover the inflorescences with a breathable paper bags. Finally, pollination of each flower makes 1 to 3 days after emasculation with newly dehisced pollen.

6. Verification of hybrids

6.1 Morphological comparisons

The old methods are still very important to achieve success in wide crosses. Generally comparison makes between parents and hybrids plants based on morphological characters, such as inflorescence color and size, leaf shape and size and stem color.

6.2 Ploidy Level

Difference in ploidy levels between the 2 parents is one of the reasons of incongruity in interspecific crosses in hydrangea. Determination of ploidy level of hybrids by chromosome counting on actively growing root tips was described by Mortreau et al. (2010). An abnormal chromosome number can slow down the growth of the pollen tube or inhibit the fusion of both gametes.

6.3 Fluorescence in situ hybridization (FISH) method

Molecular cytogenetics has been used to investigate hybridity and investigate parental contribution. Molecular cytogenetic techniques such as fluorescent in situ hybridization (FISH) associated with fluorochrome staining can be valuable method for

studying species with small and/or morphologically similar chromosomes (Maluszynska and Heslop-Harrison 1993). Fluorescence in situ hybridization (FISH) technology has opened the possibility to address chromatin regions of individual chromosomes on the basis of DNA sequence information in addition to morphological features (Schubert et al. 2001). Cerbah et al. (2001) and Zonneveld (2004) have undertaken a cytometric analysis of the DNA content in relation to the chromosome number to study the genome size variation and species relationships in the genus Hydrangea.

6.4 Molecular analysis

Molecular methods greatly facilitate selection of the progeny after hybridization. Moleclar markers may be used to reveal genetic relationships among species, assess genetic diversity among and within species, verify hybridity of progeny from intraspecific, interspecific, and intergeneric crosses, develop marker assisted selection (MAS) programs, and identify cultivars. Due to the ease of their use, markers with arbitrary primers are commonly utilized for interspecific hybrid confirmation in ornamental plants. For instance, SSRs were used for hybrid verification in Rosa (Kaul et al. 2009) and Hydrangea (Kardos et al. 2009).

7. Conclusion

Interspecific hybridization between hydrangea species has been achieved and a desirable hybrid selected. ‘Embryo rescue’ procedure has been effective for the recovery of interspecific and intergeneric hybrids involving hydrangeas. Development of reliable markers will be useful for hybrid verification in hydrangeas. A better understanding of interspecific hybrid and associated phenomena would be lead to development of commercial production of hydrangea.

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